Environmental and Social Impact Assessment (Draft)

Part 1 of 5

January 2019

THA: Eastern Economic Corridor Independent Power Project

Main Document

A MEMBER OF TEAM GROUP ISO 9001 : 2008 CERTIFIED

Gulf PD Co., Ltd

Environmental Report for submission to ADB

Pluak Daeng Power Plant Project

TEAM CONSULTING ENGINEERING AND MANAGEMENT PCL
151 Nuan Chan Rd., Nuan Chan, Bueng Kum, Bangkok 10230
Tel.(662) 509-9000 Ext. 3307 Fax (662) 509-9047

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ENVIRONMENTAL REPORT FOR SUBMISSION TO ADB
PLUAK DAENG POWER PLANT PROJECT

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CHAPTER 1

EXECUTIVE SUMMARY

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EXECUTIVE SUMMARY

1.1 PROJECT BACKGROUND

The Pluak Daeng Power Plant Project is subjected to the requirements on the preparation and submission of the EIA report to the ONEP for review and approval (under the Notification of the Ministry of Natural Resources and Environment Regarding Types and Sizes of Projects or Activities Requiring Preparation of Environmental Impact Assessment Reports; and Criteria, Procedure, Regulation and Guideline to Prepare Environmental Impact Assessment (EIA) Reports (No. 7), B.E. 2558 (2015)). Therefore, TEAM Consulting Engineering and Management PCL. was engaged to conduct the required EIA study. The EIA study for Sriracha Power Plant Project is fully complied with applicable Thai laws i.e. ONEP guidelines for EIA report for Power Plant which include environmental standards/regulations of Department of Industrial Works, Ministry of Industry, Ministry of Natural Resource and Environment, Ministry of Interior, Ministry of Transport and Communications, and Ministry of Labor, etc. and with ADB Safeguard Policy Statement (2009) requirements. The EIA report of Pluak Daeng Power Plant Project was approved by ONEP on 30 November 2016.

1.2 SUMMARIZED PROJECT DESCRIPTION

The Pluak Daeng Power Plant of Gulf PD Co., Ltd. covers area of 492 rai, 1 ngan and 20.3 square wah or approximately 492 rai, covering 13 plots of land in the Pluak Daeng Industrial Park (Industrial Park), Map Yang Phon sub-district, Pluak Daeng district, Rayong Province. The power plant is estimated 146 km east of Bangkok. The proposed Pluak Daeng Power Plant will utilize natural gas as main fuel and diesel oil as back up fuel. The total installed capacity of this power plant is 2,920 MW which will be sold to the Electricity Generating Authority of Thailand (EGAT). Major machineries and equipment of the Pluak Daeng Power Plant will be four combustion turbine generators (CTG), four heat recovery steam generators (HRSG) and four steam turbine generators (STG). The generated electricity to be sold to EGAT will be dispatched via the 500 kV Pluak Daeng Sub-station. The natural gas for the project to be supplied by PTT (Public) Co., Ltd. is expected to peak at 412 million cubic feet/day at LHV dry value and the diesel oil supply as contingency fuel, is expected to be 8,631 m^3/day. Raw water will be provided by the Eastern Water Resources Development and Management PCL with rate of 63,000 m^3/day and stored in the 189,000 m^3 reservoir. The wastewater of the power plant is derived from 2 sources: cooling system and production processes. The effluent discharged from the cooling tower will be drained into the cooling water holding pond of the power plant before discharging into the cooling water holding pond for Pluak Daeng Industrial Park. However, properties of discharged cooling water have to meet standards such as Notification of Ministry of Industry No. 2 (B.E.2539) re: wastewater discharge criteria for factory and standard of discharged wastewater quality to irrigation water route of Rayal Irrigation Department. Wastewater from production processes will be treated prior to discharge into the project's wastewater holding pond for further discharge into the central wastewater treatment system of Pluak Daeng Industrial Park. The properties of discharged wastewater into the central wastewater treatment plant have to meet the requirements of Pluak Daeng Industrial Park for effluents discharged to the central wastewater treatment system of Pluak Daeng Industrial Park.

The study of alternative consideration was conducted in accordance with the Office of the Natural Resources and Environmental Policy and Planning (ONEP) Guideline. Alternative consideration is an important step in order to mitigate environmental impact to the lowest level, increase possibility of the project design and investment. The principle criteria for alternation consideration are as follows:

- Mainly utilize the areas of the industrial estate to mitigate impacts on people's land use
- Avoid historic areas or archaeological sites
- Located in the areas with energy network or natural gas pipeline
- Have feasible engineering for both construction and maintenance
- Have enough basic infrastructure to support the need of the project
- Cause the least impact on sensitive environmental areas such as communities, religious places, schools, governmental offices and hospitals
- Avoid the areas specified in the attachment of the Notification of the Ministry of Natural Resources and Environment as specific conservative areas which have been protected by laws.

According to environmental categorization stated in ADB's Safeguard Policy Statement (2009), the project has been classified as following categories;

- Category A – Project is likely to have significant adverse environmental impacts.
- Category B – Involuntary resettlement related to the land acquisition required for the Electricity Generating Authority of Thailand (EGAT) transmission line.
- Category C – Indigenous people. There is no indigenous people will be affected by the project and no presence of indigenous people in the project area of influence.

1.3 ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

As the Pluak Daeng Power Plant is located in the Pluak Daeng Industrial Park, the potential impacts, therefore, are related to pollution from the project rather than from the project location and infrastructure of the project. The impacts related to the pollution from project operation are summarizied as follows:

1.3.1 Soil Resources

- **Baseline Condition**

Based on the field investigation, four (4) soil samples were collected and analysed. The results show that most of soil samples have low fertility. For the annual soil loss (A), is about 0.49 tons/rai/year has been predicted, less than the Soil Tolerance Goal of 2.00 tons/rai/year set by the Land Development Department (2002).

- **Potential Impacts and Mitigation Measures**

During construction phase, there is no impact to the soil fertility. For soil erosion, the average annual soil loss (A) during excavation activities is predicted of about 1.55 tonne/rai/year less than the Soil Tolerance Goal of 2.00 tonne/rai/year (Land Development Department (2002)), show that the soil erosion caused by the project during construction phase is less than the natural circumstances.

During the operation phase, an operation of electricity generation will emitted Sulfur dioxide, major cause of an acid rain. However, the propose project is used natural gas as the main fuel, emitted of Sulfur dioxide from combustion is less than other fuel fossil and prescribes that the emitted air pollutant from the project stack must be lower than those established in the Ambient Air Quality Standards. Therefore, the impact to the soil fertility is considered as “Low”.

1.3.2 Air Quality

- **Baseline Condition**

Based on the results from secondary data complication and field measurement, the ambient air quality within the proposed project site and study area are still good and the concentration of Total Suspended Particulates (TSP), Particulate Matter less than 10 microns (PM10), Nitrogen Dioxide (NO_2), Sulfur Dioxide (SO_2), and Carbon Monoxide (CO) both wet and dry seasons were in accordance with the Ambient Air Quality Standard.

- **Potential Impacts and Mitigation Measures**

During the construction phase, the potential impact which cause by the dispersion of fugitive dust from the foundation and excavation activities. The predicted results from the AERMOD model finding show that the maximum concentration of TSP and PM10 within the construction site are in accordance with OSHA Standard and the maximum concentration at the selected sensitive receptors are also in accordance with the Ambient Air Quality Standard. For the gaseous pollutants form the construction equipment and machine, the concentration of PM10, NO_2, and SO_2 are in accordance with the Ambient Air Quality Standard.

During the operation phase, the potential impact will cause by the emitted pollutants from the combustion of natural gas (main fuel) and diesel oil (backup fuel) to generate the electricity. The impact of ambient air quality has been predicted for 6 scenarios by using the AERMOD model included Impacts caused by Pluak Daeng Power Plant Project at the minimum & full operation load with natural gas and diesel oil together with the existing plants within the radius of 15 km from the project site. The predicted result from the AERMOD model finding show that the total concentration of TSP, PM10, NO_2, and SO_2, and CO (Predicted +Baseline condition) at the selected sensitive receptors and the area within the radius of 15 km from the project site are in accordance with the Ambient Air Quality Standard with the moderate. However, additional mitigation measure and monitoring programs will minimized the potential impact on the air quality to the acceptable level. Therefore, the impact to the ambient air quality is considered as “Low”.

1.3.3 Noise Level

- **Baseline Condition**

Based on the results from the secondary data complication and field measurement, the existing noise level within the project site and surrounding area in term of Leq, 24-hr., L_{max} are still in accordance with the Noise Level Standard.

- **Potential Impacts and Mitigation Measures**

During the construction phase, transportation and construction activities may generate noise that disturb worker and people in the sensitive receptor surrounding the project site. The predicted results from the simple mathematic model finding show that the noise level in term of Leq 8 hr. and Leq 24 hr. within the construction site and sensitive receptors are in accordance with the applicable standard. However, the annoyance noise level at 3 sensitive receptors are exceeded the Annoyance Noise Level Standard. In case that implement the additional mitigation measures by installation of temporary noise barrier which made of metal-sheet (1.27 mm-thickness), the noise level impact will reduced and in accordance with the Annoyance Noise Level Standard. Therefore, the noise level impact is considered as “Low”.

During the operation phase, an operation of equipment and machinery for the electricity generating activities such as Gas turbine, HRSG, and Gas compressor may generate noise that disturb the people in the sensitive receptor surrounding the project site. The predicted results finding show that the noise level in term of Leq 8 hr. and Leq 24 hr. within the project site and sensitive receptors are in accordance with the applicable standard, and the annoyance noise level at 3 sensitive receptors are still equals to the existing level. Therefore, the noise level impact is considered as "Low".

1.3.4 Surface Water Quality

- **Baseline Condition**

Based on the results from the field measurements, the surface water quality of Huai Phu Sai Brook for both wet and dry season can be categorized as Class 3-4 according to the Notification of the National Environment Board, No. 8 1994 (B.E.2537), regarding Establishment of Surface Water Quality Standards. This water sources can used for utilization and consumption through general disinfection and treatment process, agriculture, and industry purposes.

- **Potential Impacts and Mitigation Measures**

During the construction phase, the generated wastewater is about 234.2 m^3/day consists of (i) uncontaminated wastewater from construction activities which collected and conveyed to the inspection pond before discharge to the central wastewater treatment system of the Pluak Daeng Industrial Park, and (ii) wastewater from utilization and consumption of construction workers which will be collected and conveyed to a septic tank or the prefabricated waste water treatment system before discharge to the central wastewater treatment system of the Pluak Daeng Industrial Park. For discharged water of 250 m^3 from the hydrostatic test which performed 1 time will be collected and conveyed to a temporary sedimentation pond and re-used as water spraying for dust diffusion control. Therefore, there is no impact on the surface water quality during this phase.

During the operation phase, the generated wastewater are;

- ***Wastewater from the electricity generating process:*** about 48 m^3/d consists of wastewater from the water treatment plant, wastewater from the laboratory and wastewater from utilization and consumption. The generated wastewater will collected and treated before conveyed to the central wastewater treatment system of the Pluak Daeng Industrial Park which capable to treat wastewater about 2,000 m^3/d. Therefore, there is no impact on the surface water quality during this phase.

- *Cooling water:* about 12,232 m^3/d, will monitoring to ensure that the effluent quality to meet the standards of wastewater discharged from factories as specified in the Notification of Ministry of Industry, No.2 (B.E.2539) and the standards of wastewater quality, Royal Irrigation Department (for Total Dissolved Solid, TDS) before discharge to the cooling water holding pond with the capacity of at least 15,000 m^3 of Pluak Daeng Industrial Park. Therefore, there is no impact on the surface water quality during this phase.
- *Drainage water:* consist of uncontaminated storm-water which will be drained into the drainage collection system of Pluak Daeng Industrial Park and Oil contaminated storm-water which will be gradually conveyed to an oil separator to separate oil before pumping water for the central wastewater treatment system of Pluak Daeng Industrial Park. Therefore, there is no impact on the surface water quality during this phase.

1.3.5 Aquatic Ecology

- **Baseline Condition**

Based on the field measurement for 4 stations in Huai Phu Sai Brook, nearest surface water resources to the project site during wet and dry season, the results during wet season show that, there are 9-16 species of phytoplankton (Total density = 42,000-144,550 cells/m^3 and the diversity index=1.70-2.51), 8-10 species of zooplankton (Total density = 36,750-61,600 individual/m^3 and the diversity index=1.83-2.21), and 0-6 species of benthic fauna (Total density = 0-88 individual/m^2 and the diversity index=1.70-2.51) are found.

During dry season, there are 28-42 species of phytoplankton (Total density = 3,628,800-268,588,800 cells/m^3 and the diversity index=1.53-2.28), 8-12 species of zooplankton (Total density = 142,800-144,550 cells/m^3 and the diversity index=1.40-1.97), and 1-5 species of benthic fauna (Total density = 42,000 cells/m^3 and the diversity index=1.70-2.51) are found.

- **Potential Impacts and Mitigation Measures**

During the construction phase, there is no significant impact and additional mitigation measures required.

During the operation phase, discharging of cooling water which contains BOD, TDS, ClO_2, and phosphate that may cause the adverse impact on the aquatic ecology in Huai Phu Sai brook and Dok Krai Reservoir. The results from the study on the impacts of concerned pollutant finding shown that the discharging of project's cooling water was no significant impact, the final concentration of each pollutant in the Huai Phu Sai brook and Dok Krai Reservoir not cause the adverse impact to the aquatic ecology. However, provision of mitigation measures and monitoring programs for Cooling-water Management are necessary to minimize and prevent the impact.

1.3.6 Transportation

- **Baseline Condition**

The land transportation route to access the project include; National Highway No. 331(Phanom Sarakham-Sattahip), National Highway No. 36 (Krathing Lai-Pluak Ket), Rural Highway No. Ror.Yor. 2026 (Intersection at Highway No. 36–Ban Wang Tan Mon), and Rural Highway No. Ror.Yor. 3013 (Intersection at Highway No. 331–Intersection at Highway No. 3191). Most of road condition is generally good, except the National Highway No. 331 which is damaged with potholes and cracks. The traffic volume in term of V/C ratio indicating the free flow traffic condition are found in the discussed route.

- **Potential Impacts and Mitigation Measures**

There is no significant impact and additional mitigation measures required.

1.3.7 Water-use

- **Baseline Condition**

Eastern Water Resources Development and Management PLC ("East Water") is responsible for integrated raw water management in the eastern regional included project site and study area. The water resources in Rayong, Chonburi, and Chachoengsao provinces such as; Nong Pla Lai, Dok Krai, Pra Sae, Bang Phra, and Bang Pakong River. The water resources were linked to water grid which capable to supply the raw water to produce the tap water for communities' consumption, tourism businesses, and industries.

- **Potential Impacts and Mitigation Measures**

During the construction phase, there is no significant impact and additional mitigation measures required.

During the operation phase, the water consumption of the project will supply by East Water as the detailed in the confirmation letter. However, the additional mitigation measures such as; efficient water use shall be considered, water pipes shall be checked, and leaked pipes shall be fixed immediately, etc. are necessary to ensure that the water will adequate and not cause the impact on an operation of the project.

1.3.8 Electricity

- **Baseline Condition**

The project site is located at Pluak Daeng Industrial Park which has a total power demand of 17 MW (50 KVA per one-rai area). The project's electricity supply will be provided by PEA Pluak Daeng Branch. PEA will construct a 115/22 kV substation on an area of 7 rai for supply the electricity power to the Pluak Daeng Industrial Park.

- **Potential Impacts and Mitigation Measures**

During the construction phase, there is no significant impact and additional mitigation measures required.

During the operation phase, the proposed power plant will be capable to generated electricity up to 2,920 MW. Most will supplied to EGAT, and lead to more stable supply of electricity to Pluak Daeng Industrial Park and vicinity area. Therefore, there is positive impact on the power consumption of nearby communities.

1.3.9 Drainage and Flood Control

- **Baseline Condition**

The project site and study area are characterized by undulating and rolling terrains with the slopes in a range of 3-16%; hilly terrains and footing slopes at the elevation of 80 MSL. There are several natural water courses/sources. The different of an elevation between the project site and Dok Krai reservoir (downstream) is about 30 m.

- **Potential Impacts and Mitigation Measures**

During the construction phase, the existing land surface will transformed to concrete or roof which low permeability. While the construction is completed, run-off water will increase from 7.63 m^3/sec to 15.12 m^3/sec. less than 51 m^3/sec, the total capacity of Pluak Daeng Industrial Park's drainage system. Moreover, the project provided the temporary retention pond with detention time of 3 hours (at least) to minimize the impact on the drainage systems of the Pluak Daeng Industrial Park and vicinity area during this phase, and improved it to be the permanent system for the operation phase.

For the contaminated run-off about 823 m^3/hr. it will storage in 11,116 m^3 leak prevention dike with the detention time of more than 24 hrs. Therefore, there is no significant impact and additional mitigation measures required.

1.3.10 Solid-waste

- **Baseline Condition**

Total solid waste within the Pluak Daeng Industrial Park is estimated at 3,306 kg/day, comprising of 3,226 kg/day from industrial areas and about 80 kg/day from commercial/residential/office areas. All the solid waste will be collected and delivered for disposal at Map Yang Phon SAO or an external agency permitted by Map Yang Phon SAO. Moreover, hazardous waste is estimated at 165.30 kg/day, will collection and disposal by the external agency permitted by the DIW.

- **Potential Impacts and Mitigation Measures**

There is no significant impact and additional mitigation measures required.

1.3.11 Socio-economics

- **Baseline Condition**

The project site and project study area consists of 1 province, 2 districts, 4 sub-districts, and 15 villages: Map Yang Phon sub-district (6 villages), Pluak Daeng sub-district (2 villages), Mae Nam Khu sub-district (2 villages), Pluak Daeng district and Phana Nikhom sub-district (5 villages), Nikhom Pattana district, Rayong province.

Based on the secondary data complication, the total population of four (4) sub-district within the study area ranged from 7,391-14,381 person with the population density of 85-178 person/sq.km. Economic condition in these sub-district depend on 2 sectors are agricultural and industrial.

- **Potential Impacts and Mitigation Measures**

(1) Pre-construction phase

Positive impacts: the community relations activities aim to create the good relationship with local communities, support for community activities will performed regularly.

Negative impacts: most of community leaders and household living in the project study area not worry about the project development, especially community leaders and household within 3-5 km radius from the project boundary, due to the project area is remote from residential area, the project is not developed yet, and confident in the implementation of environmental impact prevention and mitigation measures. In addition, public relations campaign is performed regularly and continuously to get the people more confident on the project development.

(2) Construction phase

Positive impacts: the positive impact during this phase are increase of employment opportunities for local workers, promotion of the local economy, occupation, power development fund benefits to the community, community relation activities.

Negative impacts: based on the socio-economic survey, most of the interviewees viewed that they would not affected by the project during the construction phase. However, some of the interviewees thought that they would be affected from the project development. The most concerned are; the air pollutant/fugitive dust and noise from construction and material transportation activities, traffic congestion, water consumption and social problem such as drug and theft.

(3) Operation phase

Positive impacts: the positive impact during this phase are increased the country power generation and local administration organization income, returned benefit to communities from electricity development fund, development of local people’s potential and community relations activities.

Negative impacts based on the socio-economic survey, most of the interviewees viewed that they would not affected by the project during the operation phase. However, some of the interviewees thought that they would be affected from the project development. The most concerned are; air pollutant and noise from the operation of project, water shortage, and water quality problem.

However, the potential impact are expected to be at a low level since the project has a plan to strictly implement the mitigation measure and monitoring program and promote understanding of communities. It is scheduled to conduct several activities to enhance local participation and support efficiency of the Project's Environmental Impact Monitoring Committee. The proposed activities will be relevant to communities' needs which will make the project development sustained.

1.3.12 Public Health

- **Baseline Condition**

  Based on the public health survey, most of interviewees stated that;

  - The medical personnel and devices are inadequate (88.9%)
  - Environmental conditions such as air quality and water quality influence to the illness of people (66.7%)
  - There are social problems and crime within the project study area (88.9%)
  - During the construction phase, there would be the positive impact on the socio-economic aspect (55.6%), while the rest stated that there would be cause the environmental problem such as dust, traffic congestion, migrant and foreign workers, etc.
  - The most concerned are air quality (dust), noise from construction material and equipment transportation, blockage of drainage channel, increased number of workers, contagious diseases from workers, etc. (88.9%).
  - During the operation phase, there would be the positive impact on the socio-economic aspect and an electric security (77.8%), while the rest stated that there would be cause the environmental problem such as air pollution, acid rain, health, and the emergency situation or major hazards. The most concerned are air quality, discharging cooling water, climate change, fire or explosion, public health problems, and social problems (66.7%).

- **Potential Impacts and Mitigation Measures**

The health impact assessment was conducted in accordance with the ONEP's guidelines for Health Impact Assessment (HIA) in the EIA report, Ministry of Natural Resources and Environment, B.E. 2557 and the manual for appraisal of health effects in the EIA report for a natural gas power plant, Department of Health, B.E. 2555.

An Interaction between the project activities during the construction and operation phases and health status were considered into likelihood and severity of occurrence. Additionally, risk assessment matrix was adopted for evaluate the significance of occurrence.

In case that the potential impacts were evaluated as "significant impacts" (the significance level equal to moderate or high), the additional mitigation measures will provide to minimize the impact level to the acceptable level. The relevant mitigation measures are shown in the Environmental Management Plan.

1.3.13 Occupational Health and Safety (OHS)

The potential main impacts on occupational health and safety of construction workers and the project staff during the construction phase include working environment problems, such as dust, noise and safety-related problems, etc. During the operation phase, the operators may be affected from an improper or unsafe working environment.

The potential impacts related to OHS issues were assessed and evaluated in accordance with the relevant guideline similar to public health issues. In case that the potential impacts were evaluated as "significant impacts", the additional mitigation measures will also provide to minimize the impact level to the acceptable level.

1.3.14 Major Hazard Assessment

The risk assessment of this project has been assessed by adopted the guideline and document from the relevant organization such as World Bank, the American Petroleum Institute (API), and Department of Industrial Works (DIW) such as Techniques for Assessing Industrial Hazards, a Manual (World Bank, 1990), and Risk Base Inspection, Base Resources Document, API Publication 581 (API, 2000), Handbook of Chemical Hazard Analysis Procedures (1990) to identify, analysis, and evaluate the events of risks, their causes and potential consequences, likelihood, and severity. The results from the study are;

- ***Natural Gas and Diesel Oil:*** release of natural gas and diesel oil from it source may cause fire or explosion which affects to the environment and project properties. The analysis results found the likelihood of occurrence are less than 1×10^{-3} time/year (Or less than once in 1,000 years) and can considered as "Very Unlikely". And the results from BreezeHaz, the fire/explosion simulation model found that the most of affected areas covered only within the project boundary and the severity of consequence can considered as "Low". Therefore, the risk level can considered as "Low".
- ***Chemical Substances:*** the prevention measures for the chemical substances are strictly complied to minimized the likelihood and severity of the accidents related to the chemical substances since the design phase through installation and operation phases such as provide a curbs or bund around storage tanks large with the capable to contain the total chemical substance while it released, the chemical substances which quick reaction will store separately, and provide an appropriate and sufficient firefighting equipment, etc. Therefore, the likelihood and severity of occurrence will be low and the risk level can considered as "Low".
- ***Equipment and Machinery:*** the result of probability and severity identification, major hazard related to the equipment and machinery can considered as "Low" due to the project development will strictly follow international standards for the design, construction, operation and maintenance. In addition, the project has prepared emergency plans and training program which prompt to response an emergency situation.

1.4 Public Participation (Public Disclosure and Public Consultation)

Public participation activities were conducted in accordance with; *(1)* The Constitution of the Kingdom of Thailand B.E. 2550 (2007), Articles 56 and 57 regarding to the right to information and compliant, and Articles 67 regarding to the community right, *(2)* The Regulations of the Office of the Prime Minister on Public Hearing B.E. 2548 (2005), and *(3)* The Guidelines on the Public Participation and Social Impact Assessment in EIA Process B.E. 2557 (2014), ONEP. The main objectives of to disseminate the project information to the stakeholders together with obtain their opinions and concerns toward the project development. The summary of public participation activities are shown in table below;

Activity/sub-activities	Schedule	Participants (Person)
1. The 1st Meetings with Related Government Agencies	December 2015 to January 2016	2
2. The 1st Public Consultation		
• Provincial Level	January 27, 2016	23
• Sub-district Level	January 25-27, 2016	582
• Dokkrai Fishery Resource Management Group	March 8, 2016	31
3. Socio-economic Survey	February to March, 2016	605
4. Power Plant Visit	March 2016	402
5. The 2nd Meetings with Related Government Agencies	May 3, 2016	4
6. The 2nd Public Consultation		
• Provincial Level	May 25, 2016	25
• Sub-district Level	May 25-27, 2016	686
• Dokkrai Fishery Resource Management Group	June 13, 2016	34

The concerns and recommendations toward the project development were considered and incorporated into the impact assessment, prevention and mitigation measures and monitoring programs to get the communities and stakeholders more confident on the project development.

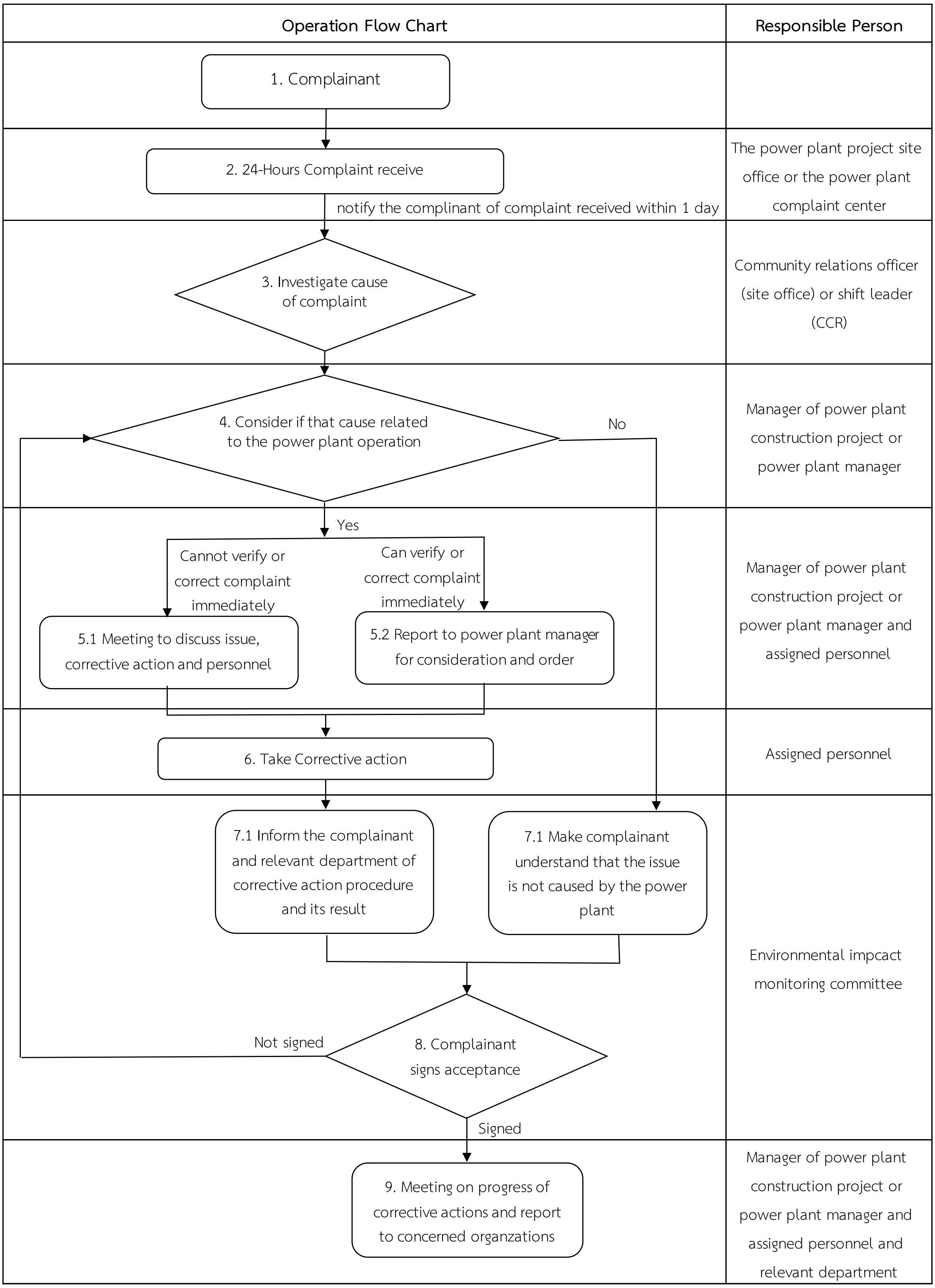
1.5 Grievance Redress Mechanism

The Compliant Management Center will be establish to provide an accessible way for individuals and communities to complain directly to the project. People or communities who had or is likely to have adverse effects can raise their problem through the project via various channel such as verbal communication, phone, letter, e- mail, fax, etc. The process of compliant management and responsible person are shown in ***Figure 1.5-1***.

1.6 Environmental Management Plan

Environmental management plan or action plan proposed in the environmental impact assessment report are consistent with significant environmental impacts. Measures and clear responsibilities during the construction phase and the operation phase are proposed. The environmental action plans encompass 15 aspects, with details described herein;

(1) General Measures
(2) Air Quality Action Plan
(3) Noise Action Plan
(4) Surface Water and Groundwater Quality Action Plan
(5) Transportation Action Plan
(6) Water Use Action Plan
(7) Solid Waste Management Action Plan
(8) Drainage and Flood Control Action Plan



Remarks: 1. Notify the Complainant of complaint cause, corrective procedure and duration of correction within 5 days.
2. Notify the complainant of progress of correction every 7 days or as mutually agreed with the complainant.

Source: Gulf PD Co., Ltd., 2016

FIGURE 1.5-1: COMPLAINT MANAGEMENT PROCESS

(9) Socio-economics Action Plan
(10) Public Relations Campaign and Public Participation Action Plan
(11) Public health/Occupational Health and Safety Action Plan
(12) Major Hazard Action Plan
(13) Green Area and Aesthetics Action Plan
(14) Heat Radiation from the Power Plant Monitoring Action Plan
(15) Rainwater pH Measurement and Acid Deposition Monitoring Action Plan

In addition, the monitoring of action plan implementation will be conducted by qualified external monitoring bodies according to ONEP qualification. The semi-annual and the annual monitoring reports will be submitted to ADB during construction and operation periods, respectively.

1.7 Recommendation

Based on the results of the EIA study, the necessary recommendations can be emphasized as follows:

(1) The project shall be implement under all conditions, strictly comply the proposed prevention and mitigation measures and monitoring programs as specified in the environmental action plan both construction and operation phases to avoid or minimize the potential environmental and social impacts on the surrounding communities and general public,

(2) In case that any modification of the project design or/and environmental action plan, the project shall be conduct an environmental study shall be conduct for making the decision, and

(3) The public participations activities shall be perform throughout the project implementation. Any comments, concerns and suggestions toward the project from concerned stakeholders shall be considered and incorporated into the project environmental management plan as appropriate.

CHAPTER 2

POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

CHAPTER 2
POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

The environmental impact assessment for Pluak Daeng Power Plant Project (by Gulf PD Co., Ltd.) is prepared to support the increasing demand for electricity and industrial developments. This project is a 2,920 Megawatt (MW) combine cycle power plant within the area of the Pluak Daeng Industrial Park (Industrial Park) at Pluak Daeng District, Rayong Province. This project uses natural gas as its primary fuel and diesel as a backup source. The Pluak Daeng Power Plant Project is required to have the environmental impact assessment prepared in accordance with the Notification of the Ministry of Natural Resources and Environment Regarding Types and Sizes of Projects or Activities Requiring Preparation of Environmental Impact Assessment Reports; and Criteria, Procedure, Regulation and Guideline to Prepare Environmental Impact Assessment (EIA) Reports (No. 7), B.E. 2558 (2015) which specified that a thermal power plant of more than 10 MW shall have the Environmental Impact Assessment (EIA) prepared and submitted to the Office of Natural Resources and Environmental Policy and Planning (ONEP) for approval and to Department of Industrial Works for construction permission. Therefore, Gulf PD Co., Ltd. engaged TEAM Consulting Engineering and Management Co., Ltd. to study and prepare the EIA report for the project. The ONEP review and approval procedure scheme for EIA report is presented in section 2.4.

2.1 POLICY, LEGAL, AND ADMINISTRATIVE FRAMEWORK

The EIA study for Pluak Daeng Power Plant Project is fully complied with applicable Thai laws i.e. ONEP guidelines for EIA report for Power Plant which include environmental standards/regulations of Department of Industrial Works, Ministry of Industry, Ministry of Natural Resource and Environment, Ministry of Interior, Ministry of Transport and Communications, and Ministry of Labor.

2.1.1 Relevant Thai Regulations

(1) Thai Environmental Standard/Regulations

(a) Ambient air quality standard

- Notification of National Environmental Committee Vol. 10 B.E.2538 (1995)
- Notification of National Environment Board No.12 (B.E.2538) re: Standard of 1 hr sulfur dioxide in Ambient Air
- Notification of National Environment Board No.24 (B.E.2557) re: Standard of Ambient Air Quality

- Notification of National Environment Board No.33 (B.E.2552) re: Standard of Nitrogen Dioxide in Ambient Air

Standard of Ambient Air Pollutant Concentration (µg/m^3)				
TSP average 24 hrs. (µg/m^3)	PM-10 average 24 hrs. (µg/m^3)	NO_2 average 1 hr. (µg/m^3)	SO_2 average 24 hrs. (µg/m^3)	SO_2 average 1 hr. (µg/m^3)
330[1/]	120[1/]	320[2/]	300[1/]	780[3/]

Remark: [1/] Notification of National Environmental Committee Vol. 10 B.E.2538 (1995) and Notification of National Environment Board No.24 (B.E.2557) re: Standard of Ambient Air Quality

[2/] Notification of National Environment Board No.33 (B.E.2552) re: Standard of Nitrogen Dioxide in Ambient Air

[3/] Notification of National Environment Board No.12 (B.E.2538) re: Standard of 1 hr sulfur dioxide in Ambient Air

(b) Noise level standard

Notification of National Environmental Committee Vol.15 B.E.2540 (1997)

Standard of Noise Level, Decibel (A)	
Leq (24 hrs.)	L_{max}
70.0	115.0

(c) Surface water quality standard

- Notification of National Environmental Committee Vol. 8 B.E.2537 (1994) in accordance with the National Environmental conservation and enhancement Act B.E.2535 (1992), subjected to the standard of surface water quality, published in Royal Gazette Vol. 111 Special Part 16D, dated 24 February 1994.

- The Royal Irrigation Department Order no. 73/2554 re: Amending of Preventive and Solutions on Poor Quality of Discharged Water into Irrigation Canal and Connected Part of the Irrigated Areas, dated 1 April 2011.

The surface water quality standard is shown in **Table 2.1-1.**

(d) Groundwater quality standard

The results of groundwater quality measurement were compared with the standards for groundwater quality as prescribed in the Notification of National Environment Board No. 20 B.E.2543 re: Prescribing Standards for Groundwater Quality. In addition, the measured parameters were compared with the suitable and maximum allowable concentration for consumption water as prescribed in the Notification of Ministry of Natural Resources and Environment re: Prescribing Academic Standards for Protection of Public Health and Environmental Pollution B.E. 2551 as shown in **Table 2.1-2.**

(2) Power Plant Standard/Regulations

Environmental standards in Thailand for gas and oil fired thermal power plants.

TABLE 2.1-1

SURFACE WATER QUALITY STANDARD

Quality	Measurement Index	Unit	Standard Quality of Surface Water[1/]				Standard Quality of Water Discharged to Irrigation Canal[2/]
			2	3	4	5	
Physical	- Depth	m	-	-	-	-	-
	- Flow rate	m/s	-	-	-	-	-
	- Temperature	°C	n’	n’	n’	n’	< 40
	- pH	-	5.0	5-9	5-9	5-9	6.5-8.5
	- Suspended Solids	mg/l	-	-	-	-	30
	- Total Dissolved Solids	mg/l	-	-	-	-	1,300
	- Conductivity	µ℧/cm	-	-	-	-	2,000
Chemical	- Dissolved Oxygen	mg/l	> 6	> 4	> 2	-	2.0
	- BOD	mg/l	< 1.5	< 2	< 4	-	20
	- COD	mg/l	-	-	-	-	100
	- Oil & Grease	mg/l	-	-	-	-	5
	- Chloride	mg/l	-	-	-	-	-
Biological	- Total Coliform Bacteria	MPN/100 ml	< 5,000	< 20,000	-	-	-
	- Fecal Coliform Bacteria	MPN/100 ml	< 1,000	< 4,000	-	-	-

Source : [1/] The notification of National Environmental Committee Vol.8 B.E.2537 (1994) in accordance with the National Environmental conservation and enhancement Act B.E. 2535 (1992), re: Standard Quality of Surface Water, published in Royal Gazette Vol.111 Special Part 16 D, dated 24 February 1994

[2/] The Royal Irrigation Department Order no. 73/2554 re: Amending of Preventive and Solutions on Poor Quality of Discharged Water into Irrigation Canal and Connected Part of the Irrigated Areas, dated 1 April 2011

Remark: n' = naturally but changing not more than 3°C

[1/] Classification of surface water quality

Class 1 Extra clean fresh surface water resources used for:

(1) Conservation not necessary pass through water treatment process require only ordinary process for pathogenic destruction

(2) Ecosystem conservation where basic organisms can breed naturally.

Class 2 Very clean fresh surface water resources used for:

(1) Consumption which requires ordinary water treatment process before use

(2) Aquatic organism of conservation

(3) Fisheries

(4) Recreation

Class 3 Medium clean fresh surface water resources used for:

(1) Consumption, but passing through an ordinary treatment process before using

(2) Agriculture

Class 4 Fairly clean fresh surface water resources used for:

(1) Consumption, but requires special water treatment process before using

(2) Industry

Class 5 The sources which are not classification in class 1-4 and used for navigation.

TABLE 2.1-2
GROUNDWATER QUALITY STANDARD

No.	Parameters	Unit	Standard		
			(1)	(2)	(3)
1.	pH	-			
2.	Water Temperature	°C	-	-	-
3.	Conductivity	µS/cm	-	-	-
4.	Turbidity	NTU	-	5	20
5.	Total dissolved solids (TDS)	mg/L	-	600	1,200
6.	Suspended solids (SS)	mg/L	-	-	-
7.	Total Hardness	Mg/L as $CaCO_3$	-	300	500
8.	Carbonate Hardness	Mg/L as $CaCO_3$	-	-	-
9.	Sulfate (SO_4)	mg/L	-	200	250
10.	Manganese (Mn)	mg/L	0.5	0.3	0.5
11.	Iron (Fe)	mg/L	-	0.5	1.0
12.	Copper (Cu)	mg/L	1.0	1.0	1.5
13.	Zinc (Zn)	mg/L	5.0	5.0	15
14.	Magnesium (Mg)	mg/L	-	-	-
15.	Calcium (Ca)	mg/L	-	-	-
16.	*E.Coli*	MPN/100 ml	-	None	-
17.	Total Coliform Bacteria	MPN/100 ml	-	<2.2	-
18.	Fecal Coliform Bacteria	MPN/100 ml	-	<2.2	-

Standard : (1) The standards for groundwater quality as prescribed in the Notification of National Environment Board No. 20 B.E. 2543 re: Prescribing Standards for Groundwater Quality

(2) The suitable concentration for consumption water as prescribed in the Notification of Ministry of Natural Resources and Environment re: Prescribing Academic Standards for Protection of Public Health and Environmental Pollution B.E.2551

(3) The maximum allowable concentration for consumption water as prescribed in the Notification of Ministry of Natural Resources and Environment re: Prescribing Academic Standards for Protection of Public Health and Environmental Pollution B.E. 2551

(a) Air emission standard

- Notification of MNRE on emission standard for a new power plant, 20 December B.E.2552 (2009).
- Notification of Ministry of industry B.E.2547 (2004) on regulation of air pollutant quantity released from power plants and power distributors.
- Pollutant quantity released from power plants and power distributors.

Type of Fuel	Standard of Air Pollutant Emission Concentration		
	TSP (mg/m^3)	NO_2 (ppm)	SO_2 (ppm)
Gas	60	120	20
Oil	120	180	260

Remark: at 1 atm or 760 mmHb, 25 °C, Dry Basis, 50% Excess Air, 7% Excess Oxygen

(b) Discharge standards

b1) Discharge standards for cooling water

Blowdown cooling water – 12,232 cubic meters/day – is the cooling water held to cool down in the cooling tower basin which has a capacity of greater than 12,232 cubic meters and thus able to receive 1 day's worth of used cooling water from the cooling tower. After that, blowdown water will be discharged to 2 cooling water holding ponds, with a capacity of 19,000 m3 each, to hold water for at least 1 day. While one pond is in use, the other will serve as an emergency pond before discharging to the Industrial Park's cooling water holding pond with a capacity for storing 1-day cooling water blowdown. These are cooling water management measures according to the Environmental Impact Assessment Report, Pluak Daeng Industrial Park Project, Expansion Phase 1 (February 2016).

Moreover, the wastewater from the cooling water will meet applicable government standards such as the Notification of Ministry of Industry No. 2 (B.E. 2539) re: Industrial Effluent Standards. Total Dissolved Solids (TDS) will meet the requirement of the Royal Irrigation Department of no more than 1,300 milligrams/liter with temperature of no more than 34 degree Celsius.

Water Quality Index	Wastewater quality from cooling tower discharge to cooling water holding pond of Pluak Daeng Industrial Park	
	The Project	Ministry of Industry[1/]
Temperature (^{o}C)	Not over 34	Not over 40
Acidity-alkalinity (pH)	5.5-9.0	5.5-9.0
Total dissolved solid (TDS, mg/l)	Not over 1,300 [2/]	Not over 3,000

Remarks : [1/] Notification of the Ministry of Industry No. 2, B.E. 2539 (1996) Regarding Industrial Effluent Standards
[2/] Effluent Characteristics discharged into irrigation systems of Royal Irrigation Department

The project is to implement an online water quality monitoring system to monitor the water in the cooling water holding pond these parameters: temperature, pH, Dissolved Oxygen (DO) and conductivity (to determine TDS). The wastewater from the cooling water will meet applicable government standards such as the Notification of the Ministry of Industry No. 2 (B.E.2539) re: Industrial Effluent Standards. Total Dissolved Solids (TDS) will meet the requirement of the Royal Irrigation Department of no more than 1,300 milligrams/liter. Moreover, the wastewater management will comply with requirements as specified in the Environmental Impact Assessment Report, Pluak Daeng Industrial Park Project, Expansion Phase 1, which had been approved by ONEP according to the letter No. Thor Sor. 1009.3/15746 dated 29th December 2015. The Pluak Daeng Industrial Park has set forth environmental impact prevention and mitigation measures and environmental monitoring measures (operation phase) for cooling tower blowdown from IPP plants.

b2) Discharge standards for process water

Wastewater from the processes include wastewater from the water treatment plant (water demineralization) coming from wastewater in the process of mixed bed regeneration and wastewater from the laboratory and consumption. Wastewater from the process will be held in one of two wastewater holding ponds with a capacity of 75 cubic meters each. Each pond can hold wastewater up to 1.5 days prior to discharge into Pluak Daeng Industrial Park central wastewater treatment system. The wastewater discharge will meet the requirements of Pluak Daeng Industrial Park as per **Table 2.1-3** using online water quality monitoring system to continuously monitor temperature, pH levels and conductivity prior to discharging from the project.

The discharge water from Pluak Daeng Industrial Park central wastewater treatment system will meet applicable government standards such as the Notification of Ministry of Industry No. 2, B.E. 2539 (1996) re: Industrial Effluent Standards as shown in **Table 2.1-3**.

(3) EIA Regulations

Notification of Natural Resources and Environmental Ministry (No. 7), B.E. 2558 (2015) on regulation of types and specifications of projects or businesses that requires an environment impact assessment (EIA) including the principles, procedures, practices and guidelines of EIA preparation.

TABLE 2.1-3
ALLOWABLE CHARACTERISTICS OF INDUSTRIAL EFFLUENT DISCHARGE TO THE CENTRAL WASTEWATER TREATMENT SYSTEM AND CHARACTERISTICS OF EFFLUENT FROM THE CENTRAL WASTEWATER TREATMENT SYSTEM OF PLUAK DAENG INDUSTRIAL PARK

No.	Water Quality Parameters	Unit	Maximum Allowance for Discharge to the Central wastewater treatment system 1/	Maximum Allowance for Discharge from the Central wastewater treatment system 2/
1	BOD_5 as 20 °C	mg/l	Not more than 500	Not exceed 20
2	COD	mg/l	Not more than 750	Not exceed 120
3	pH		5.5 – 9.0	5.5 - 9.0
4	Total Dissolved Solid (TDS)	mg/l	Not more than 3,000	Not exceed 3,000
				Not exceed 5,000 3/
5	Total Suspended Solids (TSS)	mg/l	Not more than 200 4/	Not exceed 50 5/
6	Total Kjeldahl Nitrogen (TKN)	mg/l	Not more than 100	Not exceed 100
7	Heavy Metals			
	7.1 Mercury (Hg)	mg/l	Not more than 0.005	Not exceed 0.005
	7.2 Selenium (Se)	mg/l	Not more than 0.02	Not exceed 0.02
	7.3 Cadmium (Cd)	mg/l	Not more than 0.03	Not exceed 0.03
	7.4 Lead (Pb)	mg/l	Not more than 0.20	Not exceed 0.2
	7.5 Arsenic (As)	mg/l	Not more than 0.25	Not exceed 0.25
	7.6 Chromium Trivalent (Cr^{3+})	mg/l	Not more than 0.75	Not exceed 0.75
	7.7 Chromium Hexavalent (Cr^{6+})	mg/l	Not more than 0.25	Not exceed 0.25
	7.8 Barium (Ba)	mg/l	Not more than 1.0	Not exceed 1.0
	7.9 Nickel (Ni)	mg/l	Not more than 1.0	Not exceed 1.0
	7.10 Copper (Cu)	mg/l	Not more than 2.0 6/	Not exceed 2.0
	7.11 Zinc (Zn)	mg/l	Not more than 5.0	Not exceed 5.0
	7.12 Manganese (Mn)	mg/l	Not more than 5.0	Not exceed 5.0
	7.13 Silver (Ag)	mg/l	Not more than 1.0	-
	7.14 Total Iron	mg/l	Not more than 10.0	-
8	Sulphide as H_2S	mg/l	Not more than 1.0	Not exceed 1
9	Cyanide as HCN	mg/l	Not more than 0.2	Not exceed 0.2
10	Formaldehyde	mg/l	Not more than 1.0	Not exceed 1
11	Phenols Compound	mg/l	Not more than 1.0	Not exceed 1
12	Free Chlorine	mg/l	Not more than 1.0	Not exceed 1
13	Chloride as Chlorine	mg/l	Not more than 2,000	-
14	Fluoride	mg/l	Not more than 5.0	-
15	Pesticide	mg/l	None	None
16	Temperature	°C	Not more than 45	Not exceed 40
17	Color		120 Pt-Co	120 ADMI
18	Odor		Not objectionable	-
19	Oil & Grease	mg/l	Not more than 10.0	Not exceed 5
20	Surfactants	mg/l	Not more than 30.0	-

Remarks :
[1/] Characteristics of industrial effluents allowed to be discharged to the central wastewater treatment system of Pluak Daeng Industrial Park
[2/] Notification of the Ministry of Science, Technology and Environment, No.3, B.E.2539 (1996), dated 3 January 1996 Regarding Industrial Effluent Standards for Industrial Plants and Industrial Estates, published in the Royal Government Gazette, Vol. 113, Part 13, dated 13 February B.E.2539 (1996)
[3/] In case effluent will be discharged into a receiving water source with TDS more than 3,000 mg/l, TDS in effluent shall not exceed TDS of the receiving water source by more than 5,000 mg/l.
[4/] For TSS of the water discharge into Pluak Daeng Industrial Park's central wastewater plant, the project comply with Pluak Daeng Industrial Park's regulation of 200 mg/l. Anyway, Pluak Daeng Industrial Park central wastewater treatment plant will treat the water, and discharge from their wastewater treatment plant will have TSS<50 mg/l, as per requirement by WBG EHS guideline
[5/] The project confirms that Copper (Cu) effluent standards for cooling water discharge will be complied with copper requirement of 0.5 mg/l

Source : EIA Report of Pluak Daeng Industrial Park Project, Expansion Phase 1, February 2016.

(4) Others related Thai Regulations

Project has to implement follow related Thai regulations as follow:

- Ministerial Regulations on the Prescribing Standard of Management and Operation on Safety, Occupation, and Workplace Environment Regarding to Heat Light and Noise, B.E.2559 (2016)
- Ministerial Regulations on the Prescribing Standard for Service, Management, and Proceeding on Occupational Safety, Health and Environment for Works Involving Hazardous Chemicals, B.E.2556 (2013)
- Ministerial Regulations on the Prescribing Status of Basic Fire Fighting Training Units, and Fire Fighting and Evacuation Training Units, B.E.2556 (2013)
- Ministerial Regulations on the Prescribing Standard for Service, Management, and Proceeding on Occupational Safety, Health and Environment at a Workplace for Prevention and Extinguishment of Fire, B.E.2555 (2012)
- Ministerial Regulations on the Prescribing Standard for Administration and Management of Occupational Safety, Health, and Environment at Workplace for Works Involving Electricity, B.E.2554 (2011)
- Ministerial Regulations on the Prescribing Standard for Administration and Management of Occupational Safety, Health and Environment (No.2) B.E.2553 (2010)
- Ministerial Regulations on the Prescribing Standard for Administration and Management of Occupational Safety, Health, and Environment at Workplace for Works Involving Machine, Crane, and Boiler, B.E.2552 (2009)
- Ministerial Regulations on the Prescribing Standard for Administration and Management of Occupational Safety, Health and Environment for Construction Works B.E.2551 (2008)

- Ministerial Regulations on the Prescribing Standard for Administration and Management of Occupational Safety, Health and Environment for Works Involving Heat, Light, and Sound B.E.2549 (2006)
- Ministerial Regulation on the Prescribing of Criteria and Method of Conducting Health Check up of Employees and Forwarding the Results of Health Check up to Labour Inspectors, B.E. 2547 (A.D. 2004);
- Ministerial Regulations on the Prescribing Standard for Administration and Management of Occupational Safety, Health and Environment for Confined Space Workplace, B.E.2547 (2004)
- Ministerial Regulation No. 33 (B.E. 2535) issued pursuant to the Building Control Act, B.E. 2522 (1979) Regarding High Rise Buildings
- Notification of the Department of the Labor Protection and Welfare: The Standard of the Personal Protective Equipment, B.E.2554 (2011);
- Notification of the Department of the Labor Protection and Welfare: form of Severe Incident or Accident at Work Report, B.E.2554 (2011)
- Notification of the Department of Labor Protection and Welfare: Warning Signs, Occupational Safety, Health and Environment Precaution Marks at Workplace, and Statement of Right and Responsibility of Employer and Employee, B.E.2554 (2011)
- Notification of the Department of Labor Protection and Welfare: the Criteria and Method of Training for Safety Officers in Workplace (No.2), B.E.2553 (2010)
- Notification of the Ministry of Industry on Factory Fire Prevention and Control, B.E. 2552 (2009)
- Notification of the Ministry of Labor: List of Hazardous Chemicals that Employer is Required to Arrange Medical Checkup for Employees, B.E.2552 (2009)
- Notification of the Department of Industrial Works on Guideline on Chemicals and Hazardous Substance Storage, B.E. 2550 (2007)
- Notification of the Department of the Labor Protection and Welfare: the Criteria and Procedure for Registration for License of Being Training Unit, Safety Officer at a Workplace, and Training Arrangement, B.E.2549 (2006)
- Notification of the Department of the Labour Protection and Welfare: the Criteria, Procedure and Courses For Safety Training for Confined Space Workplace, B.E.2549 (2006)
- Notification of the Ministry of Interior on Fire Prevention and Control in Workplaces, B.E. 2539 (1996)
- Notification of the Department of Labor Protection and Welfare: Submission of Application for License of Being Basic Fire Fighting Training Unit, Fire Fighting and Evacuation Unit, and Prescriptions on Places for Submission of Application

- Notification of the Department of Labor Protection and Welfare: Application form for License of Being Basic Fire Fighting Training Unit, Fire Fighting and Evacuation Unit
- Notification of the Department of The Labor Protection and Welfare: List of Hazardous Chemicals and Safety Information of Hazardous Chemicals
- Notification of The Department of The Labor Protection and Welfare: List of Hazardous Chemicals
- Notification of The Department of The Labor Protection and Welfare: Portable Fire Extinguisher
- Notification of the Department of Labor Protection and Welfare: the Criteria, Procedure and Condition for Training Executives, Supervisors and Employees Respecting Occupational Safety, Health and Environment at Workplace
- Notification of the Department of Labor Protection and Welfare: the Criteria, Procedure and Condition for Training for Safety Working Condition for Works Involving Electricity, for Employee Working with Electricity
- Notification of the Department of the Labor Protection and Welfare: the Criteria, Procedure and Condition for Preparation of Inspection Record and Certification of Electric Devices and System
- Notification of the Department of the Labour Protection and Welfare: the Criteria and Procedure for Registration as Basic Fire Fighting Training Unit, Basic Fire Fighting and Evacuation Unit
- Notification of the Occupational Safety, Health and Environment Committee: the Criteria and Condition for Allocation of Occupational Safety, Health and Environment Fund
- Rules of the Occupational Safety, Health and Environment Committee: the Criteria, Procedure and Condition for Contribution and Subsidy, Request for Contribution and Subsidy, Approval of Advance Payment, Request of Advance Payment, Loan, and Repayment to the Occupational Safety, Health and Environment Fund, B.E.2559 (2016)
- Rules of the Department of the Labour Protection and Welfare: Proceeding on Criminal Actions and Compensation Method to Fine Offender in Accordance with Laws Respecting Labor Protection and Safety at Workplace (No.2), B.E.2558 (2015)
- Rules of the Department of Labor Protection and Welfare: Curriculum of Training Course for Safety Officers (No.2), B.E.2553 (2010)
- Clarification of the Ministry of Labor: Ministerial Regulations Prescribing Administration and Management of Occupational Safety, Health and Environment at Workplace For Works Involving Heat, Light, and Sound, B.E.2549 (2006)

- Clarification of the Ministry of Labor: Ministerial Regulations Prescribing Administration and Management of Occupational Safety, Health and Environment at Workplace for Confined Space Workplace, B.E.2549 (2006)
- Guideline on Hazardous Substance Transportation, the Pollution Control Department, September 2011
- Guideline on Hazardous Chemicals Management and Administration in Workplaces, April 2011

2.1.2 Concerned International Regulations

(1) General Environmental, Health, and Safety Guidelines, International Finance Corporation (IFC), 2007

- General Environmental, Health, and Safety Guidelines: Environmental Air Emissions and Ambient Air Quality 2007
- World Health Organization (WHO). Air Quality Guidelines Global Update, 2005.
- General Environmental, Health, and Safety Guidelines: Environmental Noise Management 2007
- Guidelines for Community Noise, World Health Organization (WHO), 1999.
- Environmental, Health, and Safety Guidelines for Thermal Power Plants 2008

(2) Social Protection Strategies (2001)

As the project shall create temporary and permanent employments for skilled and unskilled labors, the project will fully comply with ADB's Social Protection Strategy (2001) which upholds international recognized labor standards and/or national labor laws, particularly on the following conventions: (1) no harmful or exploitative forms of forced labor, (2) no child labor, (3) no discrimination in respect of employment and occupation, and (4) no restrictions of freedom of association and the effective recognition of the right to collective bargaining.

(3) Safeguard Policy Statement (2009)

ADB's safeguard policy statement (SPS) was issued in 2009 and applies to all projects funded by ADB since 20 January 2010. This operational policy revision resulted in a consolidated policy outlining common objectives of ADB's safeguards, policy principles, and delivery process for the SPS. It also outlines a set of specific safeguard requirements when addressing social and environmental impacts and risks. The Pluak Daeng Power Plant project will fully comply with the relevant ADB's safeguard policy throughout the project operation period.

ADB's safeguard policy statement consists of three operational policies on the Environment, Indigenous Peoples, and Involuntary Resettlement. Objectives of ADB's environmental and social safeguards are to: (i) avoid adverse impacts of projects on the environment and affected people, where possible; (ii) minimize, mitigate, and/or compensate for adverse project impacts on the environment and affected people when avoidance is not possible, and (iii) help borrowers/clients to strengthen their safeguard systems and develop the capacity to manage environmental and social risks. Since the project is Category A for environment, Safeguard Requirements 1: Environmental and eleven policy principles have been triggered (referred to page 16 of the SPS, 2009).

(4) Other International Guidelines

Project has to implement follow related International Guidelines as follow:

- Environmental, Health, and Safety Guidelines for Wastewater and Ambient Water Quality 2007.
- Environmental, Health, and Safety Guidelines for Hazardous Materials Management 2007
- OSHA Standard, Part title: Safety and health regulations for construction, Subpart title: Occupational health and environmental controls, Standard number 1926.55 App A

2.1.3 Comparison of National Requirements and WB/IFC Requirements

A comparison table between applicable national requirements and WB/IFC requirements apply for project as details in **Table 2.1-5** and **Table 2.1-6**.

2.2 SCOPE OF THE EIA STUDY

The study of the project's environmental resources is mainly relied on the methods of environmental impact assessment defined by the Office of Natural Resources and Environmental Policy and Planning. The methods are composed of reviewing secondary data from related governmental agencies, compiling relevant reports and conducting field survey. In addition, the study of the project is chiefly emphasized on potential impact associated to the project which is expected to be affected by the project and/or generated impact to the project during construction and operation periods.

Environmental resources are studied as follow:

(1) Physical Resources consisting of

- Topography/Geology and Seismic
- Soil Resources
- Climate and Air Quality
- Noise
- Surface Water Hydrology

TABLE 2.1-5

COMPARISON OF NATIONAL REQUIREMENTS AND WB/IFC REQUIREMENTS

Subject	Parameter	Unit	Applicable Standards		Remark
			National	WB/IFC	
Ambient Air Quality	TSP, 24-hour average	μg/m^3	330	-	
	PM10, 24-hour average	μg/m^3	120	50	
	PM2.5, 24-hour average	μg/m^3	50	25	
	NO_2, 1-hour average	μg/m^3	320	200	
	SO_2, 24-hour average	μg/m^3	300	20	
	SO_2, 1-hour average	μg/m^3	780	-	
Air Emission from Power Plant	**Natural Gas**				
	TSP	ppm	60	-	
	NO_2	ppm	120	25	
	SO_2	ppm	20	-	
	Diesel Oil				
	TSP	ppm	120	50	
	NO_2	ppm	180	74	
	SO_2	ppm	260	Use of 1 % or less S fuel	
Ambient Noise	Leq 24 hr.	dBA	70	-	
	L max	dBA	115	-	
	Disturbance Noise	dBA	10	-	
	Leq 1 hr. daytime (07.00-22.00)	dBA	-	55 dBA for residential, institutional, and educational areas and 70 dBA for industrial and commercial areas	
	Leq 1 hr. nighttime (22.00-07.00)	dBA	-	45 dBA for residential, institutional, and educational areas and 70 dBA for industrial and commercial areas	
	Increasing of Leq 1 hr.	dBA	-	Not exceeded 3 dBA from the existing or background level	

TABLE 2.1-6

EFFLUENT WATER DISCHARGE LIMITS OF THE PROJECT

Parameters	Units	HESIE Waste water Effluent Standard	Thai Industrial Effluent Standards	Project Standard for Cooling Water Discharge	Project Standard for Waste Water Discharge
Temperature	°C	≤ 45	≤ 40	≤ 34	≤ 34
pH	-	5.5 – 9.0	5.5 – 9.0	5.5 – 9.0	5.5 – 9.0
Total Dissolved Solids (TDS)	mg/l	≤ 3,000	≤ 3,000	≤ 1,300	≤ 3,000
Biochemical Oxygen Demand (BOD_5)	mg/l	≤ 500	≤ 20	≤ 20	≤ 500
Chemical Oxygen Demand (COD)	mg/l	≤ 750	≤ 120	≤ 120	≤ 750
Total Suspended Solids (TSS)	mg/l	≤ 200	≤ 50	≤ 50	≤ 200
Sulfide as H_2S	mg/l	≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0
Cyanide as HCN	mg/l	≤ 0.2	≤ 0.2	≤ 0.2	≤ 0.2
Total Kjeldahl Nitrogen (TKN)	mg/l	≤ 100	≤ 100	≤ 100	≤ 100
Oil and Grease	mg/l	≤ 10.0	≤ 5.0	≤ 5.0	≤ 10.0
Formaldehyde	mg/l	≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0
Phenol Compound	mg/l	≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0
Free Chlorine	mg/l	≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0
Pesticides/ Insecticide	mg/l	None	None	None	None
Color and Odor	-	Not Objectionable	Not Objectionable	Not Objectionable	Not Objectionable
Heavy Metals:					
- Zinc (Zn)	mg/l	≤ 5.0	≤ 5.0	≤ 1.0	≤ 1.0
- Chromium (Cr+3)	mg/l	≤ 0.75	≤ 0.75	≤ 0.75	≤ 0.75
- Chromium (Cr+6)	mg/l	≤ 0.25	≤ 0.25	≤ 0.25	≤ 0.25
- Arsenic (As)	mg/l	≤ 0.25	≤ 0.25	≤ 0.25	≤ 0.25
- Copper (Cu)	mg/l	≤ 2.0	≤ 2.0	≤ 0.5	≤ 0.5
- Mercury (Hg)	mg/l	≤ 0.005	≤ 0.005	≤ 0.005	≤ 0.005
- Cadmium (Cd)	mg/l	≤ 0.03	≤ 0.03	≤ 0.03	≤ 0.03
- Barium (Ba)	mg/l	≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0
- Selenium (Se)	mg/l	≤ 0.02	≤ 0.02	≤ 0.02	≤ 0.02
- Lead (Pb)	mg/l	≤ 0.2	≤ 0.2	≤ 0.2	≤ 0.2
- Nickel (Ni)	mg/l	≤ 1.0	≤ 1.0	≤ 1.0	≤ 1.0
- Manganese	mg/l	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0

- Surface Water Quality
- Hydrogeology
- Groundwater Quality

(2) Biological Resources consisting of
- Aquatic Ecology
- Terrestrial Ecology

(3) Human Use Values consisting of
- Land Use
- Transportation
- Water Use
- Electricity Use
- Drainage and Flood Control
- Solid Waste Management

(4) Quality of Life Values consisting of
- Socio-Economics
- Public health/Occupational health and safety
- Historical and Archaeological Sites
- Aesthetic and Tourism
- Major Hazard Assessment

The study of environmental aspects are based on compilation of related data, documents and reports such as mitigation measure and impact relief report, monitoring program and examination of environmental impact assessment during construction period of the Pluak Daeng Industrial Park and other related reports. Besides, activity of public participation has been implemented by coordinating with local government agencies and local dwellers in order to continuously disseminate information of the project. Meanwhile, the study of health impact assessment has been based on compiled public health implementation reports from relevant government agencies.

2.3 METHODOLOGY

The information used in this study comprises both primary and secondary data as shown in **Table 2.3-1**.

TABLE 2.3-1

METHODS OF THE STUDY AND DATA COMPILATION FOR THE PLUAK DAENG POWER PLANT PROJECT

Potential Impact	Studied Areas	Source of data
1. Topography/Geology/Seismic	• 5-km radius around the project area, focusing on the project site	• Collected data from a 1:50,000 topographic map and from field surveys • Aerial photos from Google Earth (Version 7.1.5.1557) • Collected secondary data from Department of Mineral Resources and Meteorological Department
2. Soil resources	• 5-km radius around the project area, focusing on the project site	• Collected data from a 1:50,000 topographic map • Collected secondary GIS data from Land Development Department • Soil sampling at 4 stations during 17th-18 th March 2016
3. Climate and air quality	• Climate conditions in the eastern region, with focus on the project site, using data from the nearest meteorological station	• Collected secondary data from meteorological stations near the project area, i.e. Huai Pong air quality monitoring station, Rayong, and Laem Chabang air quality monitoring station, Chon Buri • Collected data from related reports • Conducted air quality measurement for 7 consecutive days, covering 2 seasons: wet season during 9 th-16th September 2015, and dry season during 13th -20th February 2016. The measurement was conducted at 5 stations, namely: 1. Pluak Daeng Power Plant Project Site 2. Noen Sawan community in Village No.2, Map Yang Phon sub-district

TABLE 2.3-1 (Cont'd)

METHODS OF THE STUDY AND DATA COMPILATION FOR THE PLUAK DAENG POWER PLANT PROJECT

Potential Impact	Studied Areas	Source of data
3 Climate and air quality (Cont'd)		3. Wat Prasittharam 4. Ban Map Toei School 5. Community to the west of the project area in Village No.5, Map Yang Phon sub-district
4. Noise	• 5-km radius from the project site	• Collected data from related documents and reports • Conducted noise level measurement for 5 consecutive days during 13th - 18th February 2016 at 4 stations, namely: 1. Pluak Daeng Power Plant Project Site 2. Community to the west of the project area in Village No.2, Map Yang Phon sub-district 3. Community to the south of the project area in Village No.5, Map Yang Phon sub-district 4. Community to the northeast of the project area in Village No.2, Map Yang Phon sub-district
5. Hydrology	• 5-km radius from the project site	• Collected data from related documents and reports
6. Surface water quality	• 5-km radius from the project site	• Collected data from related documents and reports • Collected surface water samples at Huai Phu Sai, covering 2 seasons: wet season during 17th -18th September 2015, and dry season on 17th March 2016 at 4 stations: 1. About 1 km upstream of effluent outlet No. 1 of Pluak Daeng Industrial Park 2. At the effluent outlet No. 1 of Pluak Daeng Industrial Park 3. At the effluent outlet No. 2 of Pluak Daeng Industrial Park 4. About 500 m downstream of effluent outlet No. 2 of Pluak Daeng Industrial Park

TABLE 2.3-1 (Cont'd)

METHODS OF THE STUDY AND DATA COMPILATION FOR THE PLUAK DAENG POWER PLANT PROJECT

Potential Impact	Studied Areas	Source of data
7. Groundwater hydrology	• 5-km radius from the project site	• Collected data from related documents and reports
8. Groundwater quality	• 5-km radius from the project site	• Collected data from related documents and reports • Collected groundwater samples at wells currently in use which are located in the project vicinity, covering 2 seasons: wet season during 17^{th} -18^{th} September 2015, and dry season on 17^{th} March 2016. The sampling was conducted at 2 stations: 1. House No.203 in Village No.2, Map Yang Phon sub-district 2. Wat Prasittharam
9. Aquatic ecology	• 5-km radius from the project site	• Collected aquatic ecological samples at Huai Phu Sai, covering 2 seasons: wet season during 17^{th} -18^{th} September 2015, and dry season on 17^{th} March 2016 at 4 stations: 1. About 1 km upstream of effluent outlet No. 1 of Pluak Daeng Industrial Park 2. At the effluent outlet No. 1 of Pluak Daeng Industrial Park 3. At the effluent outlet No. 2 of Pluak Daeng Industrial Park 4. About 500 m downstream of effluent outlet No. 2 of Pluak Daeng Industrial Park
10. Terrestrial ecology	• 5-km radius from the project site	• Collected data from related documents and reports as well as field survey during 24^{th} -26^{th} February 2016
11. Land use	• 5-km radius from the project site	• Collected relevant secondary data • Field survey during 5^{th} -8^{th} October 2015
12. Transportation	• Transport and traffic conditions around the project area and vicinity	• Collected secondary data on traffic volume from Department of Highways • Traffic counts during 13^{th}-14^{th} March 2016 at 2 stations:

TABLE 2.3-1 (Cont'd)

METHODS OF THE STUDY AND DATA COMPILATION FOR THE PLUAK DAENG POWER PLANT PROJECT

Potential Impact	Studied Areas	Source of data
		1. Rural Road No. Ror Yor 2026 (Highway No. 36 Intersection – Ban Wang Tan Mon at Km. 12+230) 2. Rural Road No. Ror Yor 3013 (Highway No. 331 Intersection – Highway No. 3191 Intersection at Km. 14+250)
13. Water use	• 5-km radius from the project site	• Collected water use data from the project and relevant agencies
14. Electricity	• 5-km radius from the project site	• Collected data from Provincial Electricity Authority
15. Drainage and flood control	• 5-km radius from the project site	• Collected relevant secondary data • Field survey
16. Waste management	• 5-km radius from the project site	• Collected waste management data from the project and relevant local administrative organizations
17. Socio-economics	• Communities within 5-km radius from the project site	• Collected socio-economic data of communities from Pluak Daeng and Nikhom Phatthana district offices including Subdistrict Administrative Organizations in the study area • Conducted interviews to obtain opinions and comments from households in the study area including relevant government agencies and community leaders so as to obtain socio-economic data and opinions about the project development. The interviews were conducted during 10^{th} -17^{th} February 2016 and 23^{th} February-4^{th} March 2016 respectively. Additionally, Huai Phu Sai water user groups were interviewed on 8^{th} March 2016.
18. Public health/ occupational health and safety	• Communities within 5-km radius from the project site	• Collected secondary data from hospitals and health offices in Pluak Daeng and Nikhom Phatthana districts, and Tambon health promoting hospitals within the study area

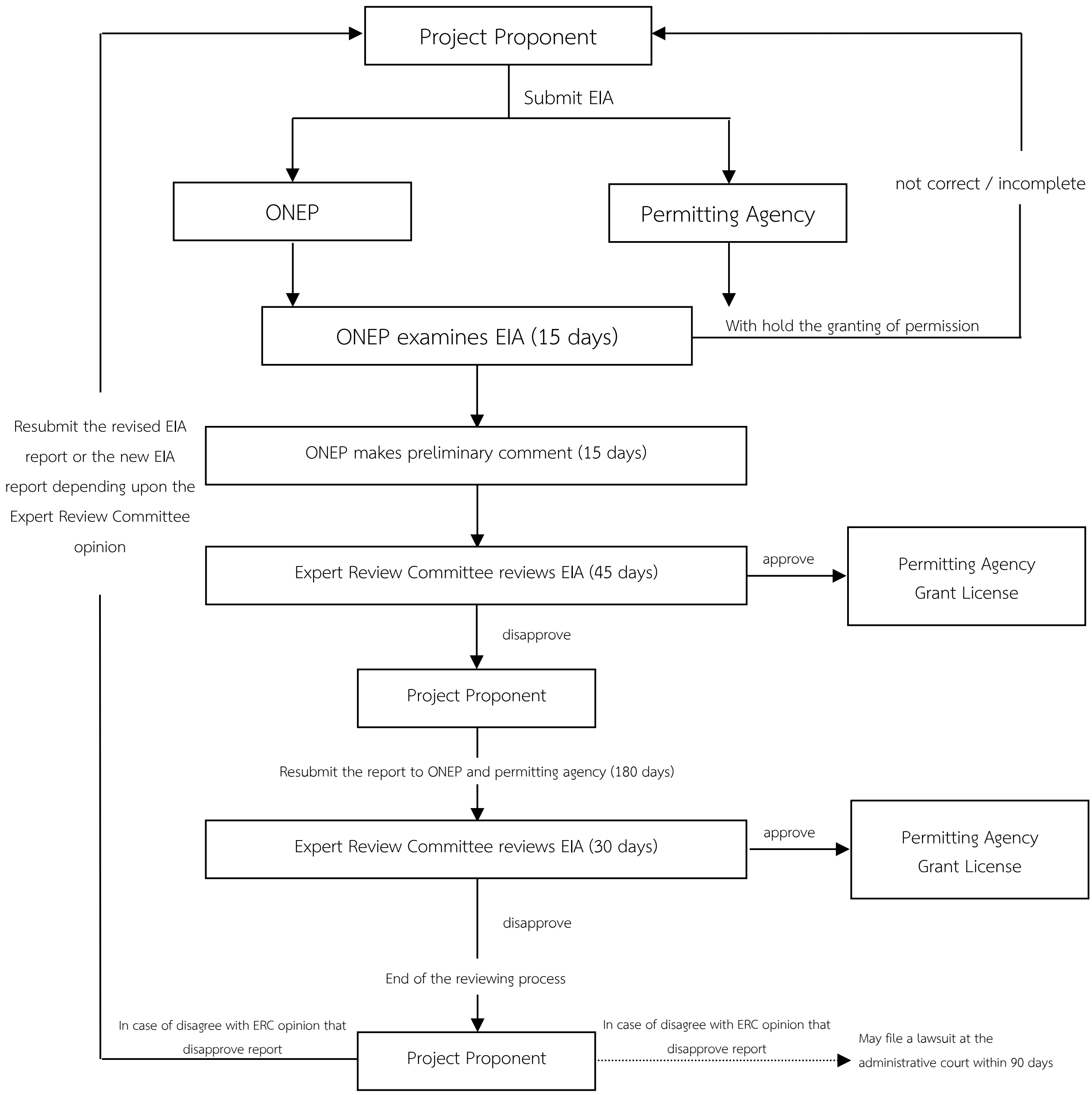
TABLE 2.3-1 (Cont'd)

METHODS OF THE STUDY AND DATA COMPILATION FOR THE PLUAK DAENG POWER PLANT PROJECT

Potential Impact	Studied Areas	Source of data
		• Interviews with local health officers were carried out during 7^{th} - 11^{th} April 2016. Health status interviews with local people were conducted along with household opinion surveys.
19. Historical, ancient, and archaeological places	• 5-km radius from the project site	• Collected relevant secondary data • Field survey during 5^{th} - 8^{th} October 2015
20. Aesthetics and tourist attractions	• 5-km radius from the project site	• Collected relevant secondary data • Field survey during 5^{th} - 8^{th} October 2015
21. Public participation	• 5-km radius from the project site	• Met and consulted with government agencies and community leaders • Organized 2 public consultation meetings to obtain people's opinions, i.e. 1^{st} meeting during 25^{th}- 27^{th} January 2016, and 2^{nd} meeting during 10^{th} - 12^{th} May 2016.

2.4 ONEP EIA REVIEW AND APPROVAL PROCESS

The EIA report of Natural Gas Pipeline to Pluak Daeng Power Plant Project must be submitted to ONEP for review and approval according to the following procedural scheme;



2.5 EIA APPROVAL

This EIA report submitted to ADB was rearranged from EIA report prepared under the requirement of regulation, issued by Ministry of Natural Resources and Environment (MNRE) of Thailand, specifying type and size of projects that will need detail EIA report to meet outline of an environmental impact assessment report (part of the Safeguard Requirement 1) of ADB. The contents of Thai EIA report in comparison with those of ADB EIA report are shown in **Table 2.5-1**. According to **Table 2.5-1**, although contents of Thai EIA do not cover all those of ADB EIA report, the missing contents were fulfilled.

The status of EIA approval is as follows:

- The EIA report of Pluak Daeng Power Plant Project was approved on 30 November 2016.

TABLE 2.5-1
COMPARISON BETWEEN CONTENTS OF THAI EIA REPORT AND THOSE OF ADB EIA REPORT

Content of Thai EIA Report	Content of ADB EIA Report
1. **Introduction** This section describes background information, purpose of the project, justification and essence of project operation, objective of report as well as content and methodology of studies.	-
	2. **Policy, Legal, and Administrative Framework** This section discusses the national and local legal and institutional framework within which the environmental assessment is carried out. It also identifies project-relevant international environmental agreements to which the country is a party.
2. **Project Description** This section describes the project in a way that the project can be clearly understood and visualized. Detailed information shall include project type, project location, project operation method and its supporting activities as well as plant layout with appropriate scale and direction. If the project	3. **Description of the Project** This section describes the proposed project; its major components; and its geographic, ecological, social and temporal context, including any associated facility required by and for the project (for example, access roads, power plants, water supply, quarries and borrow pits, and spoil disposal). It normally

TABLE 2.5-1 (Cont'd)
COMPARISON BETWEEN CONTENTS OF THAI EIA REPORT AND THOSE OF ADB EIA REPORT

Content of Thai EIA Report	Content of ADB EIA Report
will cause major impacts to the environmental resource and human life quality, there should be consideration for alternative ways to develop project, including no action. For each alternative, consideration must be based on project engineering, economic and environmental impacts equally. Comparison of advantage and disadvantage of each alternative must be pointed out, e.g. project site for port. Several sites must be studied. It should give description to show suitability of each site. The study must also consider alternatives that serve similar purpose but have different impacts to environment.	includes drawings and maps showing the project's layout and components, the project site, and the project's area of influence. 6. **Analysis of Alternatives** This section examines alternatives to the proposed project site, technology, design, and operation-including the no project alternative-in terms of their potential environmental impact; the feasibility of mitigating these impacts; their capital and recurrent costs; their suitability under local conditions; and their institutional, training, and monitoring requirements. It also states the basis for selecting the particular project design proposed, and justifies recommended emission levels and approaches to pollution prevention and abatement.
3. **Existing Environmental Condition** This section provides detailed information and related photos of non-restorable and restorable physical and biological natural resources and environment, describes details about human using value and quality of life value including existed problems within the surrounding area of the project and provides maps displaying existing environment conditions and land using surrounding the project as well as potentially impacted areas for both short and long terms.	4. **Description of the Environment (Baseline Data)** This section describes relevant physical, biological, and socio-economic conditions within the study area. It also looks at current and proposed development activities within the project's area of influence, including those not directly connected to the project. It indicates the accuracy, reliability, and sources of the data.
4. **Public Participation** This section describes the process undertaken during EIA process for engaging stakeholders, including information disclosure and consultation with affected people and other stakeholders; and summarizes comments and concerns received from affected people and other	7. **Information Disclosure, Consultation, and Participation** This section: (i) describes the process undertaken during project design and prepare action for engaging stakeholders, including information disclosure and consultation with affected people and other stakeholders;

TABLE 2.5-1 (Cont'd)

COMPARISON BETWEEN CONTENTS OF THAI EIA REPORT AND THOSE OF ADB EIA REPORT

Content of Thai EIA Report	Content of ADB EIA Report
stakeholders and how these comments have been addressed.	(ii) summarizes comments and concerns received from affected people and other stakeholders and how these comments have been addressed in project design and mitigation measures, with special attention paid to the needs and concerns of vulnerable groups, including women, the poor, and indigenous peoples; and (iii) describes the planned information disclosure measures (including the type of information to be disseminated and the method of dissemination) and the process for carrying out consultation with affected people and facilitating their participation during project implementation.
5. **Environmental Impact Assessment** Direct and indirect, short and long term environmental impacts from the project must be assessed. Application for construction permit must include study on the impacts during construction period. The study should address the severity of the impact to human in each element listed in Chapter 3. It should also include irreversible and irretrievable loss of environmental value, based on present assessment and future predicted impacts, resulting from technical basis. Prediction of impacts on complex environmental conditions can be predicted by using mathematics model to improve accuracy.	5. **Anticipated Environmental Impacts and Mitigation Measures** This section predicts and assesses the project's likely positive and negative direct and indirect impacts to physical, biological, socio-economic (including occupational health and safety, community health and safety, vulnerable groups and gender issues, and impacts on livelihoods through environmental media, and physical cultural resources in the project's area of influence, in quantitative terms to the extent Possible; identifies mitigation measures and any residual negative impacts that cannot be mitigated; explores opportunities for enhancement; identifies and estimates the extent and quality of available data, key data gaps, and uncertainties associated with predictions and specifies topics that do not require further attention; and examines global, transboundary, and cumulative impacts as appropriate.

TABLE 2.5-1 (Cont'd)

COMPARISON BETWEEN CONTENTS OF THAI EIA REPORT AND THOSE OF ADB EIA REPORT

Content of Thai EIA Report	Content of ADB EIA Report
6. **Health Impact Assessment** This section focuses on impacts from project development on health by using the result from chapter 4 and data from medical centers around project site to assess health impact of sensitive groups.	-
7. **Environmental Action Plan** This section must describe project operation to prevent and correct impacts to environmental resources and value as described in Chapter 4 and engage recommendation and suggestion from the community to action plan. In case of irreversible and irretrievable environmental damage, the report must suggest practical plan to compensate for this damage. The plan must describe in the practical method to replaced destroyed resources. This section must also describe the monitoring plan, and confirm the effectiveness of the measures to prevent and control pollution as presented in the report, in a suitable, systematic, continuous and technological way. Monitoring plan should aim at measuring the environmental impacts from project construction through to project operation. The plan should include description of monitoring site, parameters, frequency, environmental standard and measuring method, and period of reporting.	8. **Grievance Redress Mechanism** This section describes the grievance redress framework (both informal and formal channels), setting out the time frame and mechanisms for resolving complaints about environmental performance. 9. **Environmental Management Plan** This section deals with the set of mitigation and management measures to be taken during project implementation to avoid, reduce, mitigate, or compensate for adverse environmental impacts (in that order of priority). It may include multiple management plans and actions. It includes the following key components (with the level of detail commensurate with the project's impacts and risks): (i) Mitigation: (a) Identifies and summarizes anticipated significant adverse environmental impacts and risks; (b) Describes each mitigation measure with technical details, including the type of impact to which it relates and the conditions under which it is required (for instance, continuously or in the event of contingencies), together with designs, equipment descriptions, and operating procedures, as appropriate; and (c) Provides links to any other mitigation plans (for example, for involuntary resettlement, indigenous peoples, or emergency response) required for the project.

TABLE 2.5-1 (Cont'd)

COMPARISON BETWEEN CONTENTS OF THAI EIA REPORT AND THOSE OF ADB EIA REPORT

Content of Thai EIA Report	Content of ADB EIA Report
	(ii) Monitoring: (a) Describes monitoring measures with technical details, including parameters to be measured, method to be used, sampling locations, frequency of measurements, detection limits and definition of thresholds that will signal the need for corrective actions; and (b) Describes monitoring and reporting procedures to ensure early detection of conditions that necessitate particular mitigation measures and document the progress and results of mitigation. (iii) Implementation arrangements: (a) Specifies the implementation schedule showing phasing and coordination with overall project implementation; (b) Describes institutional or organizational arrangements, namely, who is responsible for carrying out the mitigation and monitoring measures, which may include one or more of the following additional topics to strengthen environmental management capability: technical assistance programs, training programs, procurement of equipment and supplies related to environmental management and monitoring, and organizational changes; and (c) Estimates capital and recurrent costs and describes sources of funds for implementing the environmental management plan. (iv) Performance indicators: describes the desired outcomes as measurable events to the extent possible, such as performance indicators, targets, or acceptance criteria that can be tracked over defined time periods.

TABLE 2.5-1 (Cont'd)
COMPARISON BETWEEN CONTENTS OF THAI EIA REPORT AND THOSE OF ADB EIA REPORT

Content of Thai EIA Report	Content of ADB EIA Report
Summary report must be prepared and shall contain the following substantial matters: 1. Type and size of the project including related activities 2. Project location with picture and map together with related maps demonstrating environmental components in the area that may be impacted by the project in scale of 1:50,000 or other appropriate scales 3. Alternative for project location and operation method that supported justification and consideration of selecting such proposed alternatives.	1. **Executive Summary** This section describes concisely the critical facts, significant findings, and recommended action.
-	10. **Conclusion and Recommendation** This section provides the conclusions drawn from the assessment and provides recommendations.

2.6 OTHER RELATED PERMITS

In order to construction and operation project, the project have to acquire related permits from relevant authorities as listed in **Table 2.6-1**.

TABLE 2.6-1

LIST OF ANTICIPATED PERMITS

Permit Details	Responsible Party	Note	Approximate Lead Time Between Submission and Approval	Permit required
1. Board of Investment (BOI)				
(a) Investment Promotion Certificate	Owner	Contractor shall prepare the project technical description support document.		
(b) Master List of imported Equipment and Materials exempt and not exempt from custom duty.	Contractor	Master list of imported equipment and material as required by Thai Law. BOI will determine which Imported Equipment and Materials is duty exempt.	45 days	90 days after NTP
(c) Application for duties and VAT exemption from BOI and Custom clearance of each shipment of imported goods and/or machinery	Contractor	Owner sign the documents to be prepared and submitted by the Contractor.	At least 14 days	Before ETA of equipment and material
(d) BOI Permission for Machinery Mortgage.	Owner			
(e) Work Permit for Foreign Skilled Technicians and Experts for Owner's account	Owner			
(f) Notification for Factory Operation Commencement	Owner			

TABLE 2.6-1 (Cont'd)

LIST OF ANTICIPATED PERMITS

Permit Details	Responsible Party	Note	Approximate Lead Time Between Submission and Approval	Permit required
2. Energy Regulatory Commission (Regulator)				
(a) Power Generation License	Owner	Contractor shall provide technical information documents and drawings required to obtain this Permit. If it is requested by the Government, the Supplier or Contractor shall prompt to provide clarification or submit the requested drawing.	6 Months	Before Construction
(c) Controlled Energy Production Permit	Owner	Contractor shall provide technical information documents and drawings required to obtain this Permit. If it is requested by the Government, the Supplier or Contractor shall prompt to provide clarification or submit the requested drawings.	6 Months	Before 1st Sync
(d) Notification of Commencement of Power Generation	Owner	Contractor shall provide technical information documents and drawings required to obtain this Permit. If it is requested by the Government, the Supplier or Contractor shall prompt to provide clarification or submit the requested drawing.	1 month	Before COD
(e) License for the operation of Natural Gas Transmission through pipelines via a natural gas transmission system	Owner	Contractor shall provide technical information documents and drawings required to obtain this Permit. If it is requested by the Government, the Supplier or Contractor shall prompt to provide clarification or submit the requested drawing.	6 Months	Before NTP - Gas

TABLE 2.6-1 (Cont'd)

LIST OF ANTICIPATED PERMITS

Permit Details	Responsible Party	Note	Approximate Lead Time Between Submission and Approval	Permit required
(f) Energy Network Announcement	Owner	Contractor shall provide technical information documents and drawings required to obtain this Permit. If it is requested by the Government, the Supplier or Contractor shall prompt to provide clarification or submit the requested drawing.	4 Months	Before NTP - Gas
(g) Permission for Any other Execution which may cause Danger or Obstruction in the Energy Network System Area (Gas Pipeline or Transmissions Line)	Owner	Contractor shall provide technical information documents and drawings required to obtain this Permit. If it is requested by the Government, the Supplier or Contractor shall prompt to provide clarification or submit the requested drawing.	4 Months	Before construction in the Network System Area
3. Ministry of Natural Resources and Environment				
3.1 Office of Natural Resources and Environmental Policy and Planning (ONEP)				
(a) Environmental Impact Assessment (EIA) for Power Plant.	Owner			
(b) Report of Environmental Mitigation Measures and Monitoring Programs during construction and commissioning period.	Contractor	Contractor shall conduct and comply with environmental mitigation measures and monitoring program related to EPC work (as stated in the EIA) and prepare monthly reports for Owner to submit to ONEP	Submission date as per EIA report	

TABLE 2.6-1 (Cont'd)

LIST OF ANTICIPATED PERMITS

Permit Details	Responsible Party	Note	Approximate Lead Time Between Submission and Approval	Permit required
4. Ministry of Industry				
4.1 Industrial Works Department (IWD)				
(a) Boiler Safety Certificate	Contractor Owner	Contractor shall arrange a third party mechanical engineer who is registered with the Industrial Works Department for boiler certification.	3 Months	Before operation of boiler
(b) Registration of Boiler Operations Engineer for plant commissioning.	Contractor	Contractor shall arrange a third party mechanical engineer who is registered with the Industrial Works Department for boiler certification.	1 Month	Before operation of boiler
(c) Registration of Boiler Operations Engineer for Plant Operation	Owner		1 Month	Before operation of boiler
(d) Boiler Control Operator Registration for plant operation after COD.	Owner		1 Month	Before operation of boiler
(e) Registration of Plant Pollution Control System Supervisor prior to Commissioning Date of Block 1, 2, 3 and 4.	Contractor		1 Month	Before Commissioning
(f) Registration to be an Operator for Supervision and Operation of Environmental Pollution Prevention Equipment for commissioning phase.	Contractor		1 Month	Before Commissioning

TABLE 2.6-1 (Cont'd)

LIST OF ANTICIPATED PERMITS

Permit Details	Responsible Party	Note	Approximate Lead Time Between Submission and Approval	Permit required
(g) Machinery Possession & Ownership Registration	Owner		4 Months	After COD
(h) Machinery Mortgage Registration.	Owner		4 Months	After COD
(i) Registration of Industrial Waste Disposal Permit after COD1 2 3 and 4, respectively.	Owner		1 Month	
(j) Dangerous Substance License (importation and possession), if applicable for" – Owner's account – Contractor's account	Owner Contractor		1 Month	
(k) Registration to be a Gas Controlled Operator – Owner's account – Contractor's account	Owner Contractor		1 Month	
5. Ministry of Transport				
5.1 Department of Highways				
(a) Permit for Transportation of Heavy Equipment	Contractor			

TABLE 2.6-1 (Cont'd)

LIST OF ANTICIPATED PERMITS

Permit Details	Responsible Party	Note	Approximate Lead Time Between Submission and Approval	Permit required
6. Ministry of Energy				
6.1 Department Of Energy Business (DOEB)				
(a) Permit for Liquid Fuel Storage Tank - Phase1:Construction Drawing Approval - phase2:Permit Approval	Owner Contractor	Contractor shall provide technical information documents and drawings required to obtain this Permit. If it is requested by the Government, the Supplier or Contractor shall prompt to provide clarification or submit the requested drawing.	3 Months 3 Months	Before Construction Before 1st fill
(b) Permit for transportation of natural gas System - Phase1:Construction Drawing Approval - phase2:Permit Approval	Owner Contractor	Contractor shall provide technical information documents and drawings required to obtain this Permit. If it is requested by the Government, the Supplier or Contractor shall prompt to provide clarification or submit the requested drawing.	3 Months 3 Months	Before Construction Before Gas in
(c) Permit for Gas Metering Station System - Phase1:Construction Drawing Approval - phase2:Permit Approval	Owner Contractor	Contractor shall provide technical information documents and drawings required to obtain this Permit. If it is requested by the Government, the Supplier or Contractor shall prompt to provide clarification or submit the requested drawing.	3 Months 3 Months	Before Construction Before Gas in
(e) Energy Network Announcement for transportation of natural gas System	Owner	Contractor shall provide technical information documents and drawings required to obtain this Permit. If it is requested by the Government, the Supplier or Contractor shall prompt to provide clarification or submit the requested drawing.	6 Months	Before Gas in

TABLE 2.6-1 (Cont'd)

LIST OF ANTICIPATED PERMITS

Permit Details	Responsible Party	Note	Approximate Lead Time Between Submission and Approval	Permit required
(g) Registration to be Worker for location using natural gas	Owner		6 Months	Before gas in
(h) Registration to be Worker for transportation of natural gas System	Owner		6 Months	Before gas in
(i) Registration to be Worker for Fuel Oil Tank	Owner		6 Months	Before 1st fill
6.2 Electricity Generating Authority of Thailand (EGAT)				
(a) Approval for Power Plant connecting to EGAT Transmission Line	Owner	Contractor shall support Owner to get the approval.		
(b) Permanent right of way for gas pipeline and/or power cable (if applicable)	Owner	Contractor shall provide technical information documents and drawings required to obtain this Permit. If it is requested by the Government, the Supplier or Contractor shall prompt to provide clarification or submit the requested drawing.	6 Months	
7. Tambol Administration Organization(TAO)				
(a) Digging and Filling	Owner		1 Month	Before Digging and Filling
(b) Permanent right of way for Gas pipeline and/or power cable (if applicable)	Owner	Contractor shall provide technical information documents and drawings required to obtain this Permit. If it is requested by the Government, the Supplier or Contractor shall prompt to provide clarification or submit the requested drawing.	18 Months	Before Construction

TABLE 2.6-1 (Cont'd)

LIST OF ANTICIPATED PERMITS

Permit Details	Responsible Party	Note	Approximate Lead Time Between Submission and Approval	Permit required
8. Ministry of Labor and Social Welfare				
(a) Work Regulations	Owner / Contractor	The permits in this section are according to regular Thai law requirements regarding workers regulations.		
(b) Alien Work Permit	Owner / Contractor			
(c) Registration of Workmen's Compensation Fund, Contribution and Submission of List of Employees.	Owner / Contractor			
(d) Notification of Safety Officer	Owner / Contractor			
(e) Social Security Registration	Owner / Contractor			
9. Customs Department				
(a) Application for Customs Card	Owner / Contractor			
(b) Custom Clearance	Owner / Contractor			
10. Telephone Organization of Thailand (TOT)				
(a) Telephone service during construction and commissioning	Contractor			

TABLE 2.6-1 (Cont'd)

LIST OF ANTICIPATED PERMITS

Permit Details	Responsible Party	Note	Approximate Lead Time Between Submission and Approval	Permit required
11. Communication Authority of Thailand (CAT)				
(a) Radio communication during construction and commissioning	Contractor			
12. Provincial Electricity Authority (PEA)				
(a) Electricity supply during construction	Contractor			
13. Ministry of Defense				
(a) Permit for Self Contained Breathing Apparatus (SCBA) and Full Face Masks for emergency use and chemical work after COD.	Owner		4 months	Before use of SCBA
(b) Permit for Self Contained Breathing Apparatus (SCBA) and Full Face Masks for emergency use and chemical work commissioning phase.	Contractor		4 months	Before use of SCBA
(c) Permit to Use of Standard Gas for Continuous Emission Monitoring System (CEMS) Gas Calibration.	Contractor		4 months	Before delivery of Standard Gas to site
(d) Permits to possess liquid Chlorine, if applicable.	Contractor / Owner		4 months	Before use of liquid Chlorine

TABLE 2.6-1 (Cont'd)

LIST OF ANTICIPATED PERMITS

Permit Details	Responsible Party	Note	Approximate Lead Time Between Submission and Approval	Permit required
14. Ministry of Interior				
14.1 Department of Land				
(a) Registration of Land Easement	Owner			
(b) Registration of Land Mortgage	Owner			
(c) Approval for the utilization of public land and the conversion of public land to private land, if applicable	Owner			
15. Pluak Daeng Industrial Park				
Regulation for factory construction in Pluak Daeng Industrial Park	Contractor	See Exhibit C; "Site Reports and Data", for Hemaraj Eastern Seaboard Industrial Estate regulations and instruction for factory construction		
Right of Way Agreement	Owner	Contractor shall provide technical information documents and drawings required to obtain this Permit. If it is requested by the Government, the Supplier or Contractor shall prompt to provide clarification or submit the requested drawing.		

CHAPTER 3

DESCRIPTION OF THE PROJECT

CHAPTER 3
DESCRIPTION OF THE PROJECT

3.1 PROJECT LOCATION

Pluak Daeng Power Plant Project (the Project) is located in Pluak Daeng Industrial Park (Industrial Park), Map Yang Phon sub-district, Pluak Daeng district, Rayong Province (**Figures 3.1-1** and **Figure 3.1-2**). The project area is totally 492 rai, 1 ngan and 20.3 square wah or approximately 492 rai, covering 13 plots of land held under land title deeds, as presented in **Table 3.1-1, Figure 3.1-3** and **Appendix 3A**. The project boundary and public ways are illustrated in **Figure 3.1-4** (The existing locations and conditions of public ways, both in the project area and Pluak Daeng Industrial Park, are presented in **Figure 3.1-5**), with its boundary described as follows (Photos of the existing conditions of the project area and surrounding areas are shown in **Figure 3.1-6**):

- North: Buffer zone of Pluak Daeng Industrial Park
- South: Public service areas in Pluak Daeng Industrial Park
- East: Buffer zone of Pluak Daeng Industrial Park
- West: Main road of Pluak Daeng Industrial Park

Sensitive receptors in the project area are listed in **Table 3.1-2** and the locations of nearby communities are shown in **Figure 3.1-7**.

3.2 ASSOCIATED FACILITIES

The project comprises the following elements

- The raw water pipeline to be constructed, operated, and maintained by Pluak Daeng Industrial Park.
- The transmission line to be constructed, operated, and maintained by EGAT.

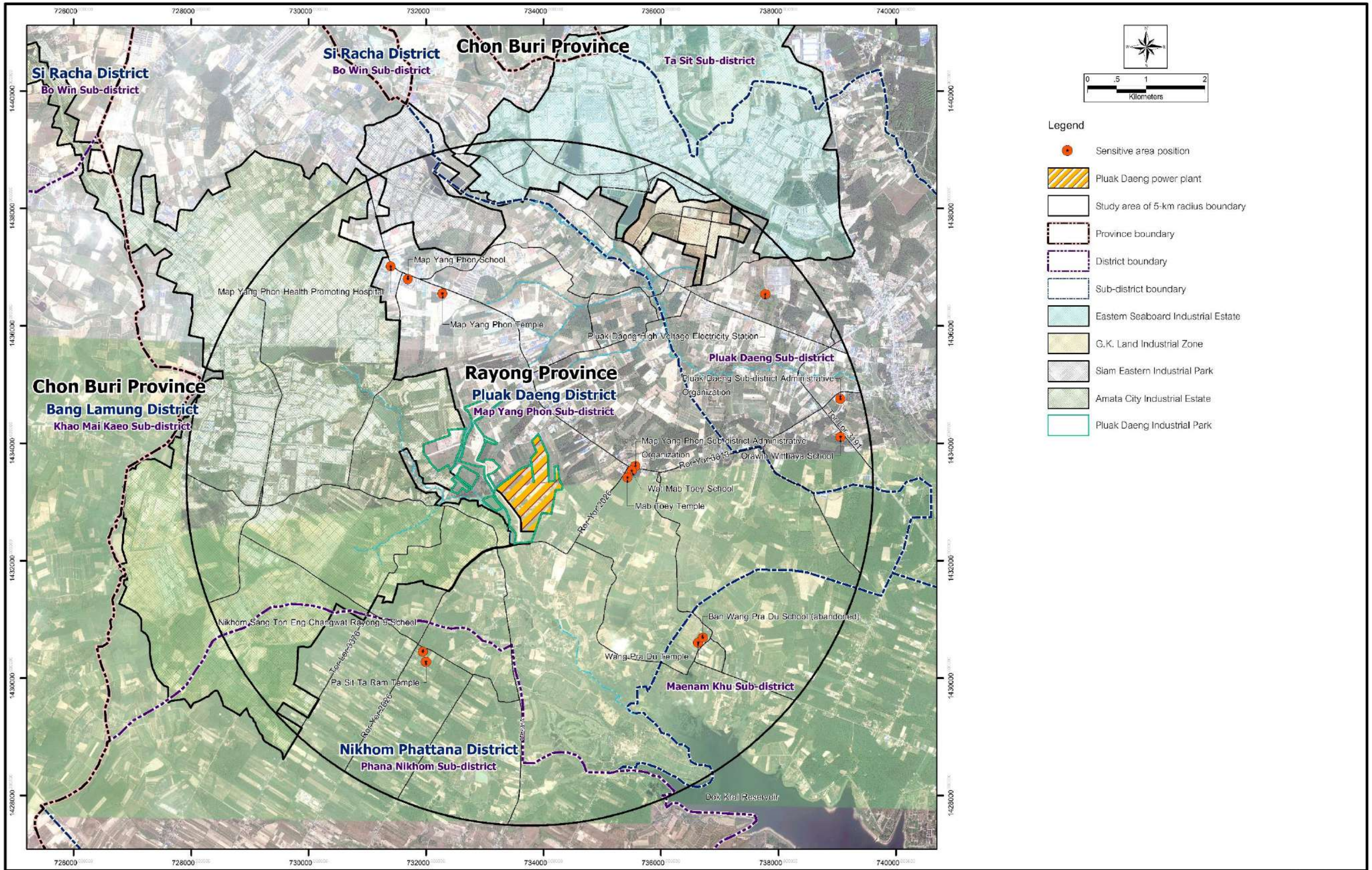


FIGURE 3.1-1: LOCATION OF PLUAK DAENG POWER PLANT PROJECT

Utilization Type	Current Project				Extension Project		Total Area	
	EIA Issue 2009		After Plan Development					
	Area (Rai)	%	Area (Rai)	%	Area (Rai)	%	Area (Rai)	%
Industrial Area	378.26	71.60	393.39	74.97	425.86	68.67	819.25	71.56
Facility System Area	91.06	17.24	90.53	17.26	105.25	16.98	195.78	17.10
- Raw Water Pond No.1	4.95	-	20.89	-	0.00	-	20.89	-
- Raw Water Pond No.2	19.99	-	0.00	-	9.08	-	9.08	-
- Raw Water Pond No.3	0.00	-	4.00	-	0.00	-	4.00	-
- Raw Water Pond No.4	0.00	-	0.00	-	2.50	-	2.50	-
- Wastewater Treatment Plant and Treated Water Holding Pond	15.92	-	10.00	-	19.24	-	29.24	-
- Water Treatment Plant	0.00	-	1.54	-	0.00	-	1.54	-
- Solid Waste Storage Station	0.38	-	0.50	-	0.00	-	0.50	-
- Office Building	4.30	-	2.50	-	0.00	-	2.50	-
- Holding Pond	3.48	-	0.00	-	0.00	-	0.00	-
- Public Service Area	0.00	-	18.61	-	0.00	-	18.81	-
- Electricity Sub-station	9.35	-	7.00	-	0.00	-	7.00	-
- Telephone Exchange	0.25	-	0.00	-	0.00	-	0.00	-
- Road	32.44	-	25.49	-	74.43	-	99.92	-
Green Area and Buffer Zone	58.93	11.16	37.63	7.17	89.01	14.35	126.64	11.06
Green Area	-	-	-	-	-	-	-	-
Buffer Zone	-	-	-	-	-	-	-	-
Buffer Zone along High Voltage Electricity Transmissionline	-	-	3.16	0.60	-	-	3.16	0.28
Total Project Area	528.25	100.00	524.71	100.00	620.12	100.00	1,144.83	100.00

Remark :

— Buffer area underneath high voltage electricity transmission line with area of 3.6 rais considered within 20 meters distance from center line is not included in green area and buffer zone.

Extension Part

Public Way

Creek, Public Ditch

IPP Power Plant

Source : Environmental Impact Assessment Report of Pluak Daeng Industrial Park Project (First Extension Phase), February 2016

FIGURE 3.1-2 : LAYOUT PLAN OF PLUAK DAENG INDUSTRIAL PARK

TEAM

TABLE 3.1-1

PROJECT AREA ACCORDING TO LAND TITLE DEEDS

OF PLUAK DAENG POWER PLANT PROJECT

Project Area					
No.	Title Deed No.	Area			Total Area (rai)
		Rai	Ngan	Sq. Wah	
1	Chor. 1237	34	2	12	34.53000
2	Chor. 1238	40	2	48	40.62000
3	Chor. 1239	34	1	40	34.35000
4	Chor. 1597	13	1	71.5	13.42875
5	Chor. 2384	64	3	49.1	64.87275
6	Chor. 2390	31	0	14.3	31.03575
7	Chor. 2395	207	2	35	207.58750
8	Chor. 31827	7	1	72	7.430000
9	Chor. 31828	2	3	46.7	2.86675
10	Chor. 31829	5	2	13.5	5.53375
11	Chor. 31830	5	3	16	5.79000
12	Chor. 31831	6	0	21.2	6.05300
13	Chor. 31832	38	0	81	38.20250
Total Area		**492**	**1**	**20.3**	**492.30075**

Source: Gulf PD Co., Ltd., 2016

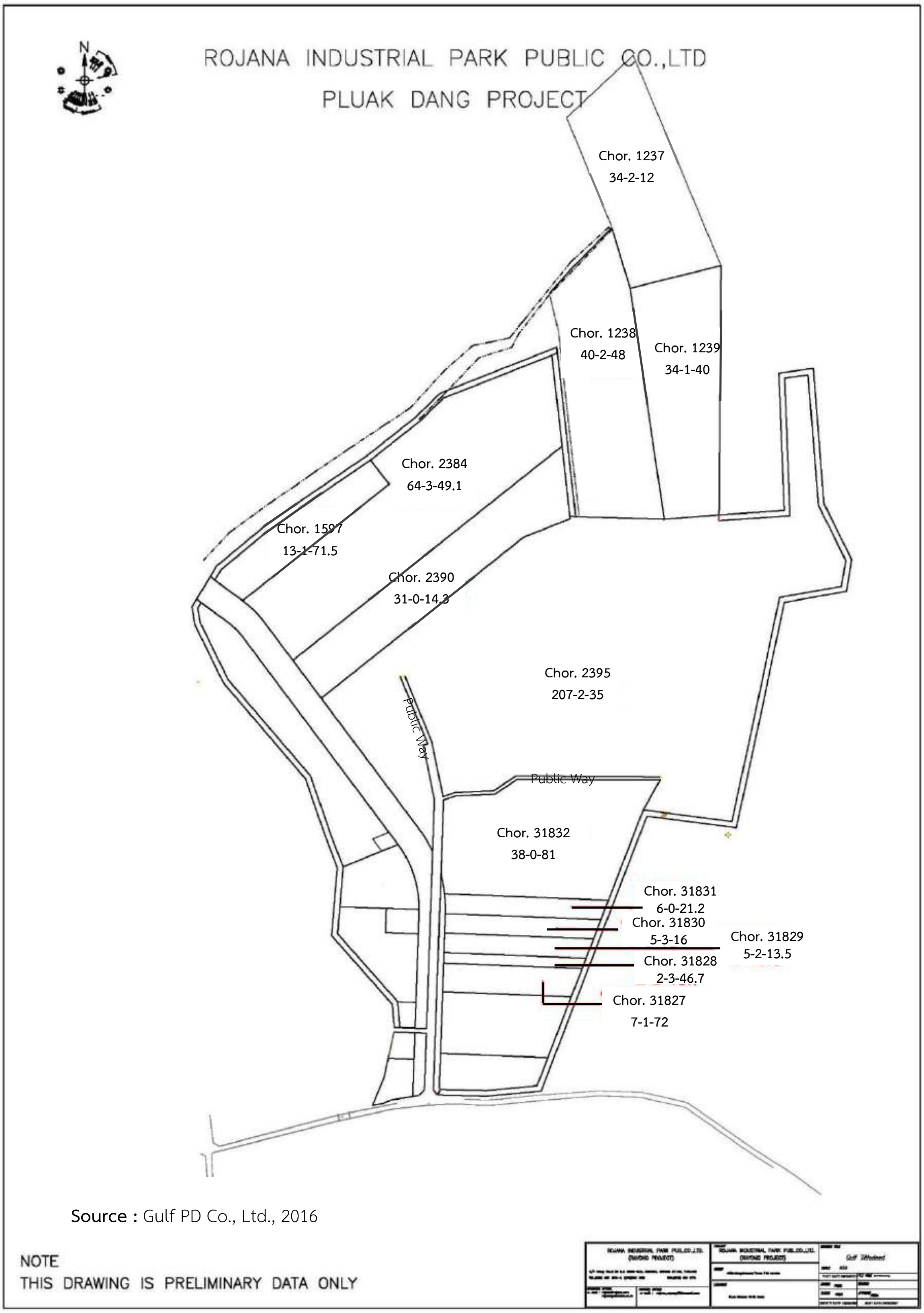


FIGURE 3.1-3 : LAND TITLE DEEDS OF PLUAK DAENG POWER PLANT PROJECT

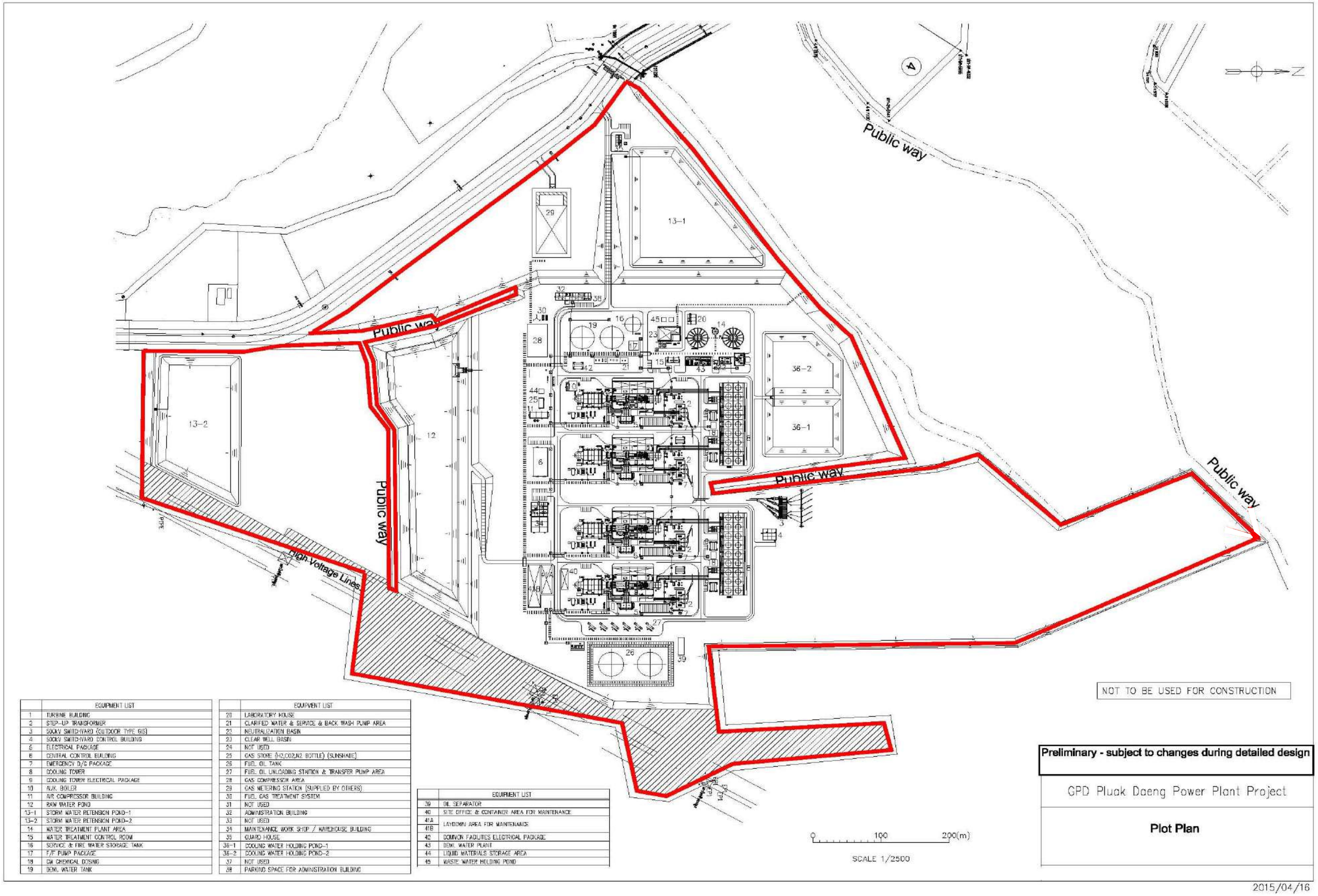


FIGURE 3.1-4 : PLOT PLAN OF PLUAK DAENG POWER PLANT PROJECT

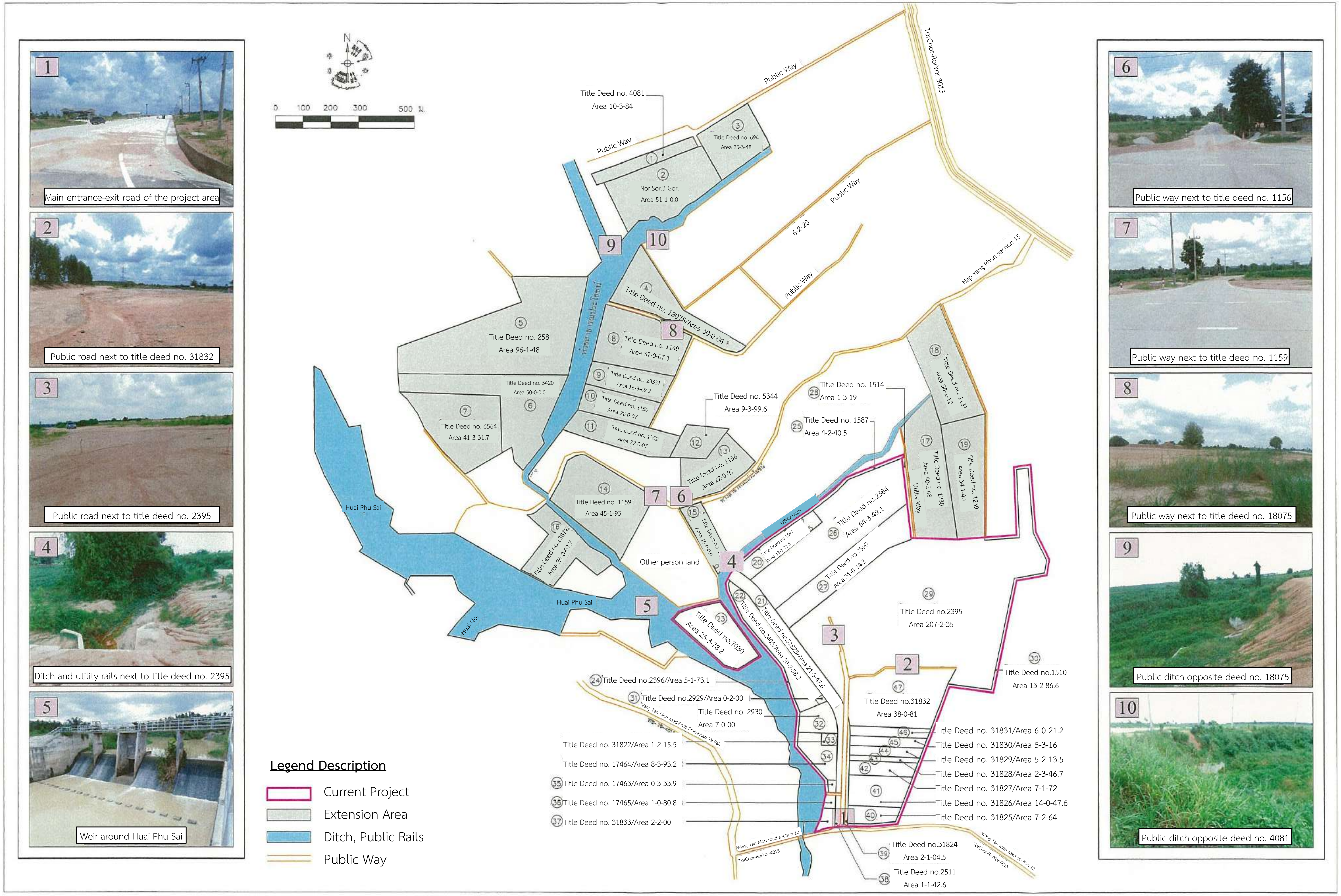


FIGURE 3.1-5 : PUBLIC WAYS IN PLUAK DAENG INDUSTRIAL PARK

FIGURE 3.1-6 : PHOTOS OF THE EXISTING CONDITIONS OF THE PROJECT AREA AND SURROUNDING AREAS

Table 3.1-2

Sensitive Receptors in the Project Vicinity

No.	Sensitive Receptors	Coordinates		Distance from the Project (km)/Direction
		E	N	
1	Map Yang Phon Subdistrict Administrative Organization (SAO)	735565	1433613	1.29/East
2	Wat Map Toei School	735503	1433533	1.21/East
3	Wat Map Toei	735430	1433415	1.12/East
4	Nikhom Sang Ton-eng Rayong 9 School	731947	1430451	2.64/Southwest
5	Wat Prasittharam	732002	1430278	2.75/Southwest
6	Map Yang Phon Tambon Health Promoting Hospital	731401	1437012	3.80/north-northwest
7	Ban Map Yang Phon School	731692	1436797	3.45/ north-northwest
8	Wat Map Yang Phon	732279	1436548	2.90/ north-northwest
9	Pluak Daeng SAO	739055	1434753	4.96/East
10	Orawin Witthaya School	739058	1434108	4.81/East
11	Pluak Daeng High Voltage Substation	737778	1436539	4.54/Northeast
12	Wat Wang Pradu	736636	1430603	3.33/Southeast
13	Ban Wang Pradu School (unused)	736715	1430692	3.33/Southeast
14	Village no. 5, Ban Khlong Phlu	733193	1429939	2.58/South-southwest
15	Village no. 7, Ban Wang Pla	732270	1430365	2.78/Southwest
16	Village no. 8, Ban Soi 13	731436	1430734	2.60/South-southwest
17	Village no. 7, Ban Wang Pradu	736569	1430927	3.10/Southeast
18	Village no. 4, Ban Khao Maphut	730854	1431065	3.17/Southwest
19	Village no. 5, Ban Wang Tan Mon	732762	1431786	1.26/Southwest
20	Village no. 1, Ban Map Toei	735578	1432703	1.46/East
21	Village no. 7, Ban Chak Oi	737267	1433299	3.08/East
22	Village no. 6, Ban Map Yang Mai	731490	1434612	2.25/Northwest
23	Village no. 6, Ban Thap Tong	736907	1434627	2.89/Northeast
24	Village no. 2, Ban Noen Sawan	733690	1434855	0.81/North
25	Village no. 4, Ban Wang Ta Phin	736444	1435467	2.94/Northeast
26	Village no. 3, Ban Map Yang Phon	733404	1436506	2.49/North
27	Village no. 6, Ban Nong Rakam	734378	1428021	4.52/South
28	Village no. 5, Ban Khlong Phlu	732735	1428558	4.04/South-southwest
29	Village no. 7, Ban Wang Pla	731629	1429178	2.52/Southwest
30	Village no. 8, Ban Soi 13	730774	1429714	3.97/Southwest
31	Village no. 4, Ban Chak Manthet	738538	1430469	5.02/Southeast

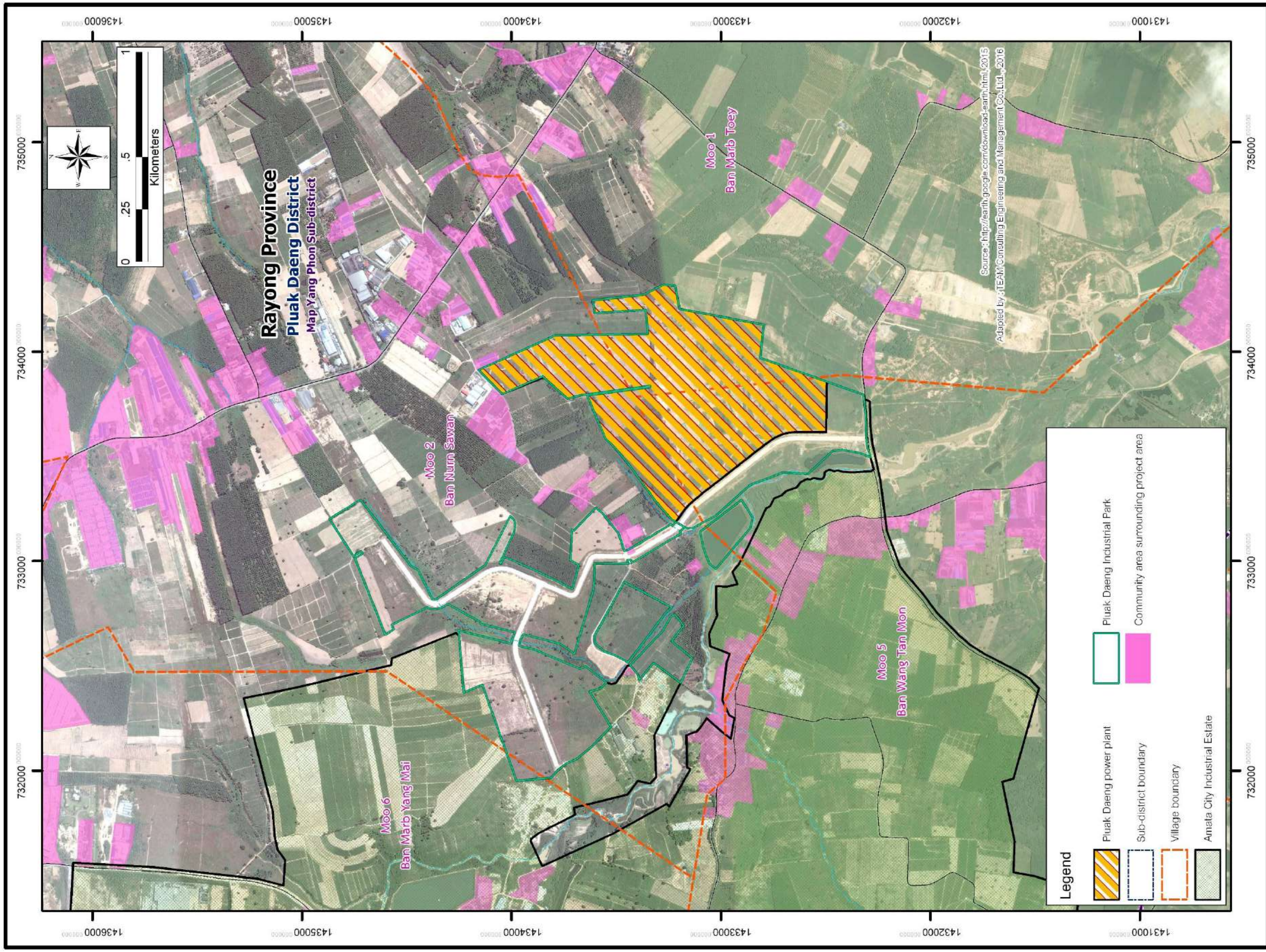


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FIGURE 3.1-7 : TOP EYE VIEW PHOTOGRAPH OF PROJECT AND COMMUNITIES NEARBY PROJECT

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The project site is about 146 kilometers east of Bangkok and can be accessed via Motorway 7. Turn left at the interchange bridge (Laem Chabang intersection) onto National Highway No.331 (new route) and travel for about 16 kilometers, until reaching another interchange bridge. Then make a U-turn under this interchange bridge towards Sattahip direction and travel on for about 8.6 kilometers before turning left to enter Pak Ruam intersection and Rural Road Ror Yor. 3013. Drive along Rural Road Ror Yor. 3013 for approximately 13.5 kilometers until reaching Wat Map Toei, then turn right onto Rural Road Ror Yor. 2026 and drive on for 2.7 kilometers to reach the entrance to Pluak Daeng Industrial Park, and then continue further for about 200 meters to the project site, which is on the right, as illustrated in **Figure 3.1-8.**

3.3 CONSIDERATION OF PROJECT IMPLEMENTATION ALTERNATIVES

The consideration on alternatives of the project implementation has been conducted to appraise project implementation alternatives on either site selection or method of project implementation. The details of alternative criteria and final selection are provided in **Chapter 6.**

3.3 LAYOUT OF THE PROJECT COMPONENTS

The layout of Pluak Daeng Power Plant Project is prepared for installation of machinery and equipment, including office building and utilities system, covering an area of 492 rai, as exhibited in **Figure 3.3-1**. Details of the project's land use plan are shown in **Table 3.3-1**.

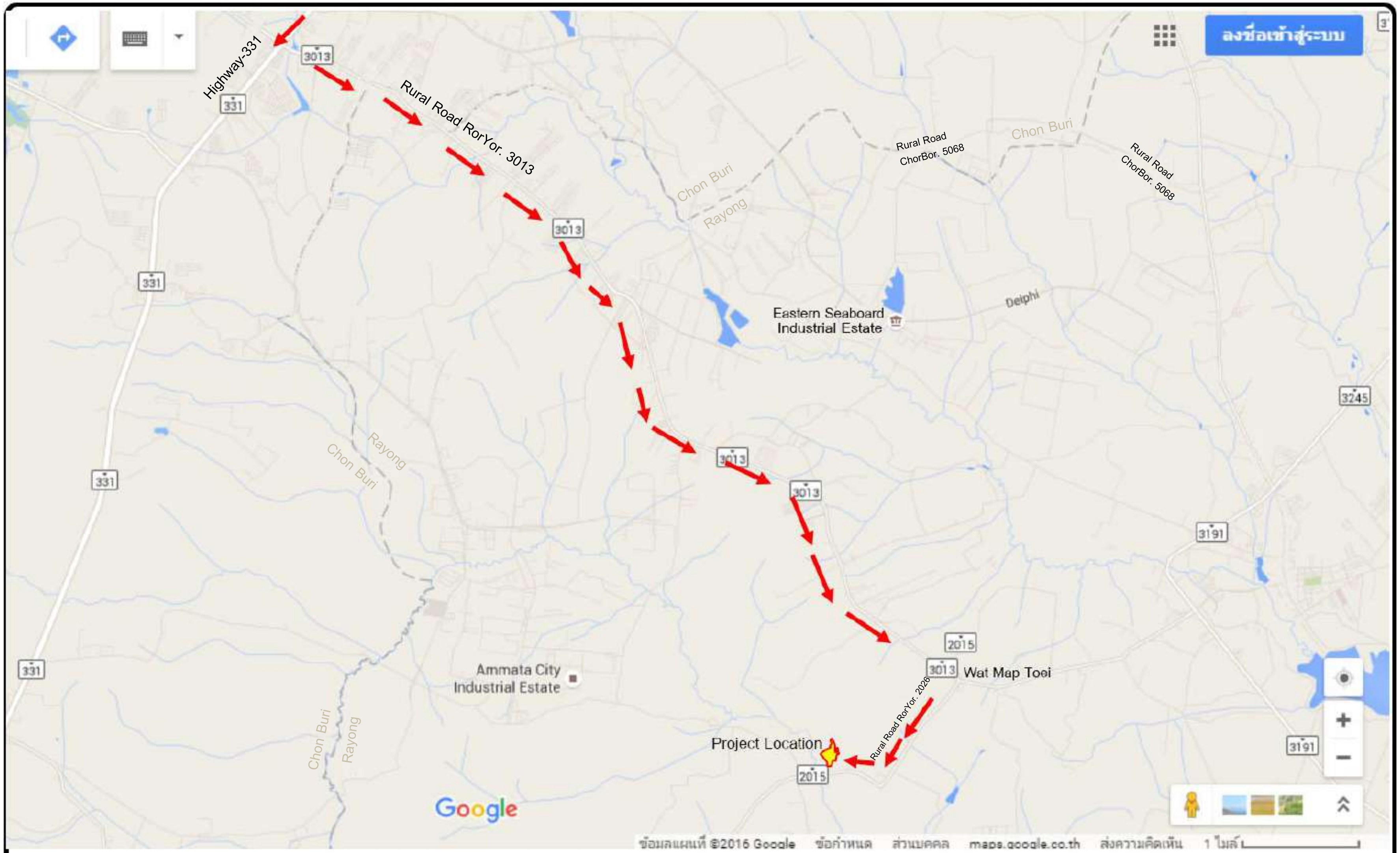

FIGURE 3.1-8 TRANSPORT ROUTE TO PLUAK DAENG POWER PLANT PROJECt

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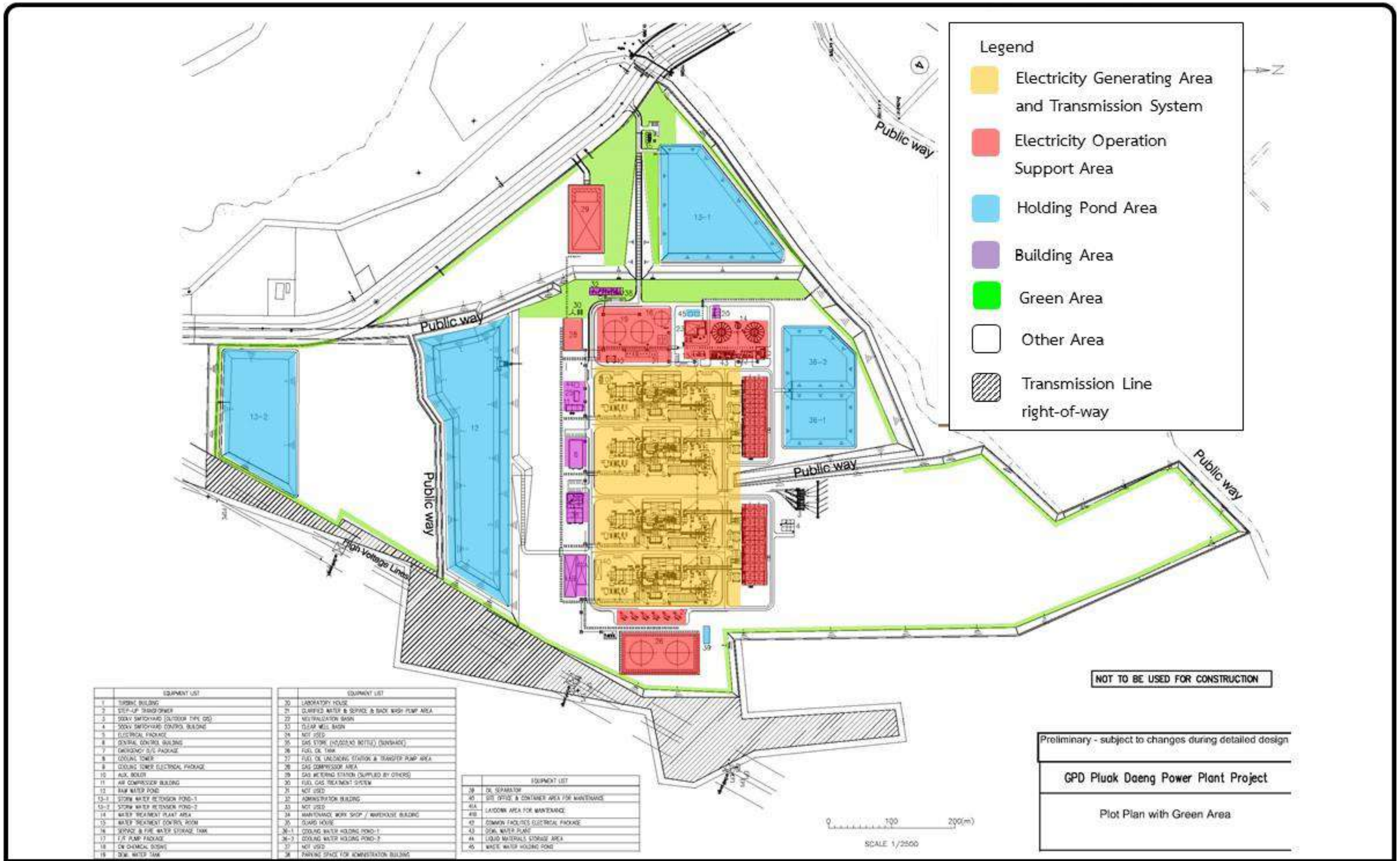

FIGURE 3.3-1 : STRCTURE DIAGRAM OF PLUAK DEANG POWER PLANT PROJECT

TABLE 3.3-1
DETAILS OF LAND USE PLAN IN PLUAK DAENG POWER PLANT PROJECT

Project Components	Approximate Area (m^2)	Percentage of the Total Area
1) **Power Block Area**		
- Power Block	111,318	14.13
- Transformer Area	1,560	0.20
Total (1)	**112,878**	**14.33**
2) **Balance of Plant Area**		
- Gas Metering Station	6,122	0.78
- Gas Compressor	2,400	0.30
- Diesel Storage Tank Area	6,726	0.85
- Water Treatment and Wastewater Treatment Areas	34,108	4.33
- Cooling Water Area	33,118	4.20
Total (2)	**82,474**	**10.47**
3) **Pond Area**		
- Raw Water Pond	45,358	5.76
- Cooling Water Holding Pond	20,221	2.57
- Wastewater Holding Pond	72	0.01
- Storm Water Pond	46,266	5.87
Total (3)	**111,917**	**14.21**
4) **Area of Buildings**		
- Control Building	1,000	0.13
- Workshop & Warehouse Building	1,200	0.15
- Administration Building and Guardhouse	800	0.10
Total (4)	**3,000**	**0.38**
5) **Green Area**	**45,000**	**5.71**
6) **Other Areas,** e.g. road, drainage ditches, pipeline installation area, right of way area of transmission line, etc.	**432,413**	**54.90**
Grand Total (m^2)	**787,682**	**100.00**

Source : Gulf PD Co., Ltd., 2016.

3.4 FUEL

3.4.1 Fuel Source and Transportation to the Power Plant

Pluak Daeng Power Plant Project has been envisioned as a result of the issuance by the Energy Regulatory Commission (ERC) of requests for proposals to Independent Power Producers (IPP) in accordance with the Notification of the Energy Regulatory Commission in 2012. The conditions of the Power Purchase Agreement have stipulated that power plants shall use natural gas as the major fuel source while diesel can be used as auxiliary fuel. It is also required that diesel can be used for power generation only after receiving an order from EGAT such as an emergency case arising from natural gas supply disruptions.

Consequently, it is essential to design a dual fuel power generation system, i.e. natural gas and diesel, for Pluak Daeng Power Plant Project, with natural gas as the main fuel source. Diesel will be used as auxiliary fuel in case EGAT issues an order when disruptions of natural gas supply occur.

The project will receive natural gas supply from PTT's onshore natural gas transmission pipeline No. 5 according to PTT's letter No. 80000502/35/2559 dated 7th March 2016 informing the Company of the tie-in point for the IPP Power Plant of Gulf PD Co., Ltd. (as presented in **Appendix 3B**). PTT is preparing for announcing the onshore natural gas transmission pipeline network No.5.

Natural gas will be received from PTT via gas transmission pipeline connected to the project site. The transmission pipeline is designed to withstand maximum pressure at the tie-in point of not less than 450 psig at a temperature of 60-83°F. **Figure 3.4-1** depicts natural gas pipeline network near the project area.

Diesel, the auxiliary fuel, will be transported by tank truck to the project area. After the truck entry into the project area, the filling station will pump diesel from tank trucks into two storage tanks. Each tank has a capacity of 14,300 m^3 and will be filled to no more than 90% capacity in compliance with the Ministerial Regulation on Fuel Storage, B.E. 2556 (2013). The aforementioned storage volume will be sufficient for 3-day reserve of fuel supply. The diesel storage tanks will be surrounded by concrete dike with capacity equal to the 100% storage volume of the largest storage tank so as to contain diesel fuel oil in case of tank failure or leakage according to the Ministerial Regulation on Fuel Storage, B.E.2556 (2013).

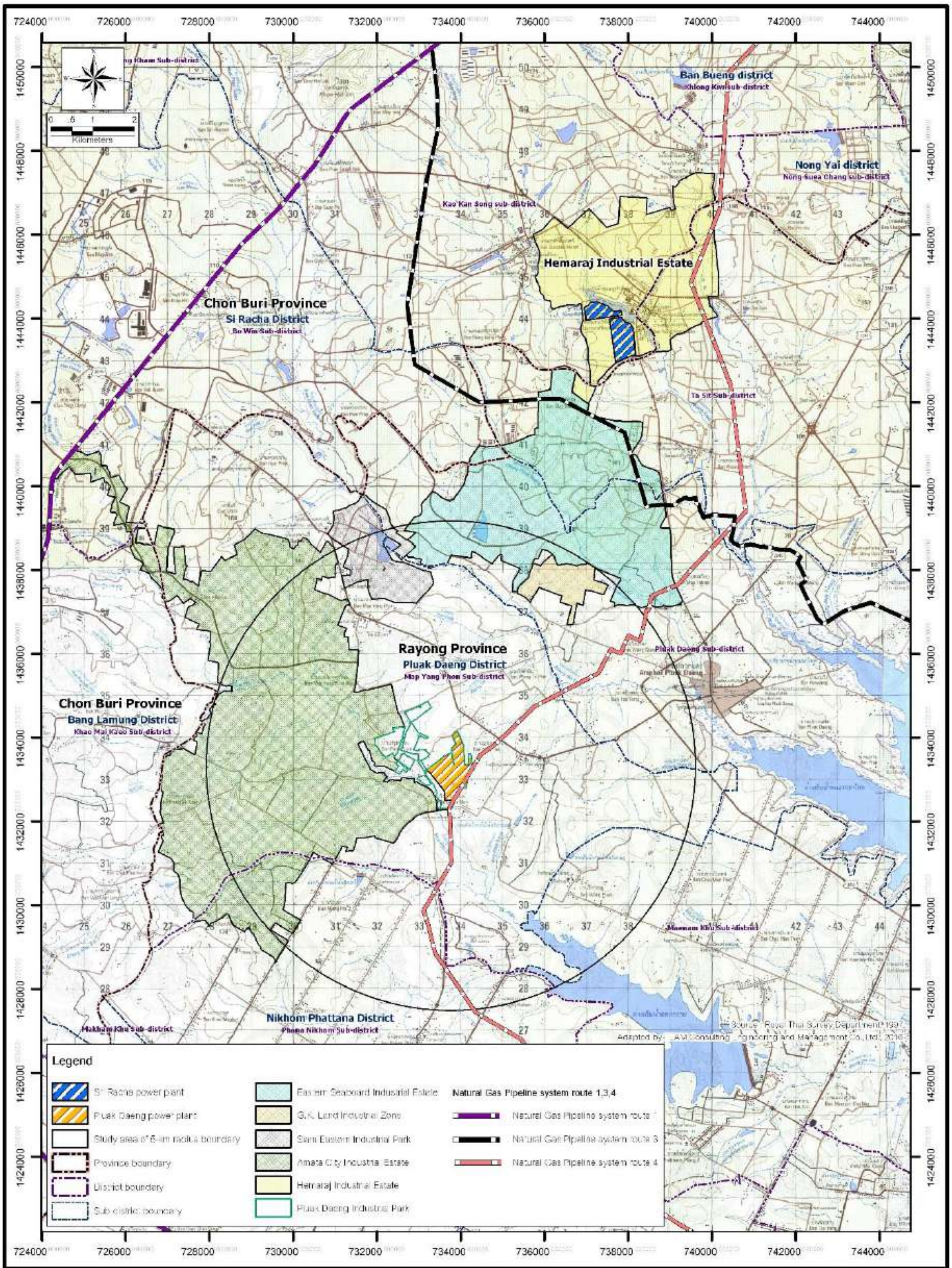

FIGURE 3.4-1 : NATURAL GAS PIPELINE NETWORK NEAR THE PROJECT AREA

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Fuel loading/unloading area will be paved with concrete and bunded so that stormwater runoff contaminated with fuel that may be spilled or leaked in the area will be collected to collector drains and then flow to an oil separator for further treatment.

3.4.2 Fuel Properties and Consumption Rate

(1) Natural Gas (Main Fuel)

(a) Fuel Properties

Natural gas is considered to be clean fuel in comparison to other fuels. The properties of natural gas to be used in Pluak Daeng Power Plant Project are similar to those of PTT's pipe natural gas in Thailand's east coast region, with details provided in **Table 3.4-1**.

Other impurities according to the PTT control standards under the natural gas purchase agreement are as follows:

- Condensate or liquid hydrocarbon shall not exceed 0.50 gallons per 1,000,000 cubic feet;
- Water vapour shall not exceed 7 pounds per 1,000,000 cubic feet; Oxygen shall not exceed 0.1% mole;
- Hydrogen sulphide (H_2S) shall not exceed 50 ppm;
- Mercury (Hg) shall not exceed 50 micrograms per cubic meter (μg/Nm^3), as detailed in **Table 3.4-1**.

(b) Fuel Consumption Rate

In case of power plant operation at full load, natural gas consumption is expected to peak at 412 million cubic feet/day at LHV dry value of about 46,600 kilojoules/kilogram. For all-year 100% load operation, natural gas requirement will be approximately 150,380 million cubic feet/year.

Diesel (Auxiliary Fuel)

(a) Fuel Properties

In the event of natural gas delivery disruptions, the project operation can still continue, using diesel fuel. The general properties of diesel to be used as the project's auxiliary fuel are presented in **Table 3.4-2.** The project's diesel reserve will be 26,000 m^3, stored in two 14,300-m^3 tanks.

TABLE 3.4-1
NATURAL GAS PROPERTIES FOR DESIGN OF PLUAK DAENG POWER PLANT PROJECT

Parameter	Component (% mole)		
	Minimum Value*	Normal Value*	Maximum Value*
Carbon Dioxide (CO_2)	4.41	1.43	0.00
Nitrogen (N_2)	2.03	1.66	0.64
Methane (C_1)	87.60	90.69	89.33
Ethane (C_2)	3.92	4.91	8.53
Propane (C_3)	1.36	0.88	1.00
Isobutane (iC_4)	0.31	0.19	0.20
Normal Butane (nC_4)	0.25	0.16	0.20
Isopentane (iC_5)	0.06	0.06	0.10
Normal Pentane (nC_5)	0.03	0.01	0.00
Hexane (C_6)	0.01	0.00	0.00
Heptane (C_7)	0.01	0.00	0.00
Octane (C_8)	0.00	0.00	0.00
Total	**100**	**100**	**100**
Parameter	**Quality Specifications**		
HHV (Sat) Btu/scf	996	1,024	1,079
Specific Gravity (SG)	0.6477	0.6136	0.6153
Wobbe Index – WI WI = HHV (Dry) / SQRT (SG)	1,260	1,330	1,400

Remarks : *Minimum value, normal value and maximum value mean minimum value/normal value/and maximum value of Wobbe Index

It is expected that natural gas will contain no more than 50 micrograms of mercury per cubic meter and no more than 50 ppm of H_2S.

Source : Gulf PD Co., Ltd., 2016

TABLE 3.4-2

GENERAL PROPERTIES OF DIESEL TO BE AUXILIARY FUEL FOR PLUAK DAENG POWER PLANT PROJECT

Parameter	Quality Value		Test Methods
	Minimum	Maximum	
Specific gravity at 15.6° C/15.6° C	0.81	0.87	ASTM D 1298
Cetane index	50	-	ASTM D 613
Viscosity (cSt) at 40°C	1.8	4.1	ASTM D 445
Pour point (°C)	-	10	ASTM D 97
Sulfur (by weight percentage)	-	0.005	ASTM D 2622
Copper strip corrosion	-	No.1	ASTM D 130
Oxidation stability (g/m^3)	-	25	ASTM D 2274
Carbon residue (by weight percentage)	-	0.30	ASTM D 4530
Water and sediment (percentage by volume)	-	-	ASTM D 2709
Water (mg/kg)		300	EN ISO 12937
Total contamination (mg/kg)		24	EN 12662
Ash (by weight percentage)	-	0.01	ASTM D 482
Flash point (° C)	52	-	ASTM D 93
Distillation temperature, 90% recovered (° C)	-	357	ASTM D 86
Polycyclic aromatic hydrocarbon (by weight percentage)		11	ASTM D 2425
Colour	-	4.0	ASTM D 1500
Lubricity, wear scar (micrometer)	-	460	CEC F-06-96

Source : Notification of Department of Energy Business Regarding Diesel Properties and Quality, B.E.2556 (2013) dated 8 November 2013

(b) Fuel Consumption Rate

In the event of power plant operation at full load, diesel consumption is expected to be 8,631 m^3/day. However, diesel fuel will be used for emergency cases only such as an order from EGAT to use diesel fuel for power generation as a result of natural gas supply disruptions. In case of diesel-fueled generation for 72 hours/year, diesel fuel consumption will be equivalent to 25,893 m^3.

3.4.3 Fuel Transportation within the Project Area

Pipeline transport will be used to deliver natural gas within the project area. Calculation sheets of thickness of the project's natural gas pipeline and oil pipeline are shown in **Appendix 3C**, with details described as follows:

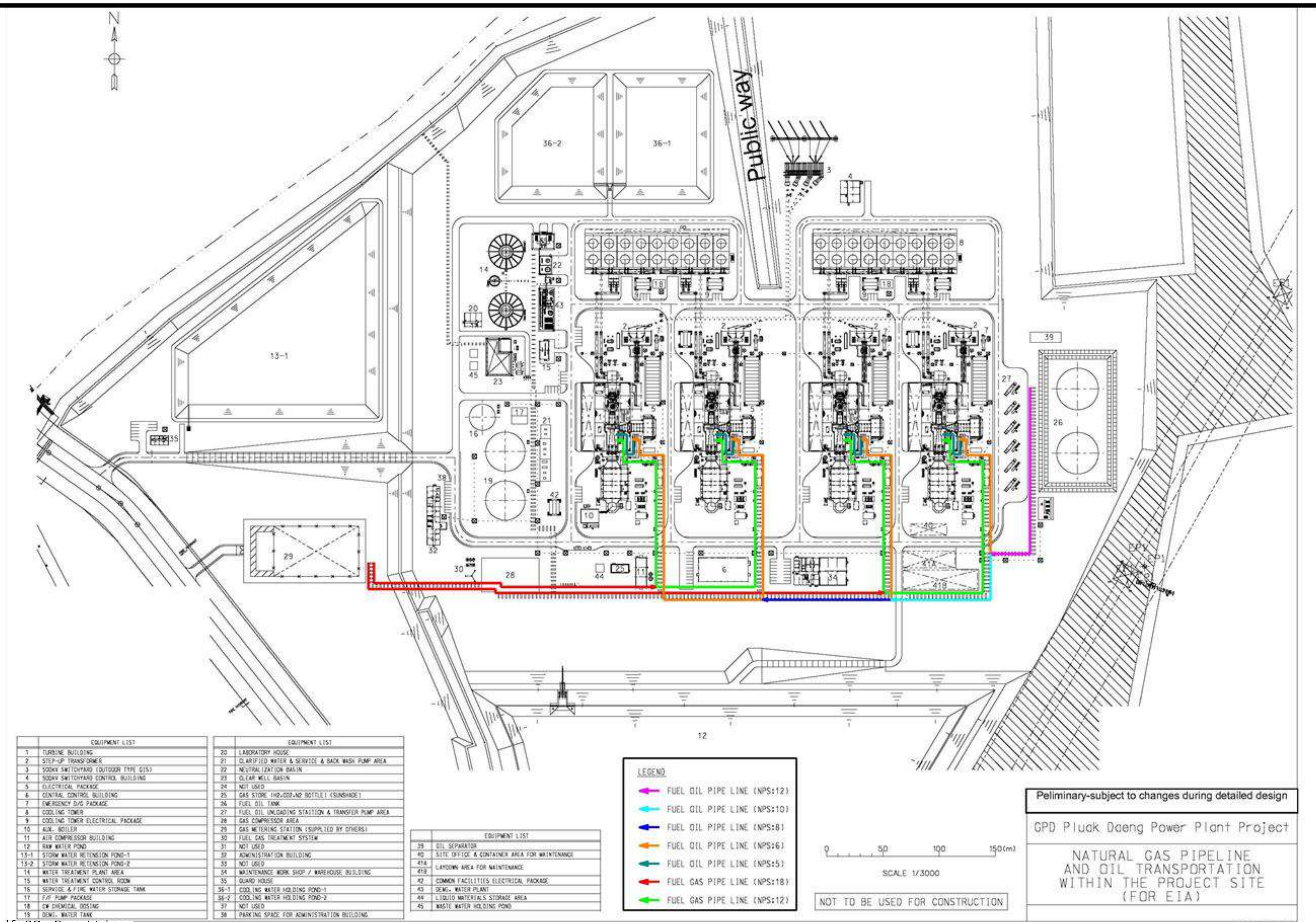
(1) Natural Gas Transmission Pipeline

The natural gas transmission pipeline alignment in the project area starts at the gas metering station as illustrated in **Figure 3.4-2**. The pipeline is made of steel in two sizes: 18 and 12 inches in diameter, with the following details.

- Two natural gas pipelines with 18 inches in diameter and 125 meters in length will be installed from the gas metering station to the gas compressor. They are designed to withstand maximum pressure up to 50 barg at a temperature of 50°C.
- Two natural gas pipelines with 18 inches in diameter will be installed from the gas compressor to the branch point at which the 18-inch pipelines will connect with the 12-inch pipelines. The 12-inch pipelines will further connect to gas turbines. The total length of 18-inch pipelines from gas compressor to branch point will be approximately 147 and 359 meters. They are designed to withstand maximum pressure up to 60 barg at a temperature of 150°C.
- Four natural gas pipelines with 12 inches in diameter will be installed from the branch points of 18-inch pipeline to the flow meter before connecting to each gas turbine (unit 1-4). Their length will be 165, 253, 163 and 428 meters, respectively. They are designed to withstand maximum pressure up to 60 barg at a temperature of 150°C.
- Four natural gas pipelines with 12 inches in diameter and 40 meters in length will be installed from the flow meters to the fuel gas heaters and then to each gas turbine. They are designed to withstand maximum pressure up to 60 barg at a temperature of 360°C.

Natural gas transmission pipeline system under the power plant operator's responsibility is gas transmission pipeline system from the gas metering station to the plant's generating units. Measures are set out for controlling and mitigating environmental impacts in the project area as follows:

- Regular pipeline leakage inspection at possible leak points, i.e. above ground connections in the gas metering station and gas compressor as specified in the project safety procedure;



Source : Gulf PD Co., Ltd.,

FIGURE 3.4-2 : NATURAL GAS AND OIL TRANSMISSION PIPELINE ALIGNMENT IN THE PROJECT SITE

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- Installation of marker posts for gas pipeline alignment and high-risk locations along the pipeline system

(2) Oil Transmission Pipeline

The oil transmission pipeline alignment in the project area, as illustrated in **Figure 3.4-2,** begins at the diesel storage tank to deliver diesel to generating units. Pipeline from the storage tank is 12 inches in diameter and the pipe size reduces to 10, 8, 6 and 5 inches to connect to the generating units, with the following details.

- Oil transmission pipeline with 12 inches in diameter and 104 meters in length will be installed from the diesel storage tank to the fuel oil transfer pump. They are designed to withstand maximum pressure up to 4 barg at a temperature of 50°C.
- Oil transmission pipeline with 12 inches in diameter and 78 meters in length will be installed from the fuel oil transfer pump to each gas turbine. They are designed to withstand maximum pressure up to 16 barg at a temperature of 50°C.
- Oil transmission pipeline with 10 inches in diameter and 140 meters in length will be connected to the 12-inch pipeline before splitting into 8-inch pipeline (114 meters long) and 6-inch pipeline (129, 175, 169 and 257 meters long) to connect to the main fuel oil pump in each generating unit. They are designed to withstand maximum pressure up to 16 barg at a temperature of 50°C.
- Four oil transmission pipelines with 5 inches in diameter and 45 meters in length will connect the main fuel oil pump to the gas turbine combustor in each generating unit. They are designed to withstand maximum pressure up to 120 barg at a temperature of 50°C. High pressure diesel injection into combustor is necessary so that fuel can atomize and thoroughly mix with air, resulting in complete combustion and avoiding localized hot spots. High temperature at hot spots will produce higher NO_x emission from combustion; consequently, high pressure injection is required so that diesel will vaporize in the combustor.

Pipelines will be placed on steel pipe rack structure for the installation of 18-inch and 12-inch natural gas pipelines, and oil pipelines of 12, 10, 8, 6 and 5 inches in diameter in the project area. Open cut excavation will be used to construct the pipe rack foundation. Steel plates will be assembled for erecting pipe racks, and each section will be welded. Environmental impact during pipe rack construction will be dust generated by open cut excavation which will be concurrently carried out with the construction of power plant foundation. After installation of gas and oil pipelines in the power plant area, hydrostatic test will be carried out to check pipeline leakage, pressurizing the pipe to a test pressure of 1.5 times the maximum operating pressure and monitoring it for 24 hours at the minimum. For the testing, 250 m^3 of water will be supplied by Pluak Daeng Industrial Park, with no chemical addition during the testing. After completion of testing, pH value, temperature, suspended solids, oil and grease will be checked according to the requirements of Pluak Daeng Industrial Park. Then the water will be discharged to the central wastewater treatment system of the Industrial Park. In this regard, Pluak Daeng Industrial Park has confirmed its capabilities to supply water to the project and that its central wastewater treatment system has sufficient treatment capabilities to receive water discharges (Certificate of capabilities for water supply and treatment of hydrostatic test water discharges is presented in **Appendix 3D**).

3.4.4 Diesel Fuel Transportation within the Project Area

For the general properties of diesel to be used as auxiliary fuel in case of natural gas delivery disruptions, maximum sulfur content of diesel fuel shall not exceed 0.005% wt which is the stipulated value in accordance with the Attachment to the Notification of the Department of Energy Business Regarding Diesel Properties and Quality, B.E.2556 (dated 8th November 2013), as detailed in **Table 3.4-2** and **Appendix 3E.** Diesel storage and transportation management procedure, transport equipment and tools, and transfer measures are described as follows:

(1) Diesel Storage and Transportation

Diesel will be transported by tank trucks to the project area. After trucks entry into the project area, the filling station will pump diesel from tank trucks into two storage tanks. Each tank has a capacity of 14,300 m^3 and will be filled to no more than 90% capacity, i.e. 13,000 m^3 per tank, in compliance with the Ministerial Regulation on Fuel Storage, B.E.2556 of the Ministry of Energy, published in the Government Gazette Vol. 130, Part 29a, Clause 33, dated 27th March B.E.2556 (2013). This storage volume will be sufficient for 3-day reserve of fuel supply. The diesel storage tanks will be surrounded by concrete dike with capacity equal to the 100% storage volume of the largest storage tank so as to contain diesel fuel oil in case of tank failure or leakage in accordance with the Ministerial Regulation on Fuel Storage, B.E.2556 (2013) of the Ministry of Energy, published in the Government Gazette Vol. 130, Part 29a, Clause 23 (4), dated 27th March B.E.2556 (2013). Fuel loading/unloading area will be paved with concrete and bunded so that stormwater runoff contaminated with fuel that may be spilled or leaked in the area will be collected to collector drains and then flow to an oil separator before being conveyed to central wastewater treatment system of Pluak Daeng Industrial Park. The following standards are applied to oil storage tanks and transfer facilities.

- Oil storage tank standard, i.e. API 650 Welded Tanks for Oil Storage
- Piping design standard, i.e. ASME B31.1 Power Piping Design Standard
- Classification of hazardous locations, i.e. API RP 500 Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities
- Fire protection system standards, i.e. NFPA 850, and NFPA 11

(2) Diesel Transfer from Oil Tank Trucks

The operating procedures and steps for transferring auxiliary diesel fuel to storage tanks are described herein.

- Upon being notified of oil delivery by the power plant's security officer, personnel shall take the following steps.
  - Inspect the petrol delivery documents of tank trucks;
  - Verify preliminarily the diesel type and properties by measuring water contamination using chemicals and record the measured values in the petrol delivery inspection form;
  - Estimate the diesel volume to be transferred and the tank will be filled to no more than 90% capacity after oil transfer;
  - Fire extinguishers will be readily available to handle an emergency case;
- Fuel level in the storage tanks will be recorded before and after the transfer;
- Safety cones will be placed around tank trucks;
- During the unloading, wheel chocks or wedges will be placed against the wheels and hand brakes will be set to prevent unintentional movement of trucks;
- Connect the ground line of trucks to that of the Company to dissipate electrostatic charges;
- Drip pans will be placed at pipe connections to collect oil in case of leaks;
- Start the pump to transfer the fuel from truck to storage tank;
- After completion of fuel transfer by contractor, drip pans will be placed to prevent any fuel leak to the ground while disconnecting the hose or at pipe connections. The collected fuel will be kept in a temporary storage tank for using in maintenance works.
- After completion of fuel transfer, personnel will recheck whether any fuel leakage occurs at pipes, pipe connections, and valves of storage tanks.
- In case of fire breakout during fuel transfer which cannot be put out, the fire emergency response plan must be complied with.

3.5 CHEMICALS

Chemical applications to the production process are to improve water quality for production process, scale inhibition and sedimentation control in water pipelines, as shown in **Table 3.5-1**.

TABLE 3.5-1

TYPE AND QUANTITY OF CHEMICALS FOR USE IN THE PROJECT

Chemical Substance	Applied Quantity (m^3/year)[2/]	Material and Size of Storage Tank	No. of Tanks	Application/Transfer in the Project Area	Chemical Storage Area/ Leakage Prevention [1/]	Chemicals Sources and Transport Methods
Raw Water Pre-treatment						
$NaClO_2$ 25%	20	PE chemical storage tank, with capacity of 40 m^3	1	Precursor for producing chlorine dioxide to control water quality/ closed pipeline system	Raw water treatment building/concrete dike around the tank	Domestic procurement and transport by chemical (liquid) tank container to the project area
HCl 35%	20	FRP chemical storage tank, with capacity of 40 m^3	1	Precursor for producing chlorine dioxide to control water quality/ closed pipeline system	Raw water treatment building/concrete dike around the tank	Domestic procurement and transport by chemical (liquid) tank container to the project area
Ferric Chloride 40%	1,120	FRP chemical storage tank, with capacity of 120 m^3	1	Sedimentation in raw water treatment system/closed pipeline system	Raw water treatment building/concrete dike around the tank	Domestic procurement and transport by chemical (liquid) tank container to the project area
Polymer	40	Chemical bags and FRP tank for solvent mixture, with capacity of 16 m^3	1	Sedimentation in raw water treatment system/closed pipeline system	Raw water treatment building/concrete dike around the tank	Domestic procurement and transport by using 25-kg chemical bags to the project area
Sodium Hydroxide (NaOH, 50%)	245	FRP chemical storage tank, with capacity of 30 m^3	1	pH Adjustment in raw water treatment system for mixed bed regeneration and in neutralization pit of demineralization system/ closed pipeline system	Raw water treatment building/concrete dike around the tank	Domestic procurement and transport by chemical (liquid) tank container to the project area

TABLE 3.5-1

TYPE AND QUANTITY OF CHEMICALS FOR USE IN THE PROJECT (CONT'D)

Chemical Substance	Applied Quantity (m^3/year)[2/]	Material and Size of Storage Tank	No. of Tanks	Application/Transfer in the Project Area	Chemical Storage Area/ Leakage Prevention [1/]	Chemicals Sources and Transport Methods
Sodium Bisulfite 1% ($Na_2S_2O_5 + H_2O \longrightarrow NaHSO_3$) (SMBS) (SBS)	15	PE chemical storage tank, with capacity of 1 m^3	1	Prevention of RO membrane damage due to free chlorine/ closed pipeline system	Demineralization building/ concrete dike around the tank	Domestic procurement and transport by using 25-kg chemical bags to the project area
Demineralization including Neutralization System						
RO Antiscalant (100%)	5	PE chemical storage tank, with capacity of 0.1 m^3	1	Prevention of scaling of RO membrane/closed pipeline system	Demineralization building/ concrete dike around the tank	Domestic procurement and transport by using 25-litre chemical tank to the project area
Sulfuric Acid (H_2SO_4, 98%)	10	Carbon steel chemical storage tank, with capacity of 3 m^3	1	Mixed bed regeneration and adjustment of pH value in neutralization pit of demineralization system /closed pipeline system	Demineralization building/ concrete dike around the tank	Domestic procurement and transport by chemical (liquid) tank container to the project area
Citric Acid ($C_6H_8O_7$, 15%)	10	PE chemical storage tank, with capacity of 2 m^3	1	Cleaning of RO membrane/closed pipeline system	Demineralization building/ concrete dike around the tank	Domestic procurement and transport by using 25-kg chemical bags to the project area
Steam Circulation System						
Oxygen Scavenger (Elimin - OX) [3/]	15	Stainless steel chemical storage	4	Control of boiler water quality/ closed pipeline system	Chemical storage building/ drip tray	Domestic procurement and transport by using 25-litre chemical tanks to the project area

TABLE 3.5-1

TYPE AND QUANTITY OF CHEMICALS FOR USE IN THE PROJECT (CONT'D)

Chemical Substance	Applied Quantity (m^3/year)[2/]	Material and Size of Storage Tank	No. of Tanks	Application/Transfer in the Project Area	Chemical Storage Area/ Leakage Prevention [1/]	Chemicals Sources and Transport Methods
		tank, with capacity of 1,000 litres				
Aqueous Ammonia (NH_3-25%)	45	Stainless steel chemical storage tank, with capacity of 1,000 litres	4	Control of boiler water quality/ closed pipeline system	Chemical storage building/ drip tray	Domestic procurement and transport by using 25-litre chemical tanks to the project area
Trisodium Phosphate ($Na_3PO_4.12H_2O$)	30	Stainless steel chemical storage tank, with capacity of 500 litres	4	Control of boiler water quality/ closed pipeline system	Chemical storage building/ drip tray	Domestic procurement and transport by using 25-kg chemical bags to the project area
Cooling Water System						
Scale and Corrosion Inhibitor[4/]	120	PE chemical storage tank, with capacity of 2 m^3	2	Prevention of scaling of cooling water system/closed pipeline system	Chemical storage building/ concrete fence around the tank	Domestic procurement and transport by using 1-m^3 chemical tank to the project area
$NaClO_2$ 25%	20	PE chemical storage tank, with capacity of 40 m^3	2	Precursor for producing chlorine dioxide to control water quality/ closed pipeline system	Raw water treatment building/concrete dike around the tank	Domestic procurement and transport by chemical (liquid) tank container to the project area
HCl 35%	20	FRP chemical storage tank, with capacity of 40 m^3	2	Precursor for producing chlorine dioxide to control water quality/ closed pipeline system	Raw water treatment building/concrete dike around the tank	Domestic procurement and transport by chemical (liquid) tank container to the project area

Remarks :

1. Chemical substances used in the project will be stored in a chemical storage building surrounded by concrete dike which has capacity equal to volume of the largest chemical storage tank in case of chemical leakage. The chemical storage is in accordance with the Notification of the Department of Industrial Works Regarding Guideline on Chemicals and Hazard Substance Storage, B.E.2550 (2007)
2. The amount of chemicals may be changed depending on the raw water quality from Eastern Water Resources Development and Management Plc.
3. Oxygen Scavenger to be used in the project is non-hazardous or of low hazard level (unlimited volume) and not carcinogenic according to the Agents Classified by IARC Monographs, Volumes 1-106 of the International Agency for Research on Cancer (IARC)
4. Scale and Corrosion Inhibitor is a compound of polyphosphate, phosphate, zinc salt, organic polymer, copper corrosion inhibitor and its chemical composition may change according to the trade formula of each manufacturer

Source : Gulf PD Co., Ltd, 2016

Of all the chemicals used in the project, 13 are neither toxic substances nor biocides. Nine chemical substances have identifiable chemical compositions according to the Chemical Reference Database Project from the Material Safety Data Sheet (MSDS) of the Chemtrack program of the Center of Excellency for Environmental and Hazardous Waste Management of Chulalongkorn University, as presented in **Appendix 3F-1**. There are four chemical substances under trade names and their chemical compositions cannot be clearly identified, i.e. polymer, RO antiscalant, oxygen scavenger, and scale and corrosion inhibitor. In this project, manufacturers' MSDS is used for reference of compounds and toxicity of these chemicals, with the following details.

(1) Polymer is applied to raw water treatment. The manufacturer's MSDS does not provide chemical compositions and states that it is non-toxic, with details given in **Appendix 3F-2**.

(2) RO antiscalant inhibits scaling on RO and membrane. Its compositions include polyphosphate salt and polymer, as detailed in **Appendix 3F -3**.

(3) Oxygen Scavenger (Elimin – OX) is used to control water quality of boiler system, composed of 5-10% Carbohydrazide (w/w). Its quantity in this product is non-hazardous or of low hazard level (unlimited volume) and is not carcinogenic according to the Agents Classified by IARC Monographs, Volumes 1-106 of the International Agency for Research on Cancer (IARC), with details provided in **Appendix 3F-4.**

(4) Scale and Corrosion Inhibitor prevents scale formation in cooling system. It is composed of polyphosphate, phosphates, zinc salt, organic polymer, and copper corrosion inhibitor, as presented in **Appendix 3F-5.**

Sources, dosages, storage volumes, and usage of each chemical substance are detailed in **Table 3.5-1**. According to the Material Safety Data Sheet (MSDS), some chemicals used in the project are governed by relevant acts, as shown in **Table 3.5-2**.

3.6 TECHNICAL DATA OF THE POWER PLANT

3.6.1 Power Plant Design

The project climate and site conditions used in the design of Pluak Daeng Power Plant are as follows:

- Dry bulb temperature (average) 32.5 °C
  (the project is designed to cover the temperature range from 13.0 to 39.9 degree Celsius. The design point already considered the mean maximum temperature of 32.5 degree Celsius, which is above the mean temperature of 28.8 degree Celsius)

TABLE 3.5-2
COMPARISON OF CHEMICAL APPLICATION ACCORDING TO RELEVANT ACTS AND TOXICITY (LD_{50})

Chemical Name	Status	Hazardous Substance Act B.E.2535 (1992) (Category)	Military Hardware Act B.E.2530 (1987)	Labour Protection Act B.E.2541 (1998)	Toxicity (LD_{50})
Sodium Chlorite 25%	Liquid	-	-	-	Acute oral toxicity (LD_{50}) = 165mg/kg [Rat]
HCI 35%	Liquid	3	-	✓	Acute oral toxicity (LD_{50}) = 900mg/kg [Rabbit]
Ferric Chloride 40%	Liquid	-	-	-	Oral toxicity (LD_{50}) = 316mg/kg [Rat]
Polymer	Solid	-	-	-	Acute oral toxicity (LD_{50}) = 3,500mg/kg [Mouse]
Sulfuric Acid	Liquid	3	-	✓	Oral toxicity (LD_{50}) = 2,140mg/kg [Rat]
Sodium Metabisulfite	Solid	-	-	-	Acute oral toxicity (LD_{50}) = 1,131mg/kg [Rat]
RO Antiscalant (100%)	Liquid	No data	No data	No data	LD_{50} = 7,400mg/kg [Rat]
Oxygen scavenger	Liquid	-	-	-	Acute oral toxicity (LD_{50}) = 5g/kg [Rat]
Aqueous Ammonia (25%)	Liquid	-	-	-	Oral toxicity (LD_{50}) = 350mg/kg [Rat]
Trisodium Phosphate	Solid	No data	No data	No data	-*
Scale and corrosion inhibitor (Organic Phosphate Acid)	Liquid	3	-	✓	-*
Sodium Hydroxide 50%	Liquid	1	-	✓	-*
Citric Acid	Solid	No data	No data	No data	Acute oral toxicity (LD_{50}) = 3,000mg/kg [Rat]

Remarks: - Not specified as hazardous substances in Hazardous Substance Act B.E.2535 (1992), Military Hardware Act B.E.2530 (1987) and Labour Protection Act B.E.2541 (1998)

Category 1 Hazardous Substance: The production, importation, exportation or possession of which shall be in accordance with the prescribed criteria and procedure.

Category 2 Hazardous Substance: The production, importation, exportation or possession of which requires an advance notification to be made to the competent official, and shall be in accordance with prescribed criteria and procedure.

Category 3 Hazardous Substance: The production, importation or exportation or possession of which requires licensing.

Category 4 Hazardous Substance: The production, importation or exportation or possession of which is prohibited.

-* No study data on experimental animals and impacts on humans from MSDS

- Relative humidity 76%
- Atmospheric pressure 1,000.9 millibars
- Elevation of the project area (above sea level) 78 meters

3.6.2 Generation Machinery and Equipment

The project's major machinery and equipment consist of gas turbines, generators, steam generators, steam turbines, condensers, and cooling tower. Technical data of each type of machinery and equipment are provided as follows:

(1) Combustion Turbines (CTs)

Four sets of dual fuel combustion turbine (CTs) will be installed, using either natural gas or diesel fuel. The power plant will be normally operated by using natural gas as its main fuel, with diesel as auxiliary fuel. Gas turbines will be driven by thermal energy produced by natural gas combustion. The project's gas turbines use Dry Low NO_x Combustor System (DLN) to control nitrogen oxides (NO_x) when natural gas is used as fuel. Water injection system will be used for reduction of NO_x emissions during diesel-powered generation.

(2) Generators

The project has 4 sets of generators, each powered by gas turbine and steam turbine to convert the thermal energy into mechanical energy by electromagnetic induction principle.

(3) Heat Recovery Steam Generators (HRSGs)

Four sets of Heat Recovery Steam Generators (HRSGs) (one set for one gas turbine) will utilize thermal energy in the exhaust gas from gas turbine to generate steam. The steam will then drive the steam turbine which will in turn drive the generator (one HRSG set for one steam turbine). HRSG consists of 3 components, i.e. economizer for preheating feed water for steam production, evaporator for steam generation, and superheater for increasing steam temperatures and enthalpy. Each HRSG will be equipped with a blowdown tank for receiving blowdown water discharged to reduce the dissolved solid concentration in boiler water as well as chemical feed system to control boiler feed water quality.

In addition, safety valves will be installed in evaporator, superheater and re-heater to prevent the working pressure from exceeding maximum allowable working pressure. From the preliminary design, HRSG steam outlet pressure and temperature are estimated as follows:

- For high pressure steam from superheater, pressure will be at 164 bar (a), and temperature at 602 ^{o}C;

- For intermediate pressure steam from re-heater, pressure will be at 34.6 bar (a), and temperature at 600 °C;
- For low pressure steam from superheater, pressure will be at 4.8 bar (a), and temperature at 300 °C;

Hot gases from each gas turbine fed into HRSG will be discharged through 60-m high stack. The stack height will help reduce air pollution in nearby areas. Moreover, continuous emission monitoring system (CEMs) will be installed to continuously measure and control pollutant concentrations emitted from the stack into the atmosphere.

(4) Steam Turbines (STs)

The project's power plant will be equipped with four units of steam turbines (STs), operating at three different pressure levels to drive steam turbines.

High pressure (HP) steam from HRSG HP superheater will be fed to drive HP steam turbine. The HP turbine exhaust steam will mix with intermediate pressure (IP) steam from HRSG IP superheater before returning to be reheated in HRSG re-heater. The reheated steam will be routed to the IP steam turbine to drive the turbine. The IP turbine exhaust steam will mix with low pressure (LP) steam from HRSG LP superheater before entering into LP steam turbine. The LP turbine exhaust steam will flow to the condenser.

(5) Condenser

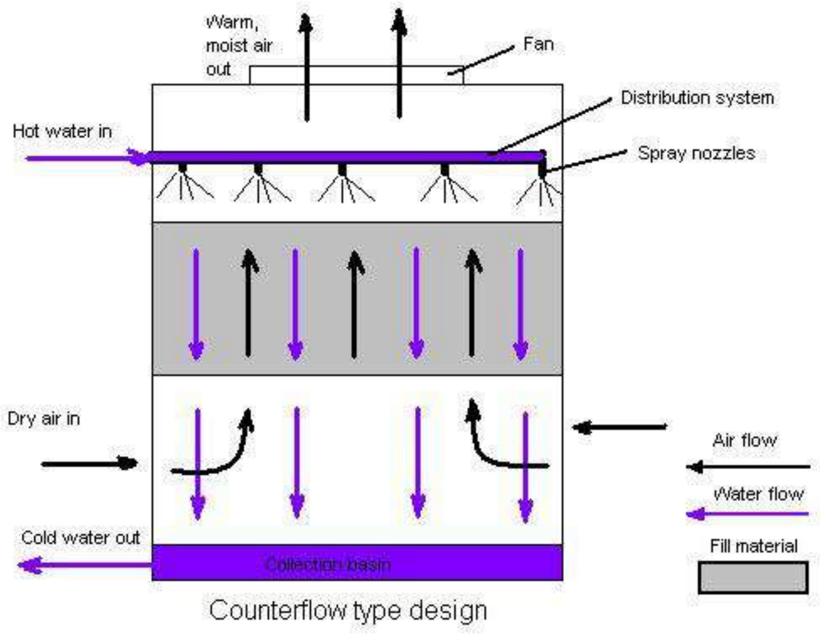
The project will have four condensers. After exiting the steam turbine, exhaust steam will be routed to the condenser-a heat exchanger between turbine exhaust steam and cooling water. The steam is converted into condensate and then reused in HRSGs. The design working pressure of condenser is 0.098 bar (a). The cooling water temperature after passing through the condenser will rise by about 9 °C.

(6) Cooling Water System

There are 4 units of cooling water system to reduce the temperature of cooling water. Hot water from the condenser is conveyed to the cooling tower to reduce the temperature. After that, cooled water is collected and stored in the cooling tower basin before being recirculated and reused in the condensation process. Blowdown water is discharged to the cooling water holding pond in order to maintain suitable water quality in the system.

Cooling tower reduces the water temperature, with the air stream flowing in the opposite direction of the water flow, resulting in evaporation of some portion of water into the atmosphere and cooling of hot water, as depicted in **Figure 3.6-1**. Preliminary design data of the cooling system are summarized in **Table 3.6-1**.

A summary of major machinery and equipment is shown in **Table 3.6-2.**



(**Source :** http://thai-draftman.blogspot.com/2010/10/cooling-tower.html)

FIGURE 3.6-1 : COOLING TOWER OPERATIONAL PRINCIPLE

TABLE 3.6-1

SUMMARY OF PRELIMINARY DESIGN DATA OF COOLING SYSTEM

Type of Cooling Tower	Counter Flow Wet Type Cooling Tower	
Circulating Water Quantity	m^3/h	37,000
Water inlet temperature (in cooling system)	degC	42.7
Water outlet temperature (from cooling system)	degC	33.7
Cooling Range	degC	9.0
Ambient wet bulb temperature	degC	28.8
Ambient dry bulb temperature	degC	32.5
Atmospheric pressure	Mbar	1,000.9
Ambient relative humidity	%	76
Evaporation volume	m^3/day	49,072 (@ 100% plant load)
Makeup water volume	m^3/day	61,304 (@ 100% plant load)
Blowdown water volume	m^3/day	12,232 (@ 100% plant load)

Remarks: 1) The above data were derived from the preliminary design of the system. In the detailed design, investigation and design must be carried out to ensure efficient operation.

2) Makeup water volume is composed of 60,560 m^3/day of water from water treatment system and 744 m^3/day of reused water from various systems.

TABLE 3.6-2
LIST OF MAJOR MACHINERY AND EQUIPMENT OF PLUAK DAENG POWER PLANT

Machinery	No. (Units)	Function	Capacity/Unit
Gas Turbine	4	Combust fuel gas burn fuel to spin turbine blades to drive electricity generator.	482 MW
Heat Recovery Steam Generator	4	Generate steam using hot exhaust gas from a gas turbine.	- High pressure steam from superheater with a pressure at 164 bar (a) and temperature at 602 ºC - Intermediate pressure steam from re-heater with a pressure at 34.6 bar (a) and temperature at 600 ºC - Low pressure steam from superheater with a pressure at 4.8 bar (a) and temperature at 300 ºC
Steam Turbine	4	Steam turbine receives steam from HRSG to spin turbine blades which will then drive a generator.	248 MW
Generator	4	Generator is driven by gas turbine and steam turbine to convert mechanical energy into electricity.	730 MW
Condenser	4	Heat exchanger. Cooling water will transfer heat from hot exhaust steam from steam turbine to be converted into condensate.	Condenser operates at a pressure of about 0.098 bar (a).
Cooling Tower	4	Reduce cooling water temperature	

Source : Gulf PD Co., Ltd, 2016

3.7 GENERATION PROCESS AND CAPACITY

3.7.1 Generation Process

Pluak Daeng Power Plant Project consists of 4 generator units, and major machines of each unit comprise 1 gas turbine, 1 steam turbine, 1 generator, and 1 heat recovery steam generator. With single shaft combined cycle configuration, the gas turbine and steam turbine jointly drive the same generator. The generation process is illustrated in **Figures 3.7-1 to Figure 3.7-6**, with the following details.

In case of natural gas-fired operation (**Figures 3.7-1 to Figure 3.7-3**), the generation process is described as follows:

(1) Natural gas from PTT natural gas transmission line will be conveyed to the fuel gas heater for heat exchange with hot water from the IP economizer of heat recovery steam generator (HRSG). The heated natural gas will be fed into the combustion chamber of gas turbine. Hot water from the fuel gas heater will be delivered to the LP economizer of heat recovery steam generator (HRSG) for steam production.

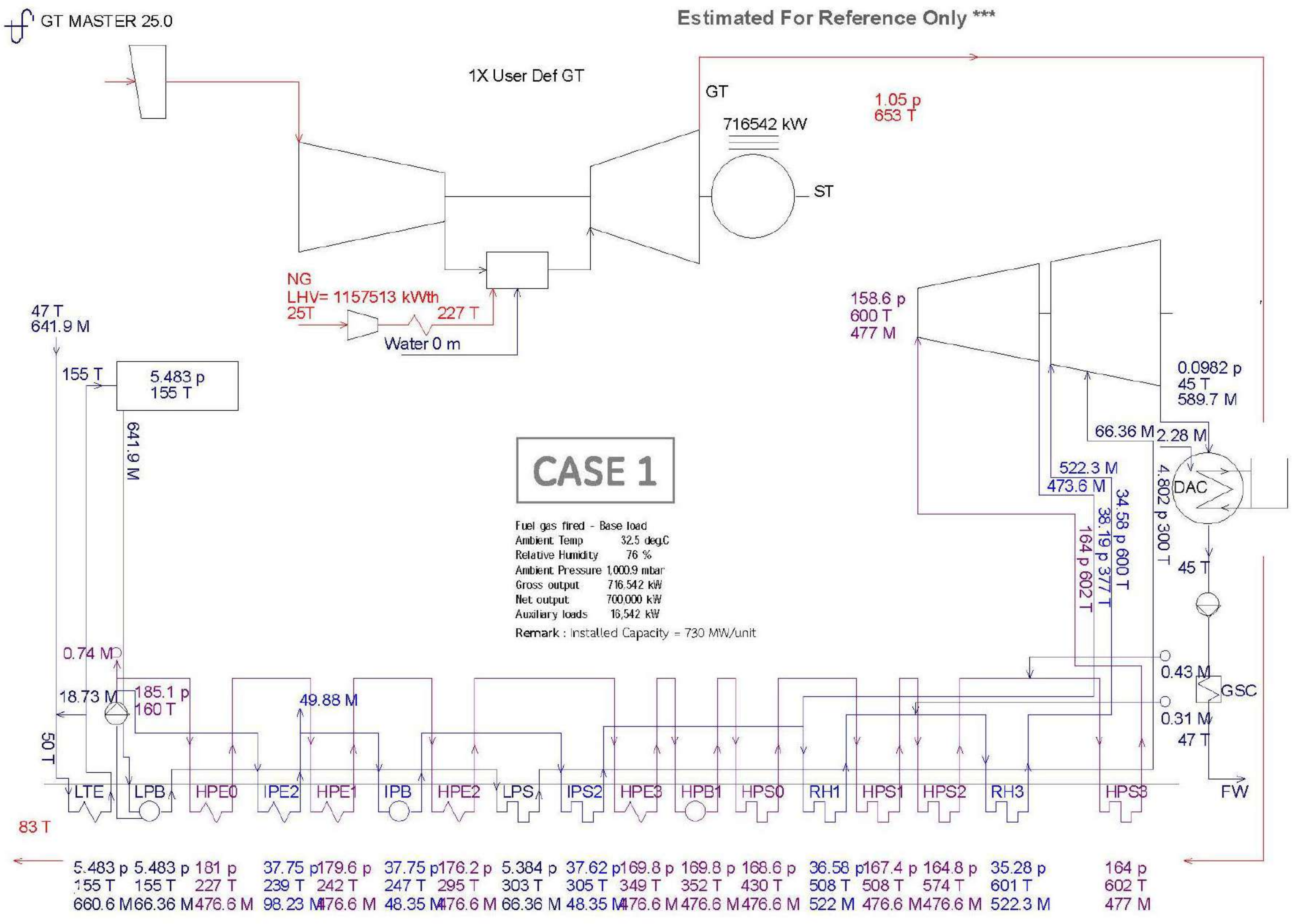
Increase of natural gas temperature using hot water from HRSG will improve the overall efficiency of combined cycle power plant.

(2) Natural gas entering the gas turbine will be combusted by dry low NO_x burner system of the steam turbine. Thermal energy from natural gas combustion will be directed to drive the steam turbine which will in turn drive the generator for electricity generation.

(3) Hot exhaust gas which still retains heat will be conveyed to the heat recovery steam generator (HRSG) for steam production.

(4) Steam from the HRSG will be directed to drive the steam turbine which will then drive the generator for power generation.

(5) After exiting the steam turbine, steam will be condensed for recirculation and reuse in the steam production process. The steam will enter the condenser for heat exchange with cooling water from the cooling tower and then be condensed and liquefied. The high temperature cooling water will be sent to the cooling tower to reduce the temperature.



p[bar], T[C], M[t/h]

FIGURE 3.7-1 : ELECTRICITY GENERATION AND HEAT BALANCE DIAGRAM OF PLUAK DAENG POWER PLANT IN CASE OF NATURAL GAS-FIRED OPERATION AT FULL LOAD (717 MW GROSS)

lotes:
.ll performance values indicated on this diagram are estimated.
'erformance values are based on new and clean condition.
'reliminary - not to be used for construction

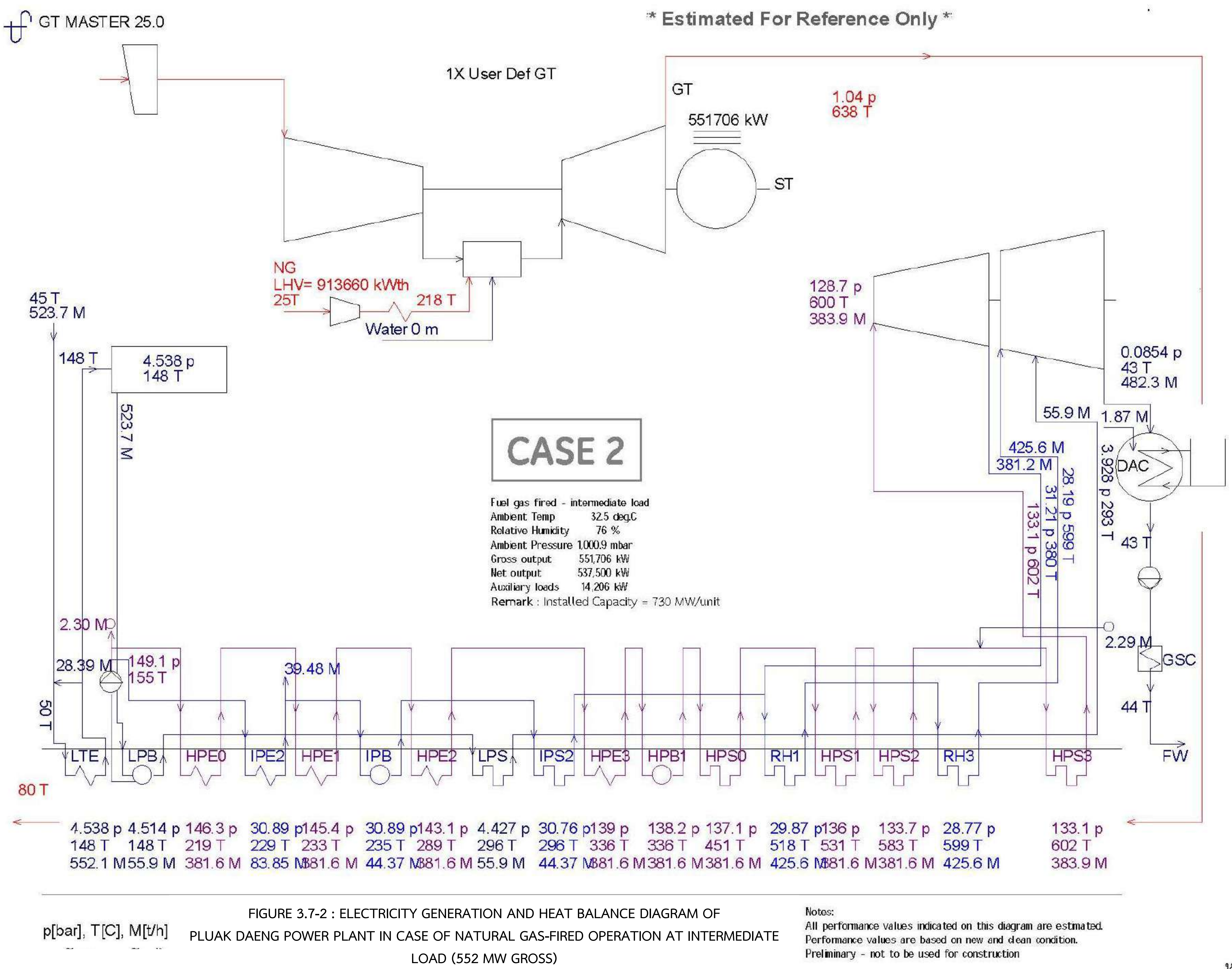


FIGURE 3.7-2 : ELECTRICITY GENERATION AND HEAT BALANCE DIAGRAM OF PLUAK DAENG POWER PLANT IN CASE OF NATURAL GAS-FIRED OPERATION AT INTERMEDIATE LOAD (552 MW GROSS)

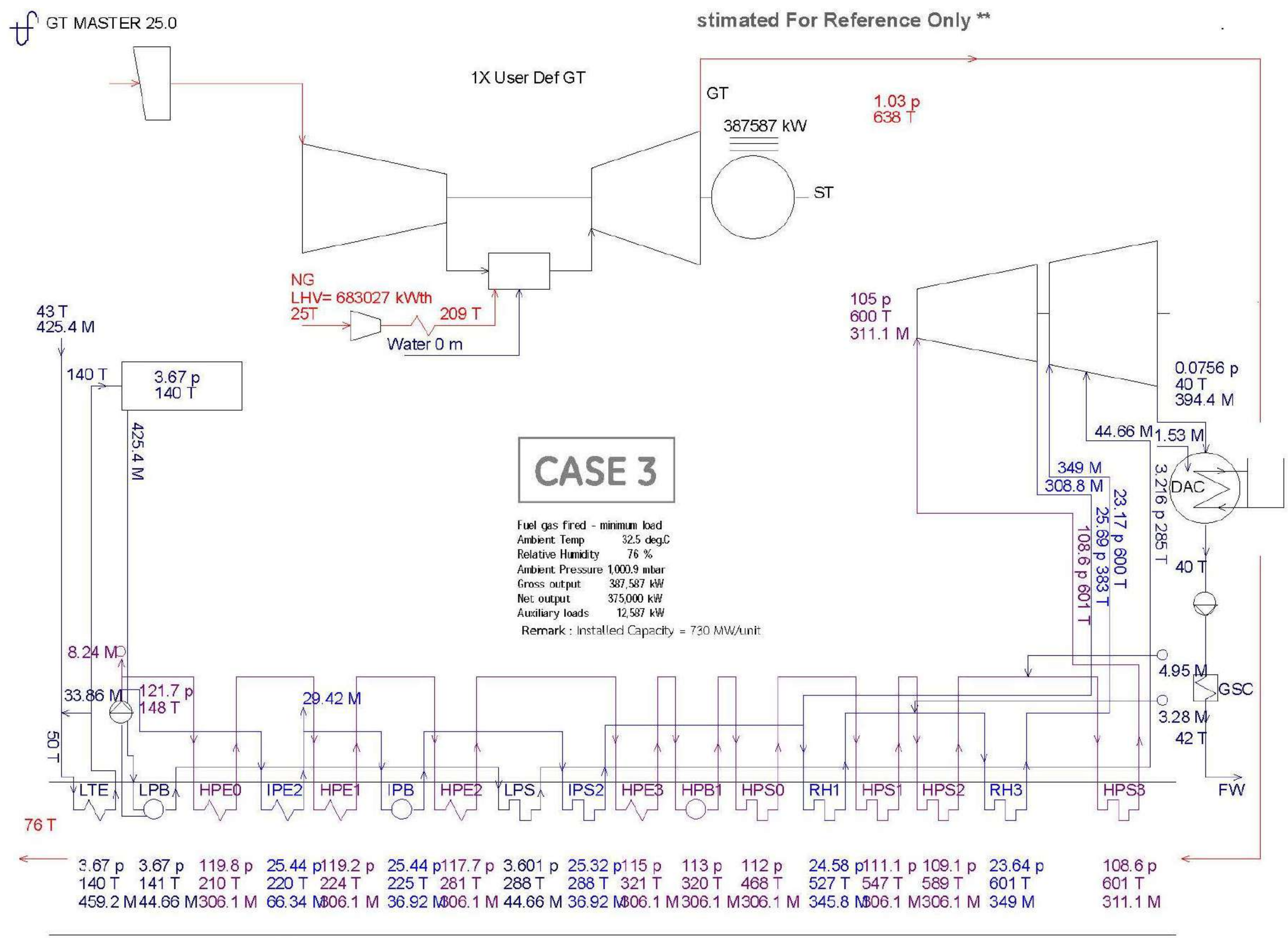


FIGURE 3.7-3 : ELECTRICITY GENERATION AND HEAT BALANCE DIAGRAM OF
PLUAK DAENG POWER PLANT IN CASE OF NATURAL GAS-FIRED OPERATION AT MINIMUM LOAD
(388 MW GROSS)

Notes:
All performance values indicated on this diagram are estimated.
Performance values are based on new and clean condition.
Preliminary - not to be used for construction

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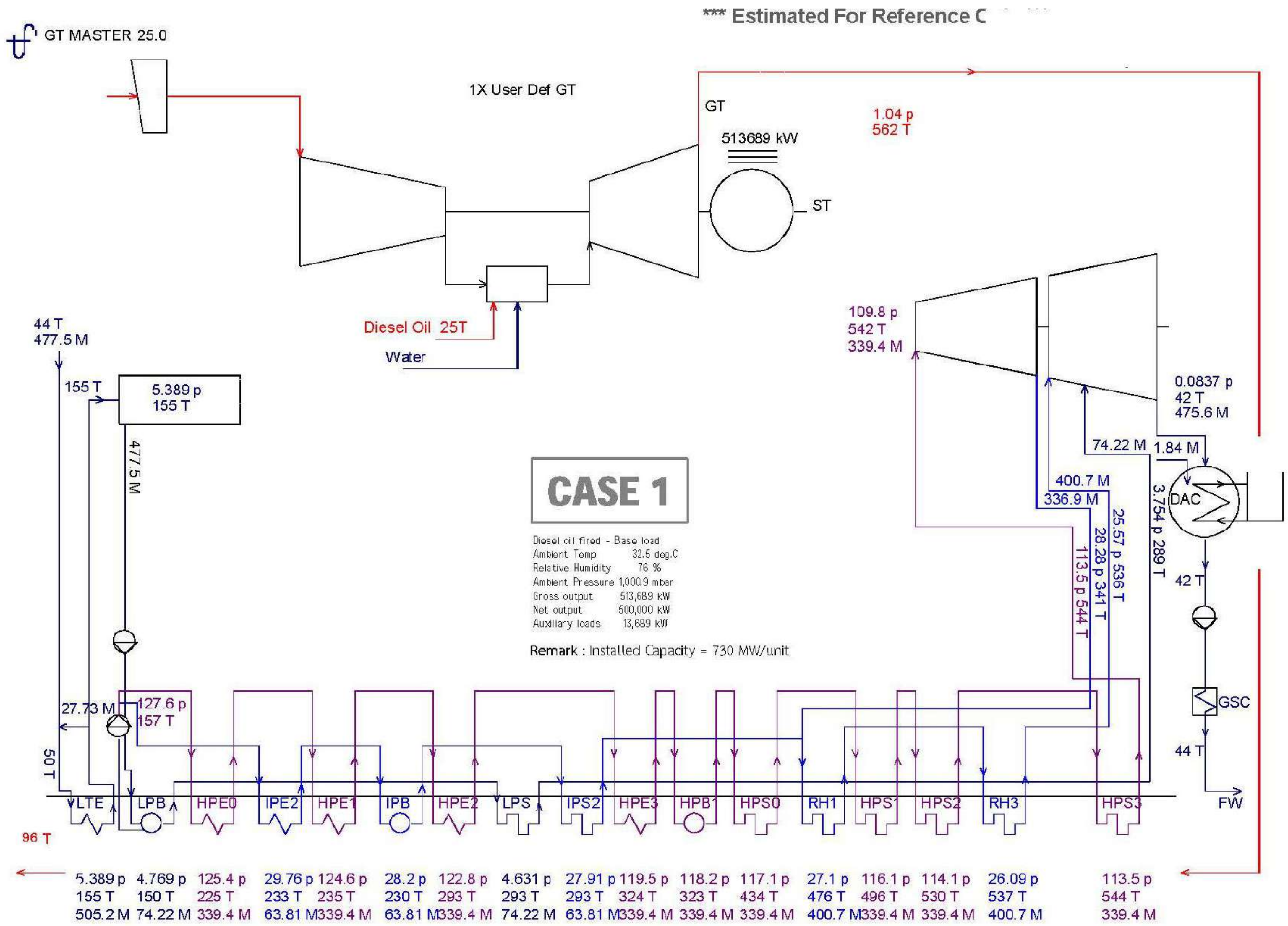


p[bar], T[C], M[t/h]

FIGURE 3.7-4 : ELECTRICITY GENERATION AND HEAT BALANCE DIAGRAM OF PLUAK DAENG POWER PLANT IN CASE OF DIESEL-FUELLED OPERATION AT FULL LOAD (514 MW GROSS)

Notes:
All performance values indicated on this diagram are estimated.
Performance values are based on new and clean condition.
Preliminary - not to be used for construction

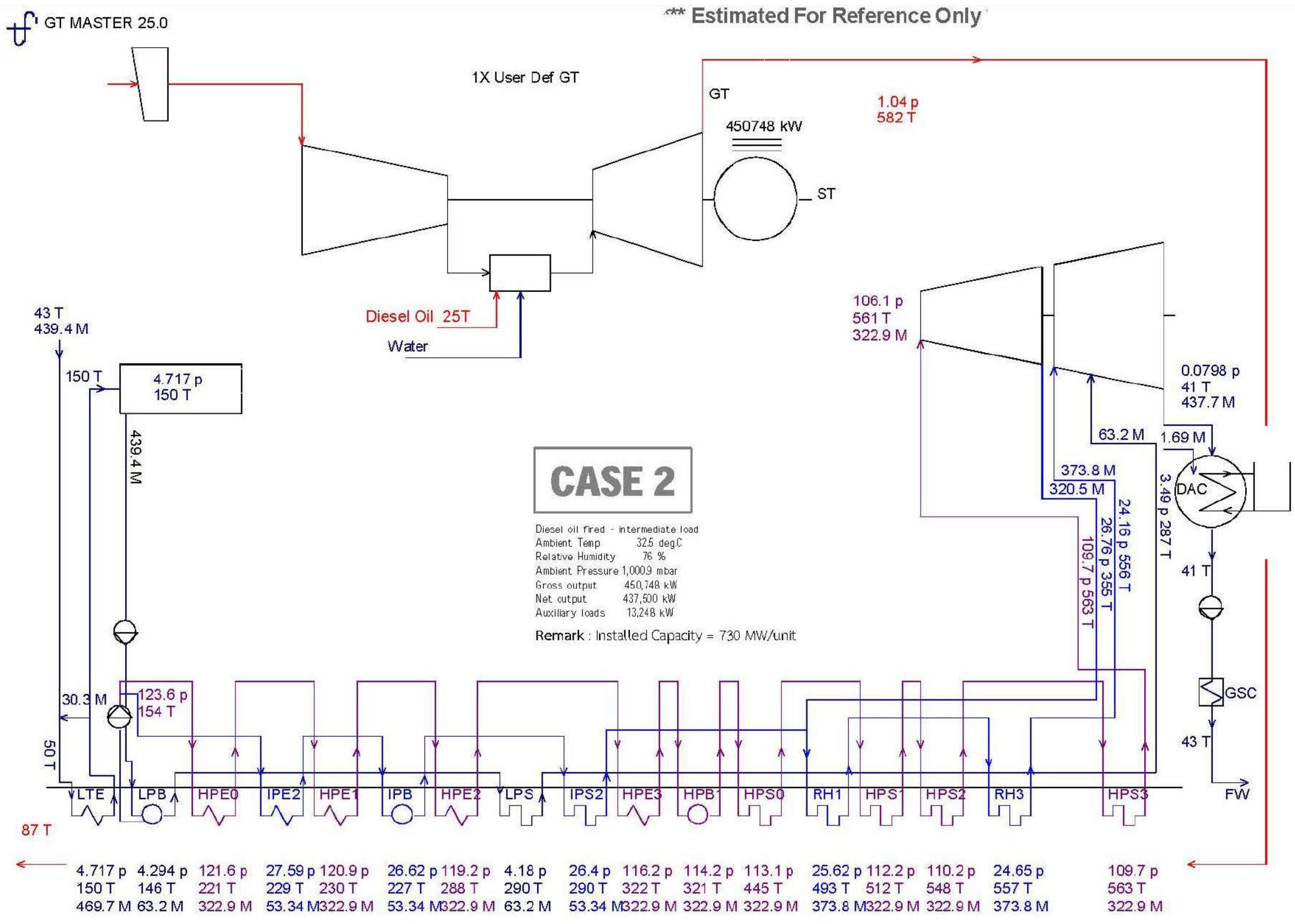


FIGURE 3.7-5 : ELECTRICITY GENERATION AND HEAT BALANCE DIAGRAM OF PLUAK DAENG POWER PLANT IN CASE OF DIESEL-FUELLED OPERATION AT INTERMEDIATE LOAD (451 MW GROSS)

Notes:
All performance values indicated on this diagram are estimated.
Performance values are based on new and clean condition.
Preliminary - not to be used for construction

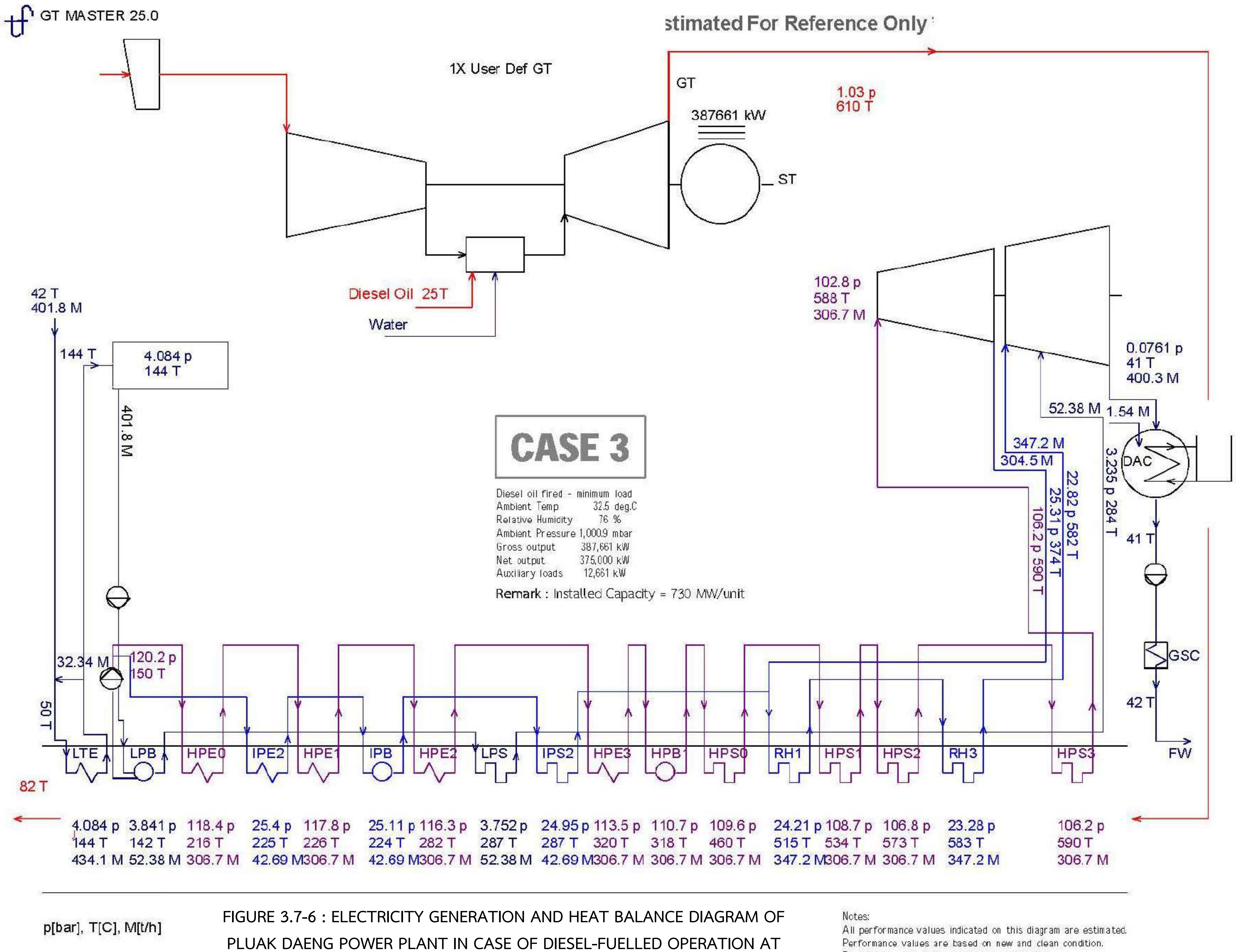


FIGURE 3.7-6 : ELECTRICITY GENERATION AND HEAT BALANCE DIAGRAM OF PLUAK DAENG POWER PLANT IN CASE OF DIESEL-FUELLED OPERATION AT MINIMUM LOAD (388 MW GROSS)

(6) The temperature of cooling water discharge will be about 9 °C higher than the inlet water temperature or at about 43 °C. The cooling water will be cooled by passing through the cooling tower where cooling tower fan will transfer heat while water is falling in the cooling tower, reducing the water temperature to about 34 °C. After that, cooled water will be collected and stored in the cooling tower basin for recirculation and reuse. Blowdown water will be discharged to two 19,000- m^3 cooling tower basins of the power plant which can hold water for at least 1 day so as to maintain the water quality of the system before discharging into the cooling tower holding pond of Pluak Daeng Industrial Park. The temperature of water discharge shall meet the effluent standard prescribed by Pluak Daeng Industrial Park.

(7) Oxides of nitrogen (NO_x) in the fuel gas stream will be controlled to be within the specified limit by Dry Low NO_x (DLN) system before the fuel gas is released to atmosphere through the HRSG stack.

In case of diesel-fuelled operation (**Figures 3.7-4 to Figure 3.7-6**), the generation process is explained as follows:

(1) Diesel oil will be pumped by fuel oil transfer pump from the storage tank to the main fuel oil pump so as to increase fuel pressure entering the gas turbine combustion chamber (there is no fuel heater in case of diesel fuelled generation).

(2) Diesel oil entering the gas turbine will be combusted in the combustion chamber. Demineralized water will be injected into the chamber to control the oxides of nitrogen (NO_x) generated by combustion process (water injection technology). The thermal energy from the fuel combustion will be directed to turn the gas turbine which will then drive the generator for electricity generation.

(3) Waste hot gas which still contains thermal energy will not be discharged but directed to HRSG for steam production.

(4) Steam from HRSG will be used to power the steam turbine which will then drive the generator to generate electricity.

(5) The turbine exhaust steam will be condensed for reuse in the steam production process. The exhaust steam will enter the condenser for heat exchange with cooling water from the cooling tower and be converted to condensate. The high temperature cooling water will be sent back to the cooling tower to reduce the temperature.

(6) The temperature of cooling water discharge will be about 9 °C higher than the inlet water temperature or at about 43 °C. The cooling water will be cooled by passing through the cooling tower where the cooling tower fan will transfer heat while water is falling in the cooling tower, reducing the water temperature to about 34 °C. After that, cooled water is collected and stored in the cooling tower basin for recirculation and reuse. Blowdown water will be discharged to two 19,000-m^3 cooling tower basins which can hold water for at least 1 day so as to maintain the water quality of the system before discharging

into the cooling tower holding pond of Pluak Daeng Industrial Park. The temperature of water discharge shall meet the effluent standard prescribed by Pluak Daeng Industrial Park.

(7) Oxides of nitrogen (NO_x) in the fuel gas stream will be controlled to be within the specified limit, using water injection system, before the fuel gas is released to atmosphere through the HRSG stack.

3.7.2 Power Plant Capacity

At present, the large turbine technology has been progressively developed, resulting in improvement of turbine efficiency and overall efficiency of combined cycle power plants. The project's gas turbine net efficiency will be about 59-60% at full load operation. The power plant capacity is as follows:

- Installed capacity: about 2,920 MW
- Net capacity: about 2,800 MW
- Net efficiency: about 59-60%

The power plant's maximum electrical output will be about 2,920 MW, part of which will be utilized within the project area while the remainder will be supplied to EGAT. In accordance with the Power Purchase Agreement (PPA) between EGAT and Pluak Daeng Power Plant, EGAT has the right to order the power plant operations from the contracted minimum capacity of 1,500 MW to the contracted maximum capacity of 2,500 MW. The design operational capacity must meet the contracted minimum net and maximum net generation requirements.

The project's installed capacity is relatively high, compared to the PPA, resulting in a rather large difference between the installed capacity and sale volume. This is due to the fact that the current gas turbine technology is much more advanced, resulting in gas turbines of greater capacity than the gas turbine technology in 2013-the year of PPA signing with EGAT. At present, some turbine manufacturers have developed combined cycle gas turbines and steam turbines with a maximum capacity (net) of 700 MW/generating unit.

Even if the aforementioned capacity is greater than the contracted capacity in the PPA with EGAT (net capacity of 625 MW/generating unit), the project's power plant will operate in compliance with the PPA, i.e. net 375 MW to net 625 MW per generating unit. The project's machines can operate at the required capacity levels according to the aforesaid loads.

The project's internal electricity demands in case of full load, intermediate load and minimum generation load, using natural gas and diesel oil fuel, are presented in **Table 3.7-1**.

TABLE 3.7-1

POWER PLANT CAPACITY OF THE PROJECT

Power Plant Operations	Gross Output (MW)	Auxiliary Load (MW)	Net Output (MW)
In case of natural gas-fired operation			
- Full load	716.542	16.542	700.000
- Intermediate load	551.706	14.206	537.500
- Minimum generation load	387.587	12.587	375.000
In case of diesel-fuelled operation			
- Full load	513.689	13.689	500.000
- Intermediate load	450.748	13.248	437.500
- Minimum generation load	387.661	12.661	375.000

Source : Gulf PD Co., Ltd, 2016

3.8 SUPPORTING SYSTEM FOR GENERATING AND DISPATCHING ELECTRICITY

The project will dispatch electricity to the EGAT by constructing 500 kV switchyard facilities within the project area in order to dispatch electricity to Pluak Daeng substation at 500 kV via New Transmission Facilities ("NTF"). Construction and Right-of-Way acquisition for NTF are both under the responsibility of EGAT.

The details of NTF are as follows:

- 8.5 km of 500 kV double circuit 4 x 1,272 MCM ACSR overhead transmission line to connect between EGAT's Pluak Daeng Substation and GPD's GIS switchyard;
- Expansion for 2 feeders to GPD's substation at the existing EGAT 500 kV Pluak Daeng substation;
- Two (2) composite overhead ground wires with fiber optic (OPGW) and two (2) sets of OPGW junction box and accessories at the take-off of the Generator's GIS switchyard.
- Typical design of 500 kV line towers is in **Figure 3.8-1**. The right of way width is 60 m (30 m each side of the centerline of the transmission tower) as shown in **Figure 3.8-2**.

Current status, the transmission line route is proposed by EGAT to Energy Regulatory Committee ("ERC") for consideration.

The route line selection will avoid or minimize the impacts from the transmission line, environmentally sensitive or protected areas will be avoided. As per announcement of Energy Regulatory Committee on the criteria for surveying or identifying the energy network, B.E. 2553, the selection of the final energy network route (in our case, transmission line route) shall give priority to minimize impacts to communities and the environment.

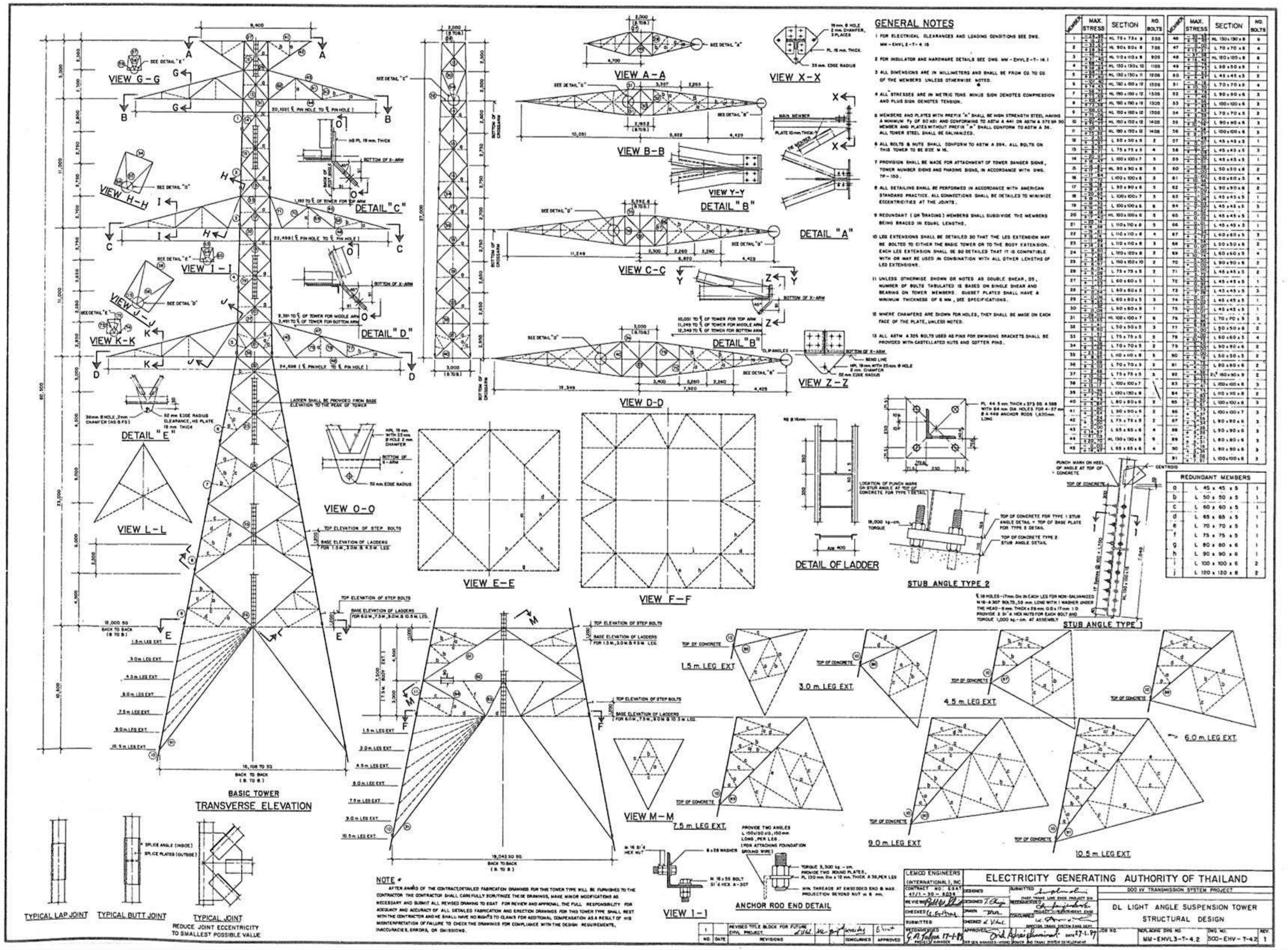


FIGURE 3.8-1 : TYPICAL DESIGN OF 500 KV LINE TOWERS

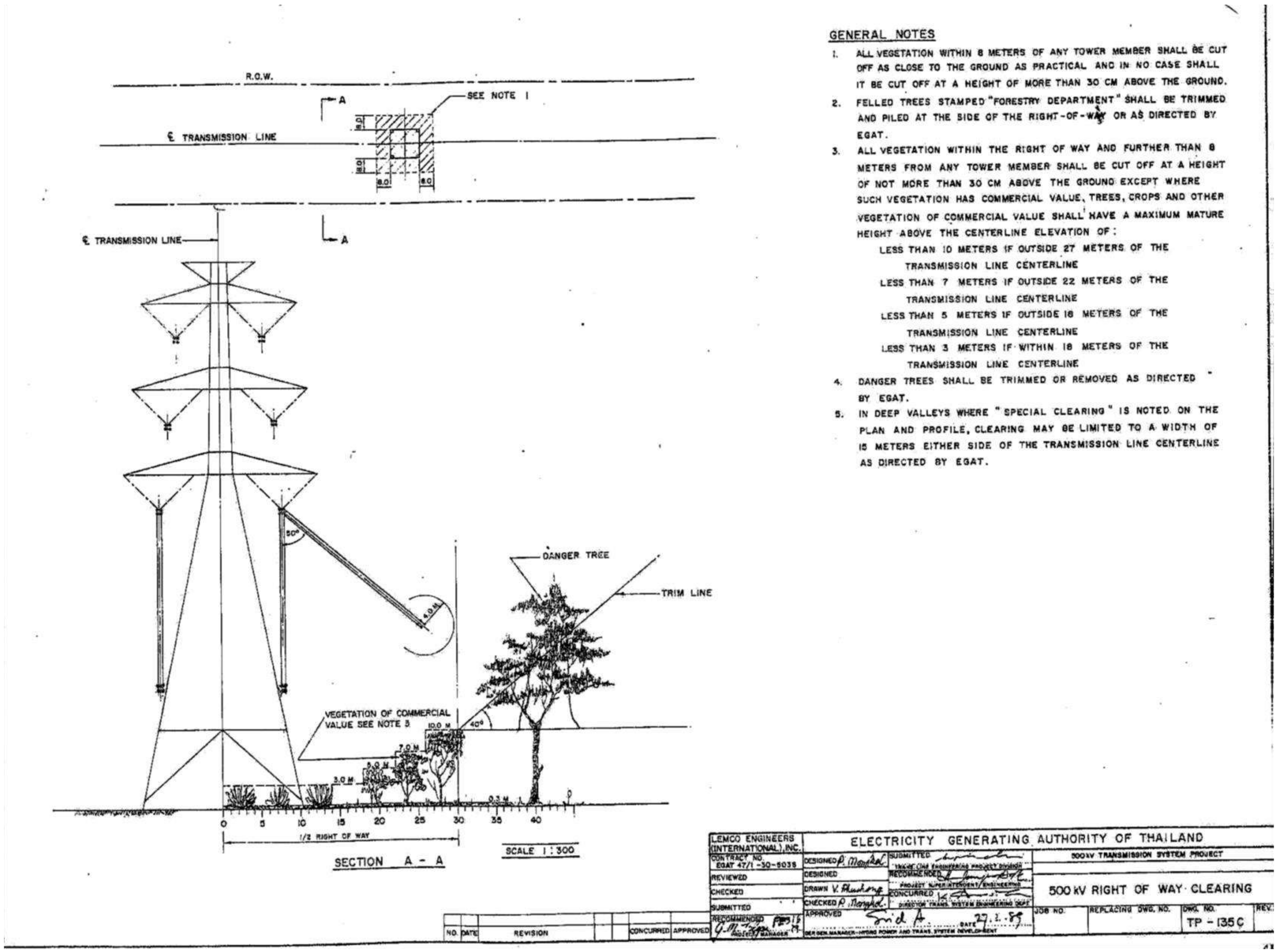


FIGURE 3.8-2 : THE RIGHT OF WAY OF 500 KV LINE TOWERS

The transmission line route is not yet officially announced. However, the area already has several 500 kV transmission lines as the EGAT's Pluak Daeng Substation is the junction substation in the area. However, there is no report on the effect of the existing transmission lines on bird migration.

According to the Notification of the Ministry of Natural Resources and Environment Re: Types and Sizes of Projects or Activities Requiring Environmental Impact Assessment Report and Rules, Procedures, Practices and Guidelines for Preparing Environmental Impact Assessment Report B.E. 2555 (2012)., Development of Transmission line project does not required an EIA or IEE.

EGAT will need to announce the Energy Network Announcement and pay compensation to land owners' before construction of the NTF. However, before selection of the NTF, EGAT will work together with ERC to select the NTF route that is the most efficient and has least impact to land owners. After the Energy Network is Announced, land owners may appeal the announce Energy Network route line. And then, after all appeals are settled, EGAT will pay compensation fees rate according to the rate that is set by ERC to land owners. The land owners may once again appeal the compensation rate if they find the rate to be low.

All the processes help ensure that land owners will be working together with ERC to minimize the impact and pay fare compensation to land owners. Which the project will monitor the Right-of-Way acquisition process and construction progress and assist as necessary if requested by EGAT.

The Right-of-Way acquisition by EGAT will be done under The Energy Industry Act 2007 (**Appendix 3G**) as governed by the Energy Regulatory Commission (ERC), with the following process:

(1) Exploration and survey process

1. EGAT, with the approval of the ERC, shall enter and temporarily make use of the land by making an announcement designating the area to be surveyed by posting up a written notification at the district office, or the minor-district office, the sub-district office and the village headman office.
2. Such announcement shall be posted via the local newspapers which are widely distributed in the locality for no less than three (3) days, notifying the scheduled date, time and duration of the act to be performed, or in accordance with the criteria set forth by the ERC.
3. The posting of such notification and the announcement in the newspaper shall be made no less than thirty (30) days prior to the use or possess of the land or property.

4. After having entered the land or property, if any damage occurs, EGAT shall pay compensation for the damage to the concerned person according to the criteria, procedures and conditions specified by the ERC.
5. The owner may appeal against the amount of compensation to the ERC within 60 days as from the receipt date of the written notification on the amount of compensation. The ERC's decision on the appeal shall be treated as final.

(2) Energy network announcement process

1. When EGAT has identified the final route for the energy network system construction, they will prepare a drawing and relevant documents for submission to the ERC for consideration and approval.
2. After the ERC has approved the drawing, the Office of ERC will make an announcement designating the energy network system boundary by posting notifications at the district office, or the minor-district office, the sub-district office and the village headman office, where the energy network system boundary is located.
3. EGAT illustrate the demarcation of the energy network boundary on the actual site and issue a written notification to the owner of land or property that is located within the boundary, or in the associated energy network system sites.

   In case the owner of land or property does not agree on such energy network boundary, they may appeal to the ERC within 30 days following the receipt of the written notification from EGAT. The ERC's decision on the appeal shall be treated as final.

   (i) EGAT shall pay for the utilization charge or pay compensation to the owner of land or property according to the criteria, procedures and conditions announced by the ERC.

   (ii) In the event that the owner of land or property is not satisfied with the amount of the utilization charge or compensation, they shall have the right to appeal to the ERC. The ERC's decision on the appeal shall be treated as final.
4. When (2), (3) and (4)(i) have been made, EGAT shall have the power to construct the energy network system within the network system boundary so permitted.

Moreover, project has set up mitigation measurement related to Construction and Right-of-Way acquisition for NTF process to assist the affected people as much as possible including

- Having representatives on site to coordinate, communicate any assist people in the area.
- Coordinate with EGAT to inform the public of the schedule for construction, and address any concerns that the people in surrounding area may have.
- For people within 5km radius from the project site, GSRC will form an environmental committee to consider and mitigate any possible impacts and also to ensure paying fair compensation for affected people.
- For people outside the 5km radius, we will form environmental committee in case-by-case basis when there are impacts from NTF construction.
- The committee set up will include representatives from EGAT, GSRC, community leaders, authorities in the area etc.

3.9 INFRASTRUCTURE AND UTILITIES SYSTEMS

3.9.1 Water Sources for Consumption

(1) Construction Phase

During construction phase, water use is primarily for consumption of construction workers who live outside the project area, and construction activities. Water for construction works is supplied by the water production system of Pluak Daeng Industrial Park (Details of the Industrial Park's water supply system are provided in **Appendix 3H).** The Industrial Park receives 2.5 million m^3/year of raw water supply from Eastern Water Resources Development and Management Plc (East Water) via Nong Pla Lai-Nong Kho raw water transmission pipeline. Raw water will be stored in the raw water pond No.1 which has a storage capacity of 201,508 m^3, before being pumped into water treatment system and distributed to clients in the Industrial Park (**Source**: Environmental Impact Assessment Report, Pluak Daeng Industrial Park Project, Expansion Phase 1, February 2016). Regarding water for workers' consumption, water supply pipes will be connected to the temporary site office building where there is a water tank of storage capacity equivalent to one day's water requirements. In case of water shortage, the contractor will purchase water from other agencies in the vicinity such as Provincial Waterworks Authority, Rayong branch, and the water will be stored in the project's reserve water tank.

The workers' water demand is about 224 m$^{3/}$day (estimation was based on the water use rate of 70 litres/person/day (Kriangsak, 1996) and the highest number of workers of about 3,200). About 55 m^3/day of water will be required for construction activities. As ready-mixed cement is selected, water usage will be mainly for cleaning construction equipment. An additional volume of 250 m^3 will be needed for only one hydrostatic test of natural gas and oil transmission pipelines (A written enquiry about capabilities for water supply and treatment of hydrostatic test water discharges is presented in **Appendix 3D**).

Water requirement for spraying the project area was also considered in order to reduce dust diffusion during construction phase. The dust diffusion primarily results from incoming-outgoing truck traffic in the project area, e.g. trucks, ready-mixed concrete tank trucks, contractor's vehicles, etc. Water spray rate is equivalent to 0.75 litres/m^2 in case of single water spray per day (Reference: National Pollutant Inventory Emission Estimation Technique Manual for Mining, Version 3.1, 2012), as shown in **Appendix 3I**. For spraying the total project area of 492.30075 rai, the approximate water demand is therefore 1,182 m^3/day in case of at least 2 water sprays/day. As a result, the maximum water use in the construction phase is 1,711 m^3/day (**Table 3.9-1**).

TABLE 3.9-1

WATER USE RATE DURING THE PROJECT CONSTRUCTION PHASE

Activity	Water Usage (m^3/day)
1. Water consumption for construction workers (estimation is based on a water use rate of 70 litres/person/day and 3,200 workers)	224
2. Water for cleaning construction equipment	55
3. Water for hydrostatic testing 1/	250 1/
4. Water sprays in the project area (in case of single spray/day, water spray rate is 0.75 litres/m^2 and water will be sprayed twice a day, covering an area of 492.30075 rai)	1,182
Total	**1,711**

Remarks : 1/ Water for hydrostatic test is required for pipeline testing only which does not occur every day.

(2) Operation Phase

Pluak Daeng Power Plant Project will receive 63,000 m^3/day of raw water supply from Eastern Water Resources Development and Management Plc (East Water). Raw water will be stored in a raw water pond with a storage capacity of 189,000 m^3. Water will be principally used in the power plant cooling system, i.e. about 60,560 m^3/day in case of natural gas-fired operation and 46,857 m^3/day in case of diesel-fuelled operation. Other water uses include service water, consumption, and irrigation, at a rate of 2,440 m^3/day in case of natural gas-fired operation and 2,047 m^3/day in case of diesel-fuelled operation. The project design aims to maximize water use efficiency, reduce water utilization, and reuse water, as described in the next section. The project has received a certificate of water supply capabilities from Eastern Water Resources Development and Management Plc (East Water) as shown in **Appendix 3J**.

3.9.2 Water for Production Process

(1) Water Sources

About 23 million m^3/year of raw water will be supplied to the power plant project by Eastern Water Resources Development and Management Plc (East Water) via Nong Pla Lai-Nong Kho raw water transmission pipeline for the power plant operations, as illustrated in **Figure 3.9-1**. East Water's survey shows that raw water distribution pipeline can be installed, branching from its raw water main pipeline to convey raw water to the project, as given in **Appendix 3I**. Details of the project's raw water sources are explained as follows:

(a) Raw Water from Eastern Water Resources Development and Management Plc

Eastern Water Resources Development and Management Plc or East Water was founded on 12th September 1992 in accordance with the Cabinet resolution. East Water's objectives are to be responsible for integrated raw water management via large water transmission pipeline systems for industrial sector and consumption; and support the plan for Eastern Seaboard Area development into the main industrial zone of the country. Its authorized capital was initially 10 million baht, with the Provincial Waterworks Authority (PWA) holding 100% of shares. In 1997, East Water had increased its authorized capital to 1,000 million baht and become a public company, raising funds from the capital market to develop its service system. East Water's authorized capital is currently 1,663.73 million baht, and its major shareholders are PWA, Industrial Estate Authority of Thailand, financial institutions-both domestic and international, The Electricity Generating Public Company Limited, and general public. To meet the water demand that has increased every year, East Water invested over 12,000 million baht in construction of 394.5-km water transmission pipeline network to link to major water resources in the eastern region, i.e. Nong Pla Lai, Dok Krai, Khlong Yai, and Pra Sae reservoirs in Rayong; Nong Kho and Bang Phra reservoirs in Chon Buri Province; and Bang Pakong River in Chachoengsao. This is aimed to create the country's only water grid that is most modern and comprehensive and capable of supplying raw water for water production to meet the water requirements of communities' consumption, tourism businesses, and industries. Its service areas include Chon Buri, Rayong, and Chachoengsao (**Source:** http://www.eastwater.com according to a search conducted on 12th July 2016).

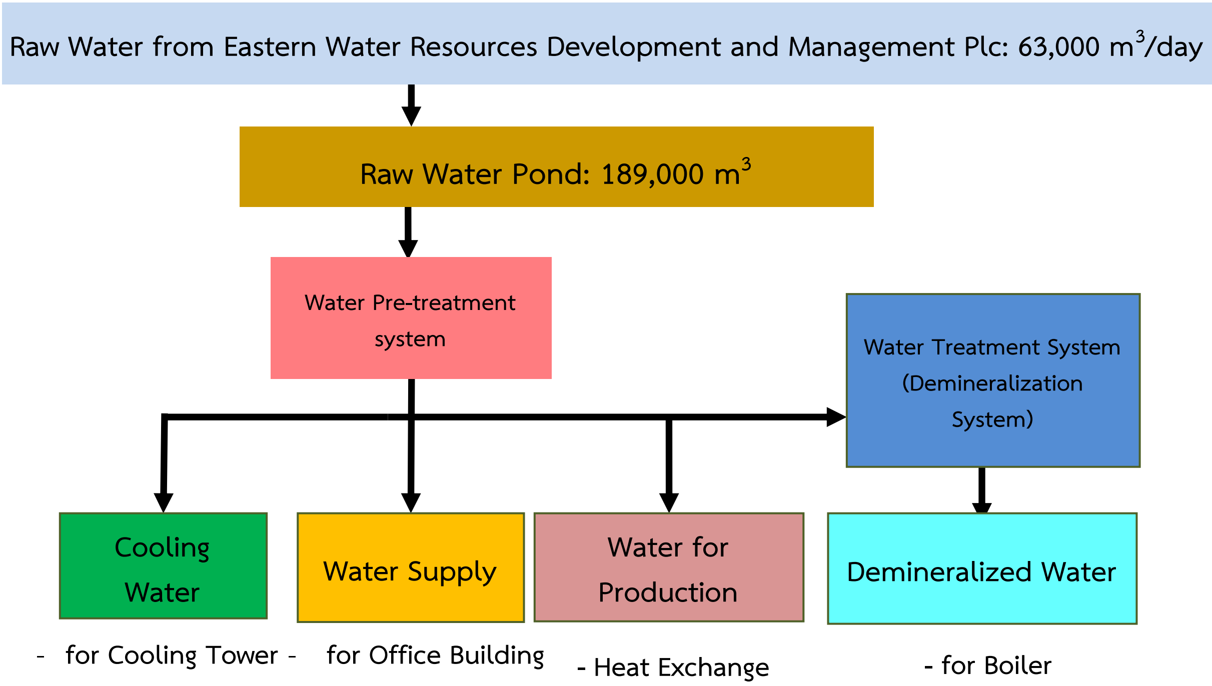


FIGURE 3.9-1 : WATER USE DIAGRAM OF THE PROJECT

- East Water's Raw Water Sources

East Water's water availability is based on water allocation by Regional Irrigation Office 9, Royal Irrigation Department, which is the main agency in charge of water management. East Water's existing water sources are Dok Krai, Nong Pla Lai, Nong Kho and Pra Sae reservoirs; Bang Pakong River; and private water sources, with the available water volume of 340 million m^3, as detailed in **Table 3.9-2**.

TABLE 3.9-2
EAST WATER'S WATER SOURCES

Water Sources	Province	Storage Capacity (million m^3)	Water Availability (million m^3/year)
1. Dok Krai reservoir	Rayong	71	116
2. Nong Pla Lai reservoir	Rayong	164	120
3. Nong Kho reservoir	Chon Buri	21	17
4. Pra Sae reservoir	Rayong	248	40
5. Bang Pakong River	Chachoengsao	-	27
6. Private water sources	Chon Buri	10	20
Total			340

Remarks : Water availability of Dok Krai reservoir is greater than its storage capacity. This means that inflow volume during the year is greater than the storage capacity and East Water can pump out more water than the reservoir storage capacity.

Source : Eastern Water Resources Development and Management Plc, 2016

- **Water Demand from Water Grid**

The water demand of water users in Rayong, Chon Buri and Chachoengsao Provinces is expected to grow continuously owing to the expanding industrial sector in the eastern region, relocation of production bases from the central region to the eastern region as a result of 2011 floods, and construction of new power plants with additional capacity of 5,000 MW. It is forecast that the water demand will rise from 303.67 million m^3 in 2016 to 364.52 and 459.00 million m^3 in the next 5-10 years, as shown in **Table 3.9-3**.

TABLE 3.9-3

FORECAST WATER DEMAND OF RAYONG, CHON BURI AND CHACHOENGSAO

Service Area	Water Demand (million m^3/year)					
	2016	**2017**	**2020**	**2023**	**2026**	**2029**
1. Rayong	181.83	189.49	214.84	235.99	235.14	243.94
2. Pluak Daeng-Bowin	26.56	32.06	54.92	97.10	110.48	113.07
3. Chon Buri	77.99	76.28	78.39	82.13	88.09	98.10
4. Chachoengsao	17.28	15.70	16.36	17.02	18.24	18.97
Total	**303.66**	**313.53**	**364.51**	**432.24**	**451.95**	**474.08**

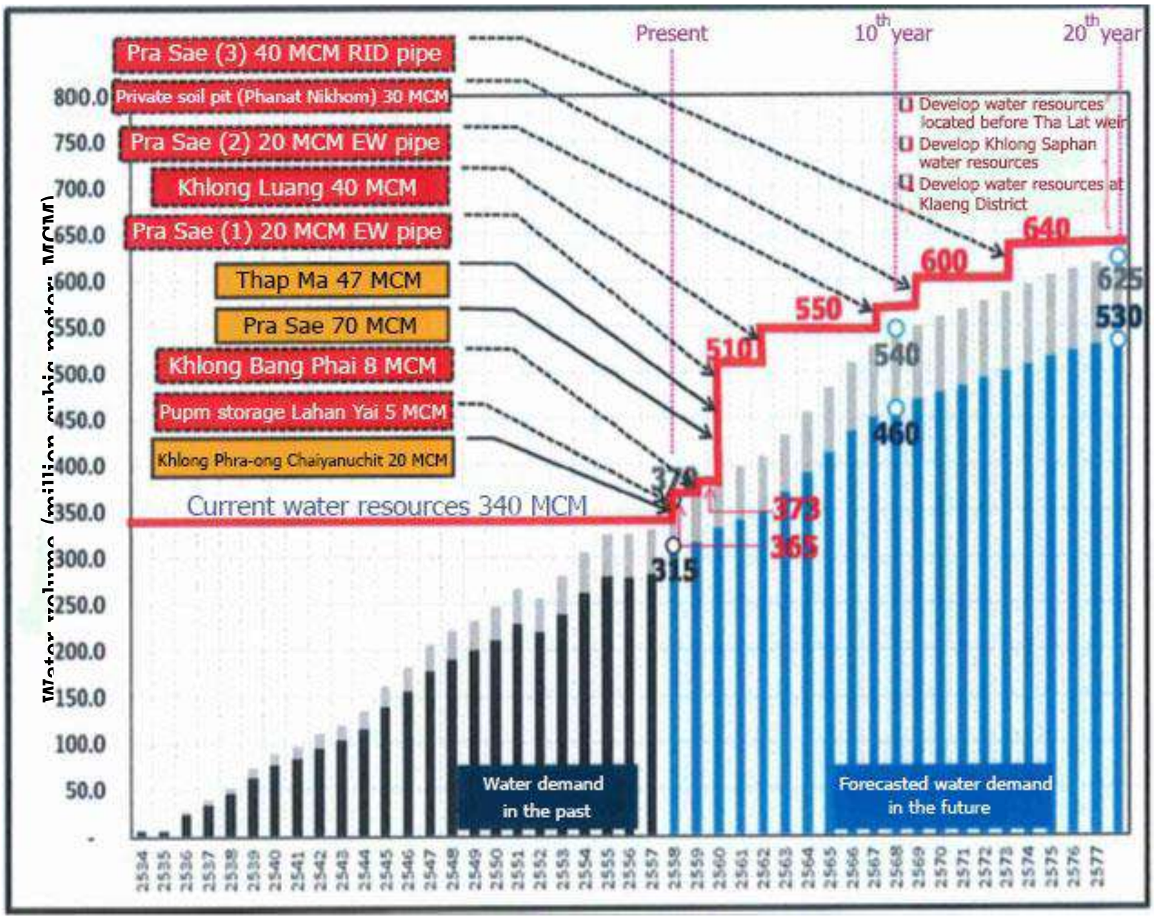
Source : Review of First quarter 2016 Sales Volume of Eastern Water Resources Development and Management Plc, 2016

- **East Water's Water Resources Plan**

The existing water sources can meet the demand up to 2017. To ensure sufficient water availability for future water requirements, East Water has a 20-year water resources development plan (as shown in **Figure 3.9-2**). About 20 million m^3 of water will be diverted from Khlong Phra-ong Chao Chaiyanuchit while 5 million m^3 will be pumped from Lahan Yai pump station. Additionally, water will be pumped and diverted from Khlong Phai, Thap Ma reservoir, Pra Sae reservoir, Khlong Luang, and private ponds in Phanat Nikhom district. The total water diversion volume will be approximately 275 million m^3. Moreover, there are water resources development plans for the upstream reach of Tha Lat weir; Khlong Saphan; and water resources in Klaeng district.

- **Water Transmission from Water Sources to the Project**

The existing water transmission network of East Water is 394.5 km long, as illustrated in **Figure 3.9-3,** linking to the eastern region's important water sources. It is planned that the project will be supplied by Nong Pla Lai-Nong Kho raw water transmission system which mainly receives water from Nong Pla Lai and Pra Sae reservoirs. The preliminary raw water pipeline alignment of the project is depicted in **Figure 3.9-4**.



Source : Eastern Water Resources Development and Management Plc, 2016

FIGURE 3.9-2 : EAST WATER'S WATER RESOURCES DEVELOPMENT PLAN

FIGURE 3.9-3 : WATER GRID OF EAST WATER IN THE EASTERN REGION

Source

FIGURE 3.9-4 : RAW WATER PIPELINE ALIGNMENT

- **East Water's Raw Water Characteristics**

As East Water will pump raw water from Nong Pla Lai reservoir to supply to the project, the raw water characteristics of Nong Pla Lai reservoir in the past 5 years (from 2011 to January-June 2016) are presented in **Table 3.9-4**.

(2) Water Consumption Rate

The overall maximum water consumption rate of the project is 63,000 million m^3/day in case of natural gas-fired operation and 47,239 million m^3/day in case of diesel-fuelled operation, with details given in **Table 3.9-5** and described herein.

(a) Cooling Water System

For cooling water system, makeup water is used to compensate for any evaporation loss in the cooling tower. Five water recirculation cycles are designed so as to control total dissolved solids (TDS) in blowdown water not to exceed 1,300 mg/litre as specified in the environmental impact prevention and mitigation measures of Pluak Daeng Industrial Park.

Water consumption rate of cooling water system is 61,304 m^3/day, divided into 60,560 m^3/day of water from water pre-treatment system and 744 m^3/day of water recirculated from steam recirculation system, excess water from sampling and water discharge from HRSG unit.

TABLE 3.9-4

RAW WATER CHARACTERISTICS OF NONG PLA LAI RESERVOIR IN THE PAST 5 YEARS (FROM 2011 TO JANUARY-JUNE 2016)

Parameter	Unit	Minimum-Maximum					
		2011	2012	2013	2014	2015	JAN-JUN 2016
pH	-	7.01-8.14	7.01-7.99	7.10-8.13	7.0-9.2	7.1-8.34	7.9-9.0
DO	mg/l	4.2-7.95	4.10-7.20	4.20-6.92	4.8-8	3.52-6.39	5.8-7.1
BOD	mg/l	1.3-2.3	1.20-2.00	1.2-2.0	1.1-4.2	1.40-2.80	1.8-3.8
COD	mg/l	12-24	10-16	10-14	ND	10-15	12.0-21.8
Turbidity	NTU	2.87-22.3	3.06-22.30	1.57-16.70	4.7-21	2.36-131	5.8-14.0
Conductivity	us/cm	160-250	160-234	183-283	213-313	178-283	199-276
Colour	Pt-Co	4.66-20.86	5.15-14.77	6.14-52.01	20-30	7.38-52.01	10-15
Calcium	mg/l as $CaCO_3$	24-27	14-26	14-72	35.7-59.1	30-72	30.8-46.1
Magnesium	mg/l as $CaCO_3$	11-18	10-17	10-19	9.2-28.2	4-19	9.6-25.5
Chloride	mg/l	12-24	12-28	12-28	18.1-30.8	14-28	17.6-34.1
Total Iron	mg/l	0.07-0.42	0.04-0.42	0.04-2.62	0.058-0.276	0.04-2.62	0.006-0.082
Manganese	mg/l	0.07-0.27	0.04-0.45	0.03-0.53	0.043-0.171	0.03-0.73	0.038-0.186
Nitrate Nitrogen	mg/l	0.03-0.34	0.02-0.34	0.02-0.18	0.03-0.29	0.02-0.38	0.00-0.11
Sulfate	mg/l	9.52-18.82	9.52-19.71	8.23-18.98	16.4-25.8	7.92-22.27	21.1-31.6
Silica	mg/l	8.64-12.57	8.64-12.47	7.55-15.10	9.8-18.3	1.38-13.09	8.95-9.83
Total Suspended Solid	mg/l	6-16	6-14	3-15	5.2-12.8	3-62	4.4-7.4
Dissolved Solids	mg/l	90-156	90-143	116-180	110-187	112-120	109-178
Total Alkalinity	mg/l	40-50	30-60	30-100	55.9-69.4	35-100	62.6-68.6
Grease & Oil	mg/l	<0.1	<0.1	<0.1	ND	<0.1	0.1-0.7
Total Phosphate	mg/l	0.02-0.07	0.01-0.07	0.01-0.12	0.0004-0.001	0.03-0.09	0.04-0.10
Phosphate	mg/l	0.06-0.21	0.03-0.21	0.03-0.37	0.03-0.83	0.09-0.28	ND-0.05
Total Kjeldahl Nitrogen	mg/l	0.59-1.15	0.59-1.15	0.80-1.29	ND	0.31-0.94	1.6-3.9
Ammonia Nitrogen	mg/l	<0.01	<0.01	<0.01-0.25	ND	<0.1	0.00-0.06
Copper	mg/l	<0.01	<0.01	<0.01	<0.003-<0.01	<0.1	0.000-0.022
Zinc	mg/l	0.01-0.12	0.01-0.13	0.02-0.07	ND	0.01-0.04	0
Fluoride	mg/l	0.11-0.41	0.13-0.29	0.19-0.36	0.07-0.32	0.17-0.42	0.20-0.74
Detergent	mg/l	<0.01	<0.01	<0.01	0.05-0.62	<0.01	0.00-0.01
Carbonate Hardness	mg/l as $CaCO_3$	37-42	28-39	28-82	47.6-69.4	35-82	34.0-66.5
Non Carbonate Hardness	mg/l as $CaCO_3$	<1	<1	<1	0-25.6	<1-5	0.0-22.6
Salinity	g/kg	0.06-0.08	0.06-0.09	0.06-0.09	0.1	0.06-0.09	0.1
TOC	mg/l	3.84-8.83	5.24-8.83	4.20-9.65	4.5-6.16	4.2-12.4	4.32-5.17
Arsenic	mg/l	0.0013-0.0019	0.0013-0.0030	0.0017-0.0038	0.0024-0.0031	0.0021-0.0046	0.0029-0.0037
Barium	mg/l	0.07-0.1	0.07-0.08	0.06-0.10	0.047-0.079	0.07-0.09	0.041-0.058
Cadmium	mg/l	<0.002	<0.002	<0.002	ND	<0.002	0
Chromium (6+)	mg/l	<0.01	<0.01	<0.01	ND	<0.01	0
Lead	mg/l	<0.01	<0.01	<0.01	ND	<0.01	0
Mercury	mg/l	<0.0005	<0.0005	<0.0005	ND	<0.0005	0.0001-0.0020
Nickel	mg/l	<0.01	<0.01	<0.01	ND	<0.01	0
Selenium	mg/l	<0.0005	<0.0005	<0.0005	ND	<0.0005	0
Silver	mg/l	<0.01	<0.01	<0.01	ND	<0.01	0
Sodium	mg/l	14.51-21.23	14.27-22.34	16.83-24.03	11.4-18.6	15.03-21.55	15.0-18.3
Cyanide	mg/l	<0.001	<0.001	<0.001	ND	<0.001	0
Phenol	mg/l	<0.001	<0.001	<0.001	0.01-0.016	<0.001	0.000-0.013
Fecal Coliform	MPN/100ml	4.5-23	7.8-130	11.0-700.0	<1.8-49	49-700	<1.8-490

Source : Eastern Water Resources Development and Management Plc, 2016

TABLE 3.9-5
MAXIMUM WATER USE RATE DURING PROJECT OPERATION PHASE

No.	Water Use Category	In Case of Natural Gas-fired Operation 1/ (m^3/day)	In Case of Diesel-fuelled Operation 2/ (m^3/day)	Purpose
1.	**Raw Water Supply (1=A+B)**	**63,000**	**47,239**	
	A. Raw water supply to the Water Pre-Treatment Plant for power plant usage	62,618	46,857	
	B. Irrigation	382	382	Tree watering
2.	**Water from Water Pre-Treatment Plant (2=C+D+E)**	**63,216** 3/	**47,455**	
	C. Sludge Cake	5	4	Sludge cake from sedimentation system will be delivered to a legally permitted company for disposal.
	D. Cooling water makeup	60,560	44,810	To replace water losses through evaporation and discharge from cooling water system
	E. Service/Fore Water Storage Tank (E=E1+ E2+ E3)			
	E1 Potable Water	30	30	For consumptive use in the power plant
	E2 Feedwater into Water Treatment Plant to produce demineralized water	2,311	2,311	
	E3 Quenching water for HRSG blowdown	310	300	To reduce temperature of blowdown water for reuse in the cooling system
3.	**Water from Water Treatment Plant (3=F+G+H)**	**2,311**	**2,311**	
	F. Demineralized water to the Demin. Water Storage Tank	1,700	1,700	
	G. Water reuse in pre-treatment system	598	598	
	H. Water discharge from the process to the neutralization pit	13	13	
4.	**Demineralized water from the demin. water storage tank (4=F-I+J+K+L)**	**599**	**5,615**	
	I. Increase/decrease in demineralized water quantity in the demin. water storage tank	+1,101	-3,915	

TABLE 3.9-5
MAXIMUM WATER USE RATE DURING PROJECT OPERATION PHASE (CONT'D)

No.	Water Use Category	In Case of Natural Gas-fired Operation 1/ (m^3/day)	In Case of Diesel-fuelled Operation 2/ (m^3/day)	Purpose
	J. Water for GT water Injection to control nitrogen oxides	0	5,074	To control nitrogen oxides in water injection system of gas turbine during diesel fueled operation
	K. Water use in laboratory	5	5	Purified water for laboratory use
	L. HRSG feedwater			
	L1 Water flow through sampling rack	70	70	For steam system sampling and testing by passing through sampling rack in the steam system
	L2 HRSG makeup water for steam cycle drain	180	180	To replace water discharges from steam piping system
	L3 HRSG makeup water for boiler blowdown	344	286	To replace boiler blowdown water
5.	**Recirculation and reuse of water discharge in cooling tower (5=L3+E3-M)**	**494**	**480**	
	M. Evaporation into atmosphere from boiler blowdown system	160	106	
6.	**Cooling Water (6=D+N)**	**61,304**	**45,540**	
	N. Water reuse in cooling tower from various systems (N=L1+L2+5)	744	730	
	O. Evaporation into atmosphere from cooling water system	49,072	36,456	
	P. Discharge from cooling water system	12,232	9,084	
7.	Blowdown water inflow into the project's cooling water holding pond (P)	12,232	9,084	
8.	Wastewater inflow into the project's wastewater holding pond (8=E1+H+K)	48	48	
Total water use volume		**63,000**	**47,239**	

Remarks : 1/ Maximum water use rate in case of natural gas-fired operation at 100% load
2/ Maximum water use rate in case of diesel-fuelled operation at 100% load
3/ Water volume from water pre-treatment plant of item 2 is greater than that of item 1 as water reuse volume (598 m^3/day) from water treatment plant is included.

(b) Demineralized Water, Potable Water and Service Water

Demineralized water usage includes 344 m^3/day for HRSG, 180 m^3/day for steam circulation system, 70 m^3/day for water sampling, and 5 m^3/day for laboratory. In case of diesel oil fueled generation at full load (514 MW Gross, 500 MW Net), the demineralized water use rate of the project is 5,074 m^3/day for controlling nitrogen oxides in the feedwater of GT water injection system. This water will be taken from the demineralized water storage tank; therefore, it will not have any impact on the overall water use.

In addition, about 30 m^3/day of water supply will be used for consumption and 310 m^3/day of service water for heat recovery from HRSG blowdown.

(3) Raw Water Pond

Pluak Daeng Power Plant Project will receive 63,000 m^3/day or not more than 23 million m^3/year of raw water supply from East Water. The raw water will be stored in one 189,000 m^3 raw water pond.

Raw water from East Water will be conveyed to the aforesaid raw water pond before being conveyed to water pre-treatment system or it may be directly fed into water treatment system without passing through the raw water pond. In case of low water level in the raw water pond, the project will receive water from East Water to be kept as raw water reserve up to the specified level.

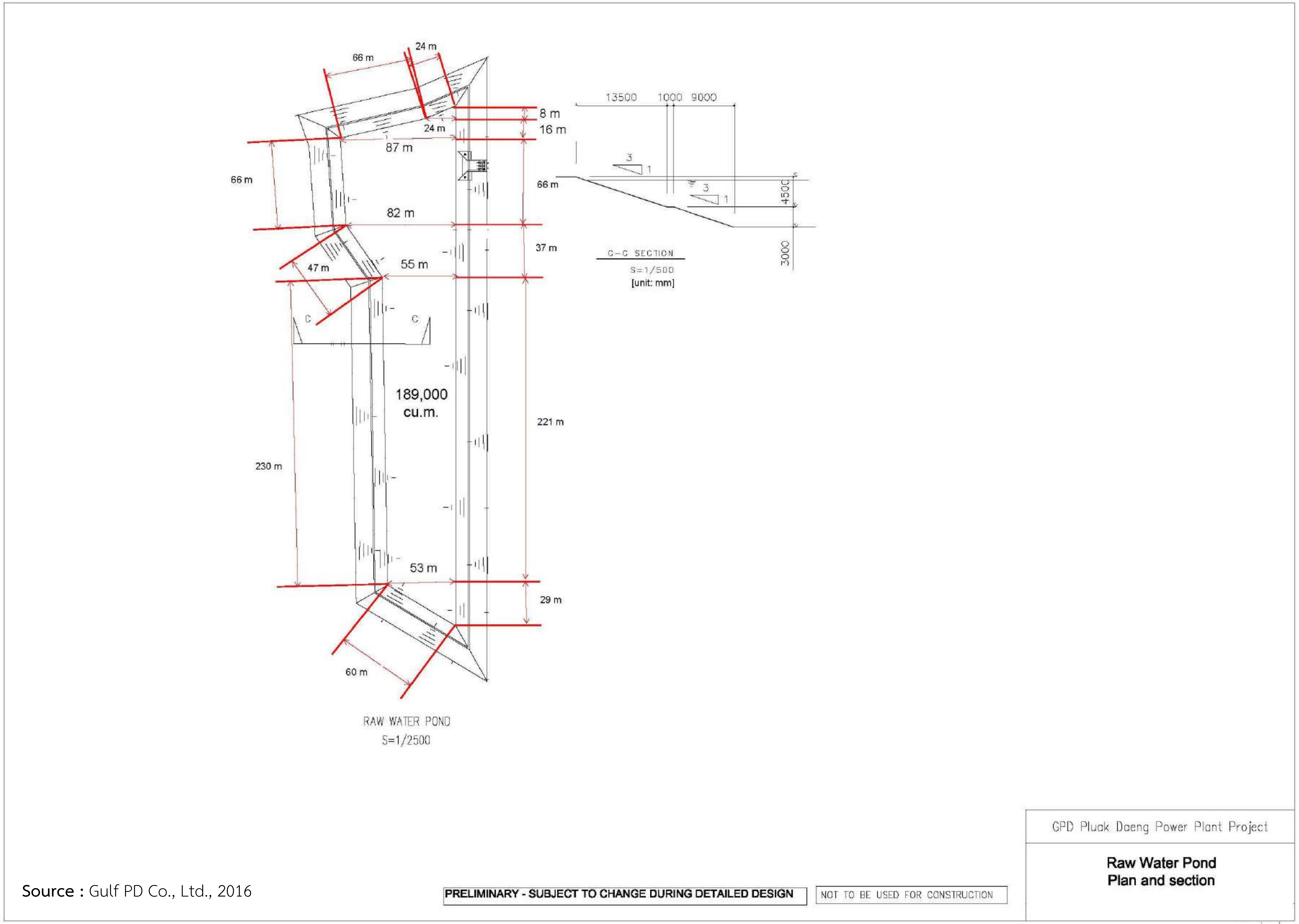
The location of raw water pond is depicted in **Figure 3.3-1** and its cross section in **Figure 3.9-5**. Calculation sheets of pond sizing are shown in **Appendix 3K**.

(4) Water Treatment System

Water treatment system consists of 2 steps: water pre-treatment and water treatment, using demineralization system, as follows:

(a) Water Pre-treatment System

Suspended solids in raw water will be removed by coagulant addition, i.e. Ferric Chloride and polymers, to water to cause coagulation of suspended solids and sedimentation in the clarifier. Sludge will be pumped out from the clarifier and conveyed to the thickener so as to reduce sludge volume. After that, sludge will be dewatered on belt filter press and the liquid effluent will be recirculated to the clarifier. The sludge which is generated at about 5 tons/day will be stored before being delivered for further disposal in accordance with the Ministry of Industry's Notification on Disposal of Waste or Unusable Materials, B.E.2548 (2005) or delivered to an industrial waste disposal company permitted by the Department of Industrial Works for further disposal. Moreover, sodium hydroxide will be added in the water treatment process for pH adjustment and sedimentation.



Source : Gulf PD Co., Ltd., 2016

FIGURE 3.9-5 : CROSS SECTION OF THE PROJECT'S RAW WATER POND

The pre-treated water will be partly fed into the cooling tower and the remainder will flow into the filter tank for removal of suspended solids again before being stored in a 4,200-m^3 service water storage tank. The service water supply will be distributed to various systems, i.e. water treatment system (or demineralization system), service water system and water supply system.

The water pre-treatment system capacity is about 3,000 m^3/hour or 72,000 m^3/day, which is adequate for the project's maximum pre-treatment requirement of 62,618 m^3/day. This pre-treatment system will operate 24 hours and its production rate can be adjusted to be lower than the maximum capacity by adjusting the water inflow rate to be same as the water demand rate.

Calculation sheets of water pre-treatment system and service water storage tank capacity are presented in **Appendix 3L** and **Appendix 3M,** respectively.

(b) Water Treatment System

Water treatment system or demineralization system is described as follows:

In the demineralization system, pre-treated water from the water pre-treatment system will flow into reverse osmosis (RO) system where sodium metabisulfite will be added to remove residual chlorine and antiscalant will be applied to prevent scaling of RO membrane. The RO system design must take into account the RO membrane life span which will be shortened if residual chlorine enters RO system. Even if chlorination is not used in the project's water pre-treatment system and the raw water supply from East Water is untreated, sodium metabisulfite injection system is designed for the project's RO system to remove any residual chlorine in raw water. In the operation phase, water quality will be tested to check the residual chlorine levels. If no residual chlorine is found, sodium metabisulfite addition is not required.

The RO water will be conveyed to the mixed bed ion exchange unit for demineralization and the demineralized water will then be stored in two 6,600-m^3 demineralized water storage tanks. The demineralized water will be added to various systems, e.g. steam generation system to replace HRSG blowdown, water injection system for gas turbine to control NO_x emissions in case of diesel-fueled operation, etc.

The demineralization system has a capacity of 1,800 m^3/day which is sufficient to meet the project's demineralized water demand of 1,700 m^3/day. This system can be operated 24 hours/day to replenish two 6,600-m^3 demineralized water storage tanks. It will automatically stop when the water level in the tank is high (full) and start when the water level is lower than the set point (water volume is lower than the set point).

If the water demand is 1,700 m^3/day, the demineralization system must be operated 23 hours/day (1,700/1,800 x 24 = 22.67).

Calculation sheets of demineralization system and demineralized water storage tank capacity are presented in **Appendix 3L** and **Appendix 3M,** respectively.

Wastewater from water treatment system is discharged from the mixed bed ion exchange unit which will be conveyed to the neutralization basin for pH adjustment before being stored in the wastewater holding pond. After that, the wastewater with quality as specified by Pluak Daeng Industrial Park will be sent to its central wastewater treatment system.

(1) Power Plant Water Consumption

The preliminary forecast of water usage indicates that the project's maximum water demand will be about 63,000 m^3/day in case of natural gas-fired operation and 47,239 m^3/day in case of diesel-fueled operation. Water balance schematic diagram in both operational scenarios at different loads are illustrated in **Figures 3.9-6** to **Figure 3.9-8** and **Figures 3.9-9** to **Figure 3.9-11**. Water consumption rates of both operational scenarios at full load are shown in **Table 3.9-5**, with the project's water use rates summarized as follows:

Natural Gas-fired Operation at Full Load (717 MW Gross, 700 MW Net)

- 63,000 m^3/day of raw water will be supplied to the power plant, which will be fed into water pre-treatment system at a rate of 62,618 m^3/day and used for irrigation at a rate of 382 m^3/day.
- For water pre-treatment system, water inflow volume will be 63,216 m^3/day, consisting of 62,618 m^3/day of raw water and 598 m^3/day of recycled water from demineralization system. The pre-treated water of 63,216 m^3/day will be used in various systems, consisting 60,560 m^3/day for cooling water makeup, 310 m^3/day for quenching water for HRSG blowdown, 30 m^3/day for consumptive use in the power plant, and 2,311 m^3/day for demineralization system. Moreover, 5 m^3/day of sludge cakes from sedimentation system will be sent to a legally permitted company for disposal.

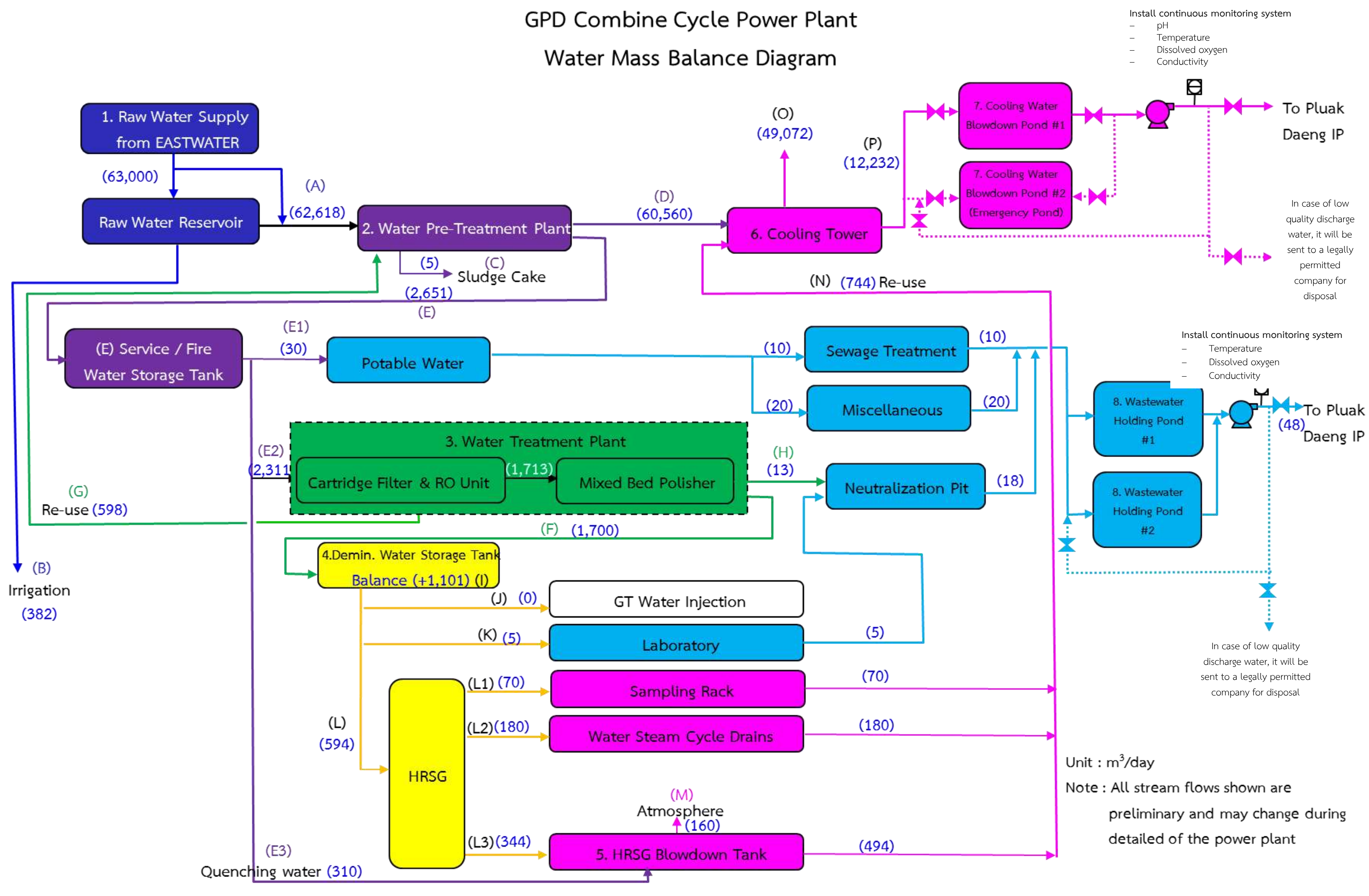


FIGURE 3.9-6 : WATER BALANCE SCHEMATIC DIAGRAM OF PLUAK DAENG POWER PLANT IN CASE OF NATURAL GAS-FIRED OPERATION AT FULL LOAD (717 MW GROSS/700 MW NET)

TEAM

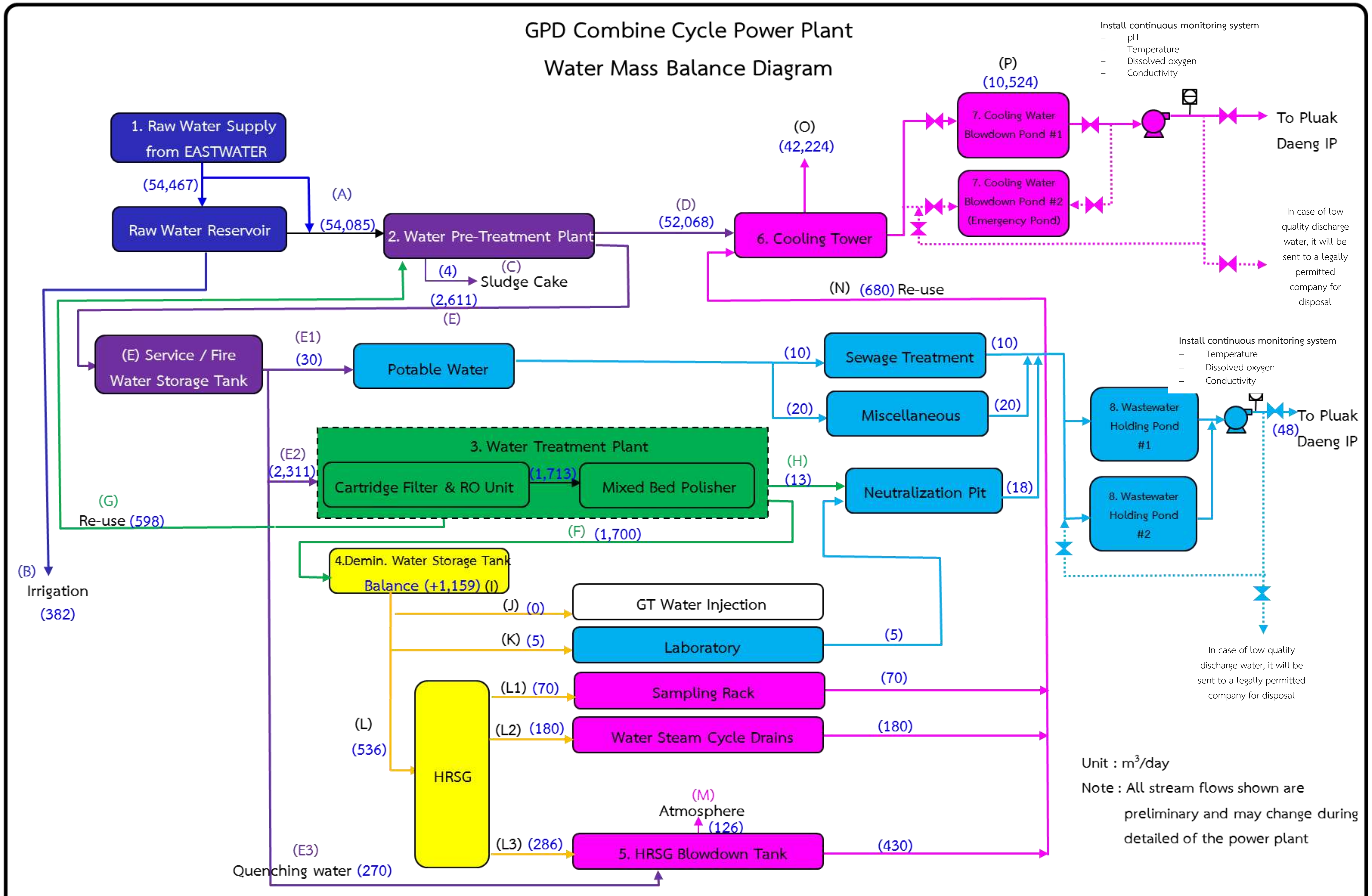


FIGURE 3.9-7 : WATER BALANCE SCHEMATIC DIAGRAM OF PLUAK DAENG POWER PLANT IN CASE OF NATURAL GAS-FIRED OPERATION AT INTERMEDIATE LOAD (552 MW GROSS/537.5 MW NET)

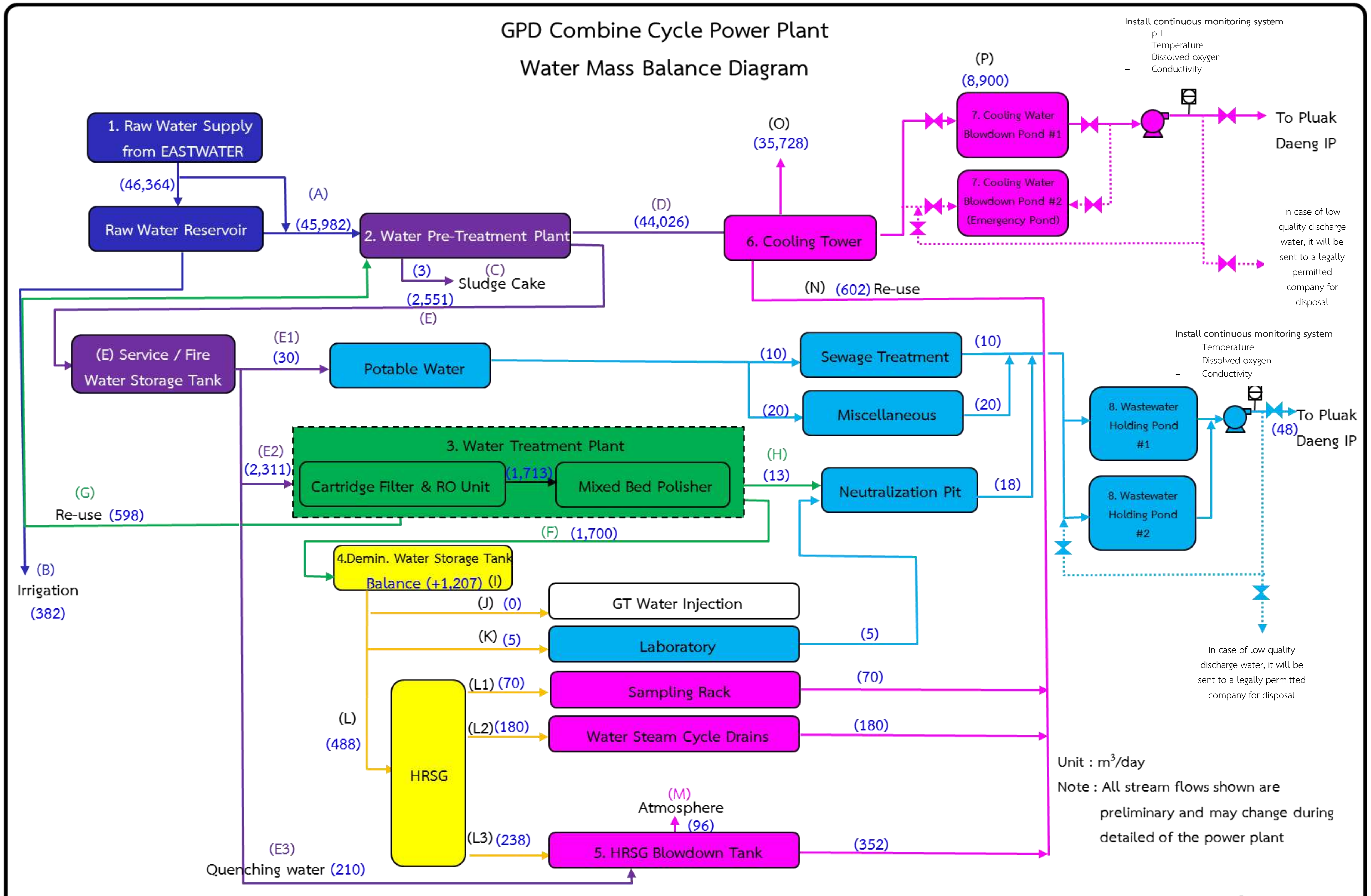
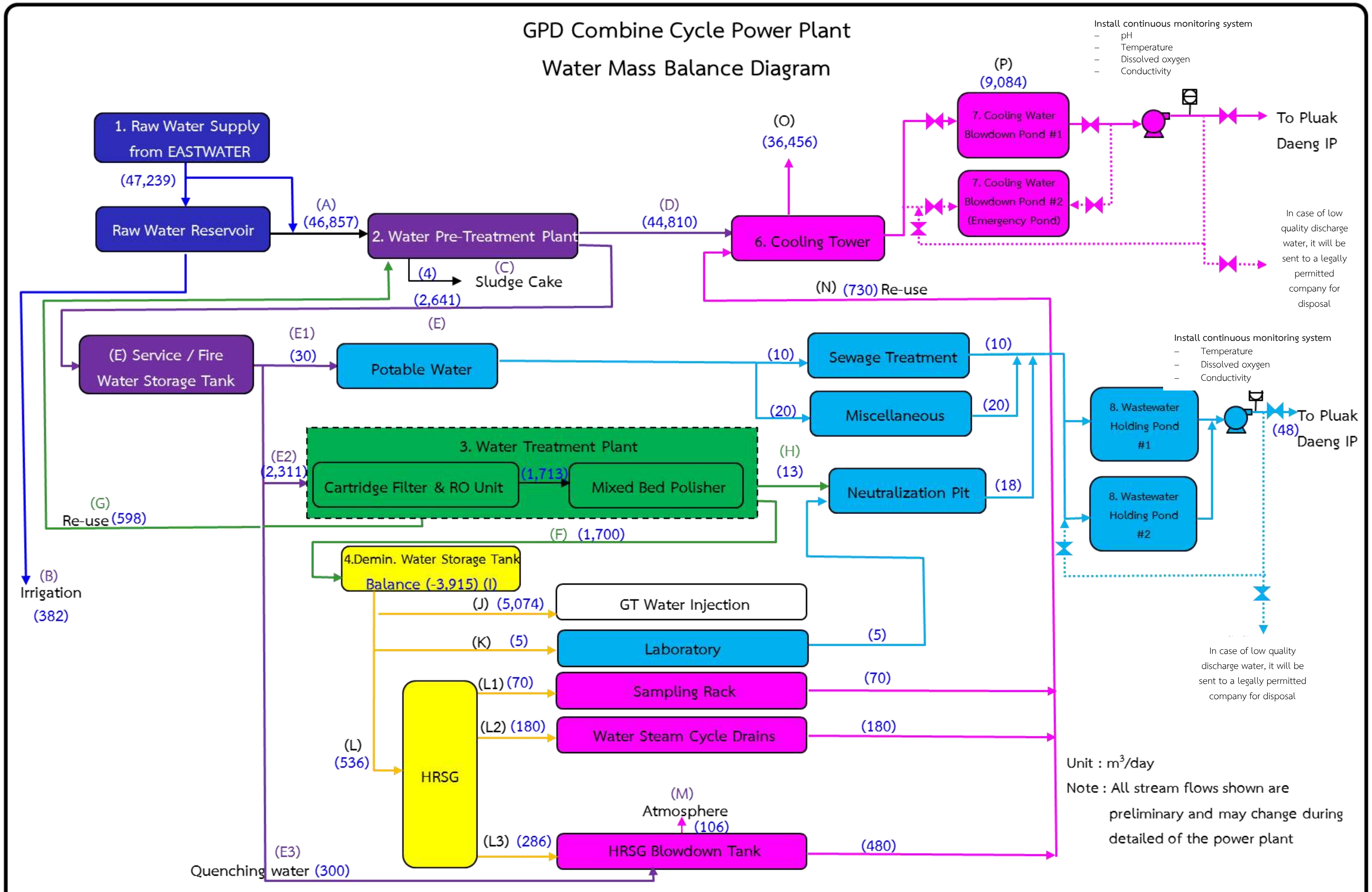


FIGURE 3.9-8 : WATER BALANCE SCHEMATIC DIAGRAM OF PLUAK DAENG POWER PLANT IN CASE OF NATURAL GAS-FIRED OPERATION AT MINIMUM LOAD (388 MW GROSS/375 MW NET)

TEAM



รูปที่ 2.9-9 :ผังสมดุลการใช้น้ำของโครงการกรณีที่ใช้น้ำมันดีเซลเป็นเชื้อเพลิงที่ 100% LOAD
(514 MW GROSS/500 MW NET)

TEAM

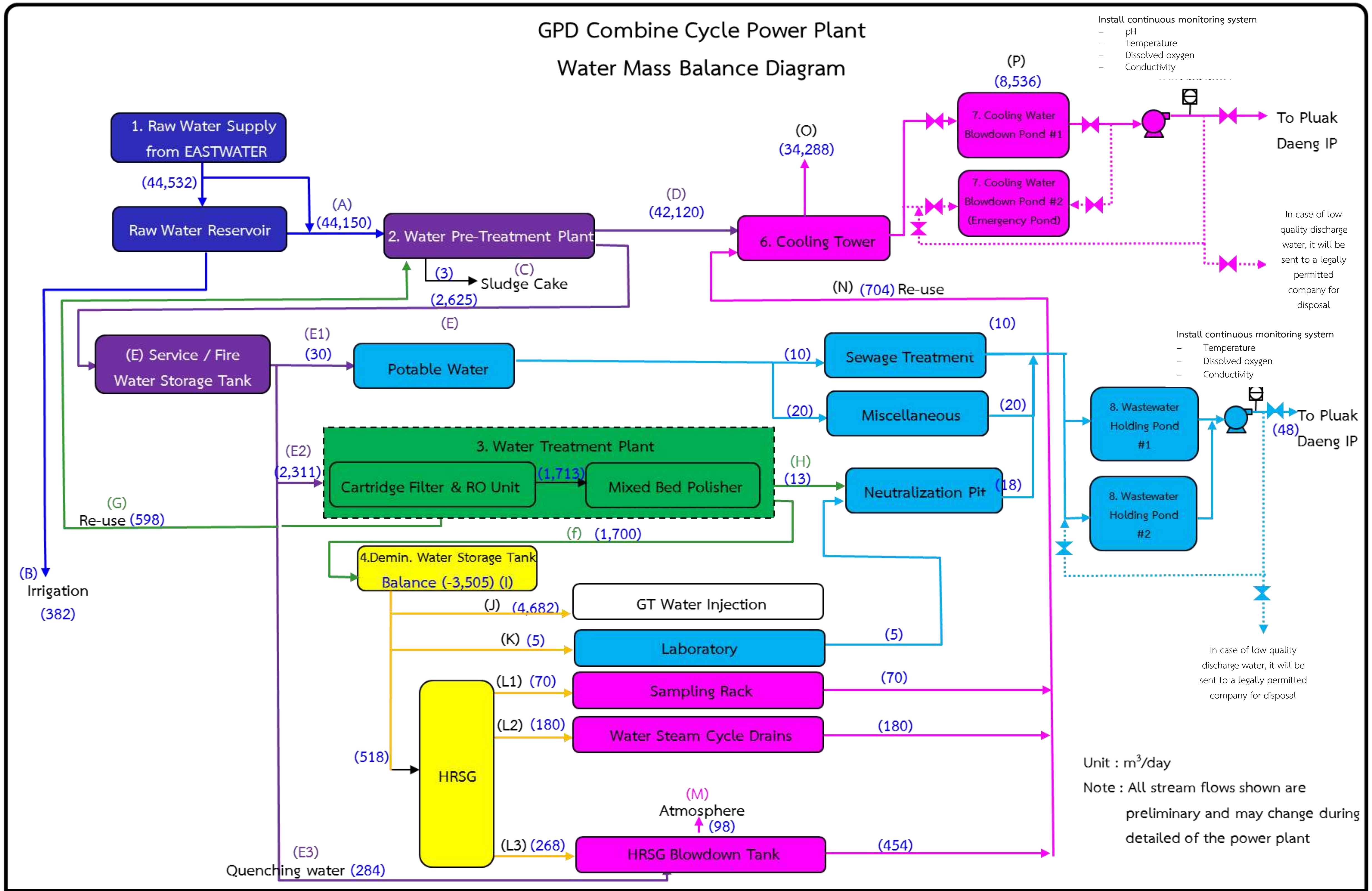


FIGURE 3.9-10 : WATER BALANCE SCHEMATIC DIAGRAM OF PLUAK DAENG POWER PLANT IN CASE OF DIESEL-FUELLED OPERATION AT INTERMEDIATE LOAD (451 MW GROSS/437.5 MW NET)

TEAM

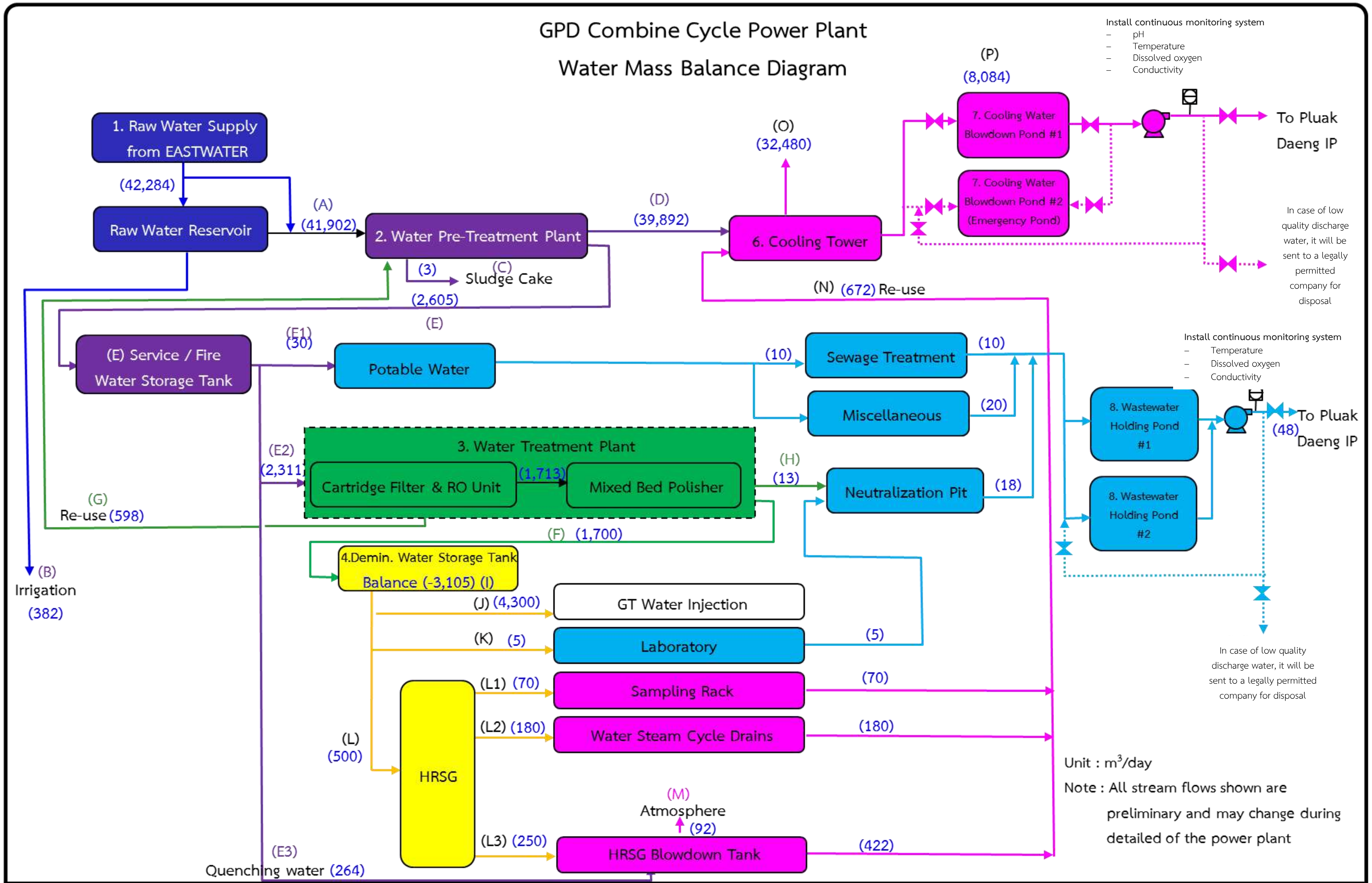


FIGURE 3.9-11 : WATER BALANCE SCHEMATIC DIAGRAM OF PLUAK DAENG POWER PLANT IN CASE OF DIESEL-FUELLED OPERATION AT MINIMUM LOAD (388 MW GROSS/375 MW NET)

TEAM

- Water inflow into demineralization system will be 2,311 m^3/day (from water pre-treatment system). The outflow volume from the system will be 2,311 m^3/day, comprising 1,700 m^3/day of demineralized water, 598 m^3/day of RO reject to be reused in water pre-treatment system, and 13 m^3/day of wastewater from mixed bed regeneration unit which will be routed to the neutralization basin for pH adjustment before being discharged to the wastewater holding pond.
- 599 m^3/day of the total demineralized water production of 1,700 m^3/day will be utilized while the remaining volume of 1,101 m^3/day (1,700 - 599) will be stored in the demineralized water storage tanks as reserve water for diesel-powered generation. The two demineralized water storage tanks have a total capacity of 13,200 m^3 which is sufficient for 3-day diesel fueled power generation. When the demineralized water reserve in the demineralized water storage tanks reaches its full storage level (taking about 13,200/1,101 = 12 days when operating on gas fuel to reach the full storage level), production of demineralized water will decrease to 599 m^3/day for generation process only as the reserve water storage is already full. Demineralized water usage of 599 m^3/day includes laboratory use (5 m^3/day), HRSG makeup water (70 m^3/day) to replace the water loss in random sampling and testing of water quality, HRSG makeup water (180 m^3/day) to replace cycle drain, and makeup water to compensate for HRSG blowdown (344 m^3/day).
- 344 m^3/day of HRSG blowdown water will be cooled down by 310 m^3/day of quenching water from the pre-treatment system. This water volume of 654 (344 + 310) m^3/day will partially evaporate into atmosphere (160 m^3/day) and the remaining 494 m^3/day will be recirculated to the cooling tower for reuse.
- Water used in random sampling and testing (70 m^3/day) and steam cycle drain (180 m^3/day) will be recirculated to the cooling tower for reuse.
- Cooling water inflow will be 61,304 m^3/day, divided into 60,560 m^3/day of pre-treated water, 70 m^3/day of recirculated water from water quality testing system, 180 m^3/day of recirculated water from steam piping system, and 494 m^3/day of recirculated water from boiler system. This makeup water will replace evaporation loss and cooling tower blowdown water. Five water recirculation cycles are designed in order to control total dissolved solids (TDS) in blowdown water not to exceed 1,300 mg/litre as specified in the environmental impact prevention and mitigation measures of Pluak Daeng Industrial Park. Evaporation loss in the cooling tower will be 49,072 m^3/day and cooling tower blowdown will be 12,232 m^3/day.

- 12,232 m^3/day of cooling tower blowdown will be directed to cooling water holding pond before discharging to the cooling water holding pond of Pluak Daeng Industrial Park. The effluent properties must meet the effluent standard of Pluak Daeng Industrial Park.
- Wastewater discharges into the project's wastewater holding pond will be 48 m^3/day. The inflows consist of wastewater from consumption in the power plant, including wastewater from general consumption (20 m^3/day) and grey water from bathrooms (10 m^3/day which will be treated in septic tank or onsite wastewater treatment system before flowing into the project's wastewater holding pond); laboratory wastewater (5 m^3/day) to be directed to the neutralization basin for pH adjustment before being discharged to the project's wastewater holding pond); and wastewater from mixed bed regeneration process (13 m^3/day) to be conveyed to the neutralization basin for pH adjustment before being released to the project's wastewater holding pond). Quality of effluents from the project's wastewater holding pond will be tested before being routed to the central wastewater treatment system of Pluak Daeng Industrial Park. The effluent properties must meet the effluent standard of Pluak Daeng Industrial Park for effluents discharged to the central wastewater treatment system of Pluak Daeng Industrial Park.

Diesel-fuelled Operation at Full Load (514 MW Gross, 500 MW Net)

- 47,239 m^3/day of raw water will be conveyed to the water pre-treatment plant at a rate of 46,857 m^3/day and used for irrigation at a rate of 382 m^3/day.
- For water pre-treatment system, water inflow volume will be 47,455 m^3/day, consisting of 46,857 m^3/day of raw water and 598 m^3/day of recycled water from demineralization system. About 47,455 m^3/day of pre-treated water will be distributed to various systems, consisting of 44,810 m^3/day for cooling water makeup, 300 m^3/day for quenching water for HRSG blowdown, 30 m^3/day for consumptive use in the power plant, and 2,311 m^3/day for demineralization system. Moreover, 4 m^3/day of sludge cakes from sedimentation system will be sent to a legally permitted company for disposal.
- Water inflow into demineralization system will be 2,311 m^3/day (from water pre-treatment system). The outflow volume from the system will be 2,311 m^3/day, comprising 1,700 m^3/day of demineralized water, 598 m^3/day of RO reject to be reused in water pre-treatment system, and 13 m^3/day of wastewater from mixed bed regeneration unit which will be routed to the neutralization basin for pH adjustment before being discharged to the wastewater holding pond.

- Even though the demineralized water production rate is 1,700 m^3/day, the diesel fueled operation will require 5,615 m^3/day of demineralized water. As a result, 3,915 (5,615 – 1,700) m^3/day of demineralized water has to be withdrawn from the demineralized water storage tanks. The two demineralized water storage tanks has a total capacity of 13,200 m^3 which is sufficient for 3-day continuous diesel fueled power generation (13,200/3,915 = 3.37 days). Nonetheless, when the demineralized water reserve is used up during diesel fueled operation process, the operation must switch to use natural gas and produce demineralized water reserve to be stored in the demineralized water storage tanks for next diesel fueled operations. Demineralized water usage of 5,615 m^3/day includes 5,074 m^3/day for GT water injection system to control NO_X emissions while using diesel fuel, laboratory use (5 m^3/day), HRSG makeup water (70 m^3/day) to replace the water loss in random sampling and testing of water quality, HRSG makeup water (180 m^3/day) to replace steam cycle drain, and makeup water to compensate for HRSG blowdown (286 m^3/day).
- 286 m^3/day of HRSG blowdown water will be cooled down by using 300 m^3/day of quenching water from the water pre-treatment system. This water volume of 586 (286 + 300) m^3/day will partially evaporate into atmosphere (106 m^3/day) and the remaining 480 m^3/day will be recirculated to the cooling tower for reuse.
- Water used in random water quality sampling and testing (70 m^3/day) and steam cycle drain (180 m^3/day) will be recirculated to the cooling tower.
- Cooling water inflow will be 45,540 m^3/day, divided into 44,810 m^3/day of pre-treated water, 70 m^3/day of recirculated water from water quality testing system, 180 m^3/day of recirculated water from steam piping system, and 480 m^3/day of recirculated water from boiler system. This makeup water will replace evaporation loss and cooling tower blowdown water. Evaporation loss in the cooling tower will be 36,456 m^3/day and cooling tower blowdown will be 9,084 m^3/day.
- 9,084 m^3/day of cooling tower blowdown will be sent to cooling water holding pond and its quality checked before flowing to the cooling water holding pond of Pluak Daeng Industrial Park. The effluent properties must meet the effluent standard specified by Pluak Daeng Industrial Park.
- Wastewater discharges into the project's wastewater holding pond will be 48 m^3/day. The inflows consist of wastewater from consumption in the power plant, including wastewater from general consumption (20 m^3/day) and greywater from bathrooms (10 m^3/day which will be treated in septic tank or onsite wastewater treatment system before being conveyed to the project's wastewater holding pond); laboratory wastewater (5 m^3/day) to be directed to the neutralization basin for pH adjustment before being discharged to the project's wastewater holding pond); and wastewater from mixed bed regeneration process (13 m^3/day) to be sent to the neutralization basin for pH adjustment before being

released to the project's wastewater holding pond). Quality of effluents from the project's wastewater holding pond will be tested before being directed to the central wastewater treatment system of Pluak Daeng Industrial Park. The effluent properties must meet the effluent standard of Pluak Daeng Industrial Park for effluents discharged to the central wastewater treatment system of Pluak Daeng Industrial Park.

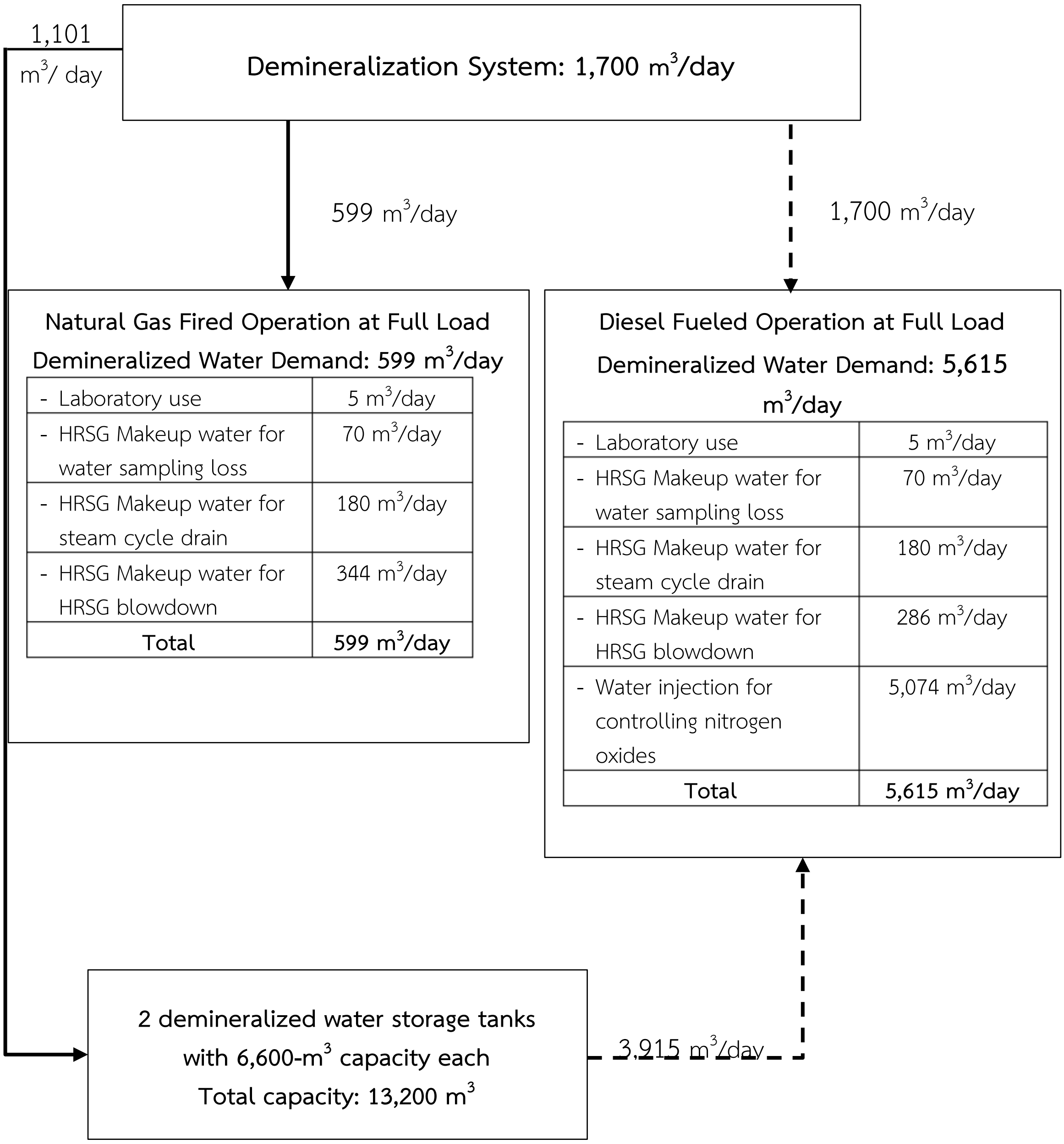
2.9.3 Demineralized Water

Demineralization system has a capacity of 1,700 m^3/day and the demineralized water will be kept in demineralized water storage tanks. The demineralized water will be produced in 2 cases: natural gas fired operation, and diesel fueled operation (**Figure 3.9-6** to **Figure 3.9-8** and **Figure 3.9-9** to **Figure 3.9-11**), with details given as follows:

(1) Natural Gas-fired Operation at Full Load (717 MW Gross, 700 MW Net): Demineralized water demand is 599 m^3/day, comprising laboratory use (5 m^3/day), HRSG makeup water (70 m^3/day) to replace the water loss in random sampling and testing of water quality, HRSG makeup water (180 m^3/day) to replace cycle drain, and makeup water to compensate for HRSG blowdown (344 m^3/day). The demineralized water production will be higher than the water demand by 1,101 (1,700 – 599) m^3/day. This surplus water of 1,101 m^3/day will be added to increase the water reserve in the demineralized water storage tanks (+1,101 m^3/day), as illustrated in **Figure 3.9-6**.

(2) Diesel-fuelled Operation at Full Load (514 MW Gross, 500 MW Net): Demineralized water demand is 5,615 m^3/day, comprising GT water injection (5,074 m^3/day) for controlling NO_X emissions, laboratory use (5 m^3/day), HRSG makeup water (70 m^3/day) to replace the water loss in random water sampling, HRSG makeup water (180 m^3/day) to replace steam cycle drain, and makeup water to compensate for HRSG blowdown (286 m^3/day). The demineralized water production volume is less than the water demand by 3,915 (5,615 - 1,700) m^3/day. This water deficit will be made up by withdrawals from the reserve water in demineralized water storage tanks, resulting in water storage depletion (- 3,915 m^3/day), as illustrated in **Figure 3.9-9**.

Consequently, the project's demineralization system will be operated in two cases: water storage in demineralized water storage tanks, and water withdrawal from the storage tanks (**Figure 3.9-12**). The project will have 2 demineralized water storage tanks, with 6,600-m^3 capacity each (13,200 m^3 in total capacity), which will be sufficient for 3-day continuous diesel-fuelled operation (13,200/3,915 = 3.37) at full load (500 MW Net). The demineralized water storage tanks can be replenished during 12-day continuous gas fired operation (13,200/1,101 = 11.99) at full load (717 MW Gross, 700 MW Net).



Remarks: The project will have 2 demineralized water storage tanks, with 6,600-m^3 capacity each (13,200 m^3 in total capacity), which will be sufficient for 3-day continuous diesel-fuelled operation at full load (514 MW Gross, 500 MW Net)

FIGURE 3.9-12 : WATER STORAGE AND WITHDRAWAL SCHEMATIC DIAGRAM OF DEMINERALIZED WATER STORAGE TANKS

3.10 STORMWATER DRAINAGE MANAGEMENT APPROACH

(1) Construction Phase

Local rainfall in the construction area may be contaminated by soil sediment, sand or construction waste. During construction phase, the existing site area will become paved with concrete or roofed, resulting in permeability reduction or increase of runoff coefficient in comparison to the existing conditions. The runoff volume will be higher according to the project construction schedule-a rise from 7.63 m^3/s to 15.12 m^3/s after completion of construction (Details are explained in Chapter 5, item 5.15 Drainage and Flood Control).

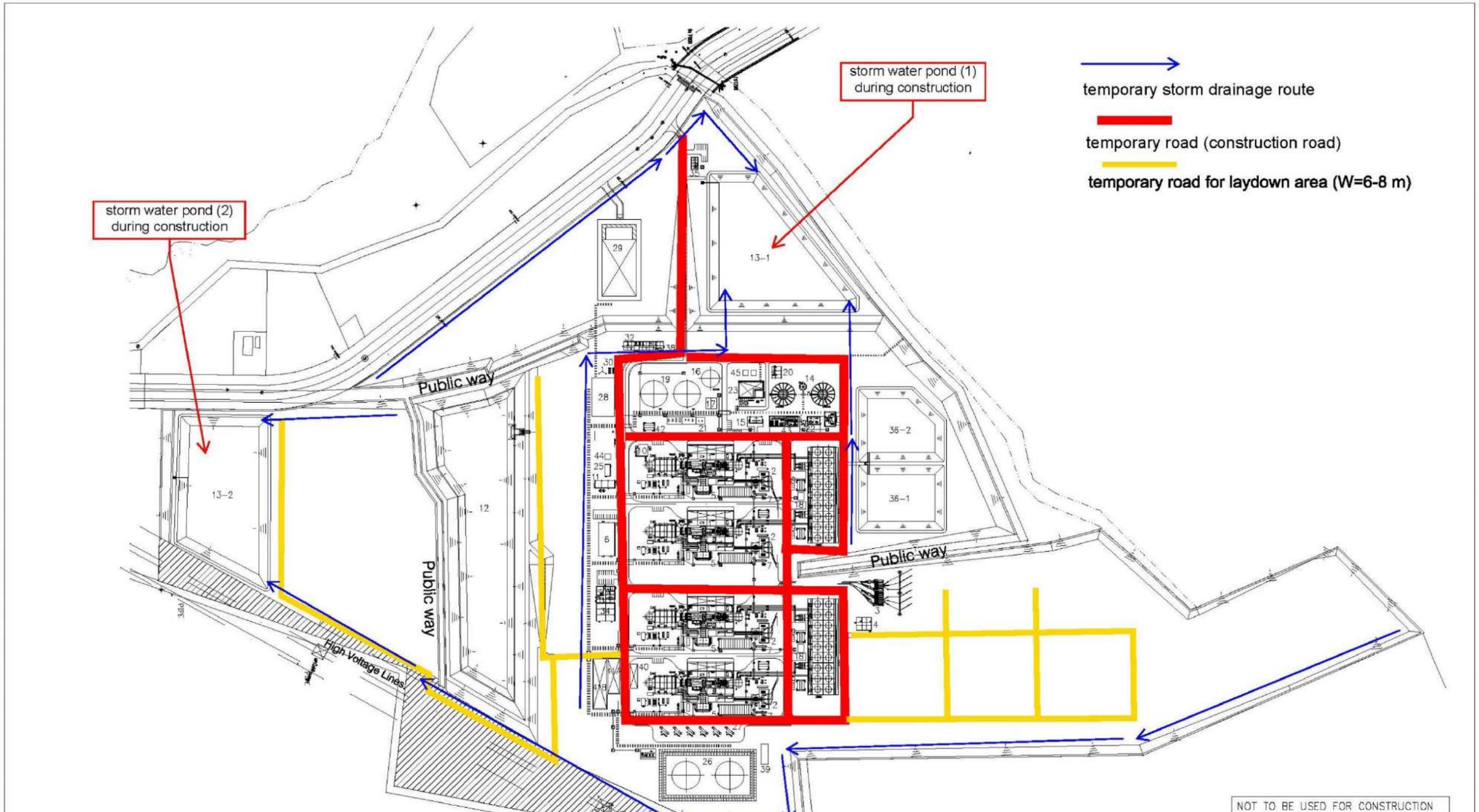
Temporary drainage system has been designed along road alignment or building boundary for construction phase. The system is separated into non-contaminated storm drain and contaminated storm drain. Non-contaminated stormwater runoff will be intercepted and drained into the project's stormwater retention pond with a capacity of 99,797 m^3 which is capable of retaining stormwater for 3 hours. This retention period will allow soil or sand sedimentation before releasing clear water to storm drains of Pluak Daeng Industrial Park, as depicted in **Figure 3.10-1**. Stormwater retention pond will be constructed since the beginning of construction works. Temporary storm drains will be improved to become permanent reinforced concrete storm drains in the operation phase.

(2) Operation Phase

The project's storm drain system is designed to be a gravity system draining into 2 stormwater retention ponds in the project area, with a total capacity of 99,797 m^3. The system is capable of retaining stormwater for 3 hours, without any increase in stormwater discharge rate compared to pre-project conditions (rainfall intensity is 100 mm per hour x 3 hours, and the pre-project and post-project C values are 0.3 and 0.7 respectively). Stormwater in the stormwater retention pond can be pumped to supply raw water to the power plant. In addition, it can be sent to storm drains of Pluak Daeng Industrial Park which are separated from wastewater system for the Industrial Park's clients. Flow directions of the project's storm drain system are shown in **Figure 3.10-2**. The project's storm drain system will be clearly separated from other wastewater systems.

Calculation sheets of storm drain system and retention pond are provided in **Appendix 3N**.

In case stormwater is not pumped for reuse in the project but discharged to storm drains of Pluak Daeng Industrial Park, storm drain system of the Industrial Park can accommodate such runoff volume. Stormwater discharge rate from the project area is equivalent to 6.56 m^3/s which equals the pre-project rate. The Industrial Park's storm drain section passing in front of the project site can handle a peak stormwater discharge rate of about 51 m^3/s.



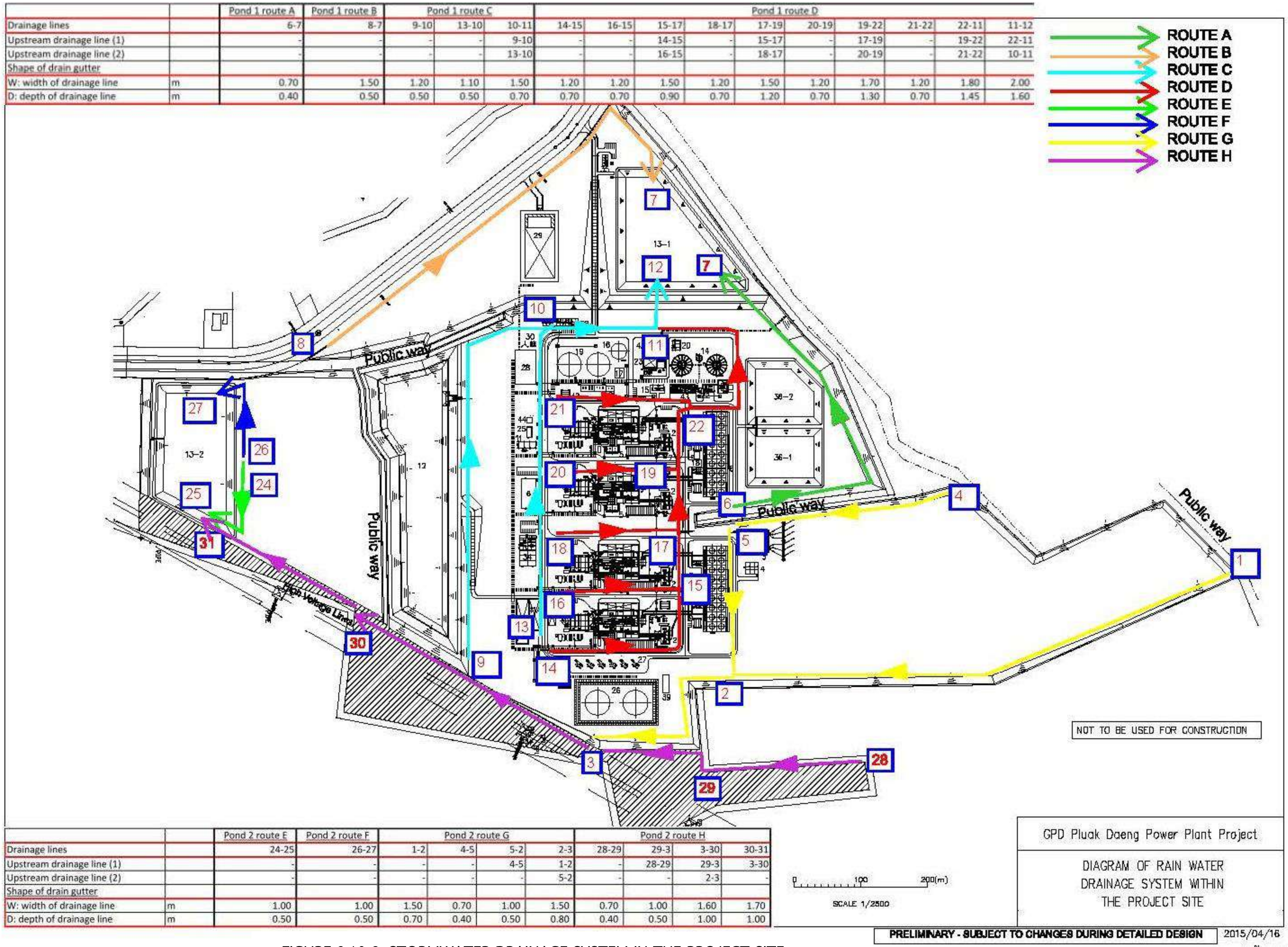
	EQUIPMENT LIST
1	TURBINE BUILDING
2	STEP-UP TRANSFORMER
3	500kV SWITCHYARD (OUTDOOR TYPE GIS)
4	500kV SWITCHYARD CONTROL BUILDING
5	ELECTRICAL PACKAGE
6	CENTRAL CONTROL BUILDING
7	EMERGENCY D/G PACKAGE
8	COOLING TOWER
9	COOLING TOWER ELECTRICAL PACKAGE
10	AUX. BOILER
11	AIR COMPRESSOR BUILDING
12	RAW WATER POND
13-1	STORM WATER RETENSION POND-1
13-2	STORM WATER RETENSION POND-2
14	WATER TREATMENT PLANT AREA
15	WATER TREATMENT CONTROL ROOM
16	SERVICE & FIRE WATER STORAGE TANK
17	F/F PUMP PACKAGE
18	CW CHEMICAL DOSING
19	DEMI. WATER TANK

	EQUIPMENT LIST
20	LABORATORY HOUSE
21	CLARIFIED WATER & SERVICE & BACK WASH PUMP AREA
22	NEUTRALIZATION BASIN
23	CLEAR WELL BASIN
24	NOT USED
25	GAS STORE (H2,CO2,N2 BOTTLE) (SUNSHADE)
26	FUEL OIL TANK
27	FUEL OIL UNLOADING STAITION & TRANSFER PUMP AREA
28	GAS COMPRESSOR AREA
29	GAS METERING STATION (SUPPLIED BY OTHERS)
30	FUEL GAS TREATMENT SYSTEM
31	NOT USED
32	ADMINISTRATION BUILDING
33	NOT USED
34	MAINTENANCE WORK SHOP / WAREHOUSE BUILDING
35	GUARD HOUSE
36-1	COOLING WATER HOLDING POND-1
36-2	COOLING WATER HOLDING POND-2
37	NOT USED
38	PARKING SPACE FOR ADMINISTRATION BUILDING

	EQUIPMENT LIST
39	OIL SEPARATOR
40	SITE OFFICE & CONTAINER AREA FOR MAINTENANCE
41A 41B	LAYDOWN AREA FOR MAINTENANCE
42	COMMON FACILITIES ELECTRICAL PACKAGE
43	DEMI. WATER PLANT
44	LIQUID MATERIALS STORAGE AREA
45	WASTE WATER HOLDING POND

FIGURE 3.10-1 : TEMPORARY DRAINAGE SYSTEM AND STORMWATER PONDS DURING CONSTRUCTION PHASE

		Pond 1 route A	Pond 1 route B	Pond 1 route C			Pond 1 route D									
Drainage lines		6-7	8-7	9-10	13-10	10-11	14-15	16-15	15-17	18-17	17-19	20-19	19-22	21-22	22-11	11-12
Upstream drainage line (1)		-	-	-	-	9-10	-	-	14-15	-	15-17	-	17-19	-	19-22	22-11
Upstream drainage line (2)		-	-	-	-	13-10	-	-	16-15	-	18-17	-	20-19	-	21-22	10-11
Shape of drain gutter																
W: width of drainage line	m	0.70	1.50	1.20	1.10	1.50	1.20	1.20	1.50	1.20	1.50	1.20	1.70	1.20	1.80	2.00
D: depth of drainage line	m	0.40	0.50	0.50	0.50	0.70	0.70	0.70	0.90	0.70	1.20	0.70	1.30	0.70	1.45	1.60



		Pond 2 route E	Pond 2 route F	Pond 2 route G				Pond 2 route H			
Drainage lines		24-25	26-27	1-2	4-5	5-2	2-3	28-29	29-3	3-30	30-31
Upstream drainage line (1)		-	-	-	-	4-5	1-2	-	28-29	29-3	3-30
Upstream drainage line (2)		-	-	-	-	-	5-2	-	-	2-3	-
Shape of drain gutter											
W: width of drainage line	m	1.00	1.00	1.50	0.70	1.00	1.50	0.70	1.00	1.60	1.70
D: depth of drainage line	m	0.50	0.50	0.70	0.40	0.50	0.80	0.40	0.50	1.00	1.00

FIGURE 3.10-2: STORMWATER DRAINAGE SYSTEM IN THE PROJECT SITE

Calculation sheets of stormwater discharge rate from the project area and storm drain capacity of Pluak Daeng Industrial Park are given in **Appendix 3O**.

Local rainfall in areas with possibility of oil contamination, e.g. concrete dike around the diesel storage tank, etc., will be collected within the diked area. The dike is compacted earth core concrete dike, 2.85 m high, with slope of 1:2. Moreover, HDPE sheets will be installed below the top surface of the dike to prevent seepage and the reinforced concrete structures will be 10 centimetres thick, as presented in **Figure 3.10-3**. The oil contaminated runoff will be sent to an oil/water separator to separate oil before being pumped to the central wastewater treatment system of Pluak Daeng Industrial Park. The locations of oily areas and oil/water separators are shown in **Figure 3.10-4**. Calculation sheets of dike capacity in oily areas for 10-year rainfall intensity (116.22 mm/hour) in 15 minutes are given in **Appendix 3P**.

The study report of flood impact regarding to cooling water discharge from Pluak Daeng Power Plant Project, Pluak Daeng district, Rayong Province (2014), as provided in **Appendix 3Q**, shows that Pluak Daeng Power Plant is situated on a hill on the left bank of Huai Phu Sai. A small stream traverses the northern area of the Industrial Park through the middle part before joining Huai Phu Sai, where there is a weir in front of the Industrial Park. The stream then flows further into Dok Krai reservoir. Therefore, the existing flood probability in the project area and study area is based on 2 factors: overflows from the small stream passing the northern area of the Industrial Park or overflows from Huai Phu Sai, with a weir on the channel blocking the streamflow during flood seasons, and continuous heavy rainfall in the river basin.

The environmental impact study of power plant cooling water discharge also analyzed the streamflow pattern in the project area, using MIKE 11 HD model to analyze floods at different return periods, from 5 years to 100 years, for both pre- and post-project conditions. The analysis results regarding flood level changes due to the discharge of cooling water from Pluak Daeng Power Plant are presented as follows:

Cooling water discharge of the project will not cause any increase in the maximum flood level: The project's cooling water discharge volume is very small. When compared to the flood volume from the upstream areas at 5 - to 100-year return periods, it is found that the maximum flood level is in the range of 90.4 – 141.4 m^3/s. This is much higher than the project's cooling water volume (0.142 m^3/s) which is equivalent to about 0.16% and 0.10% of the maximum flood volume at return periods of 5 years and 100 years respectively.

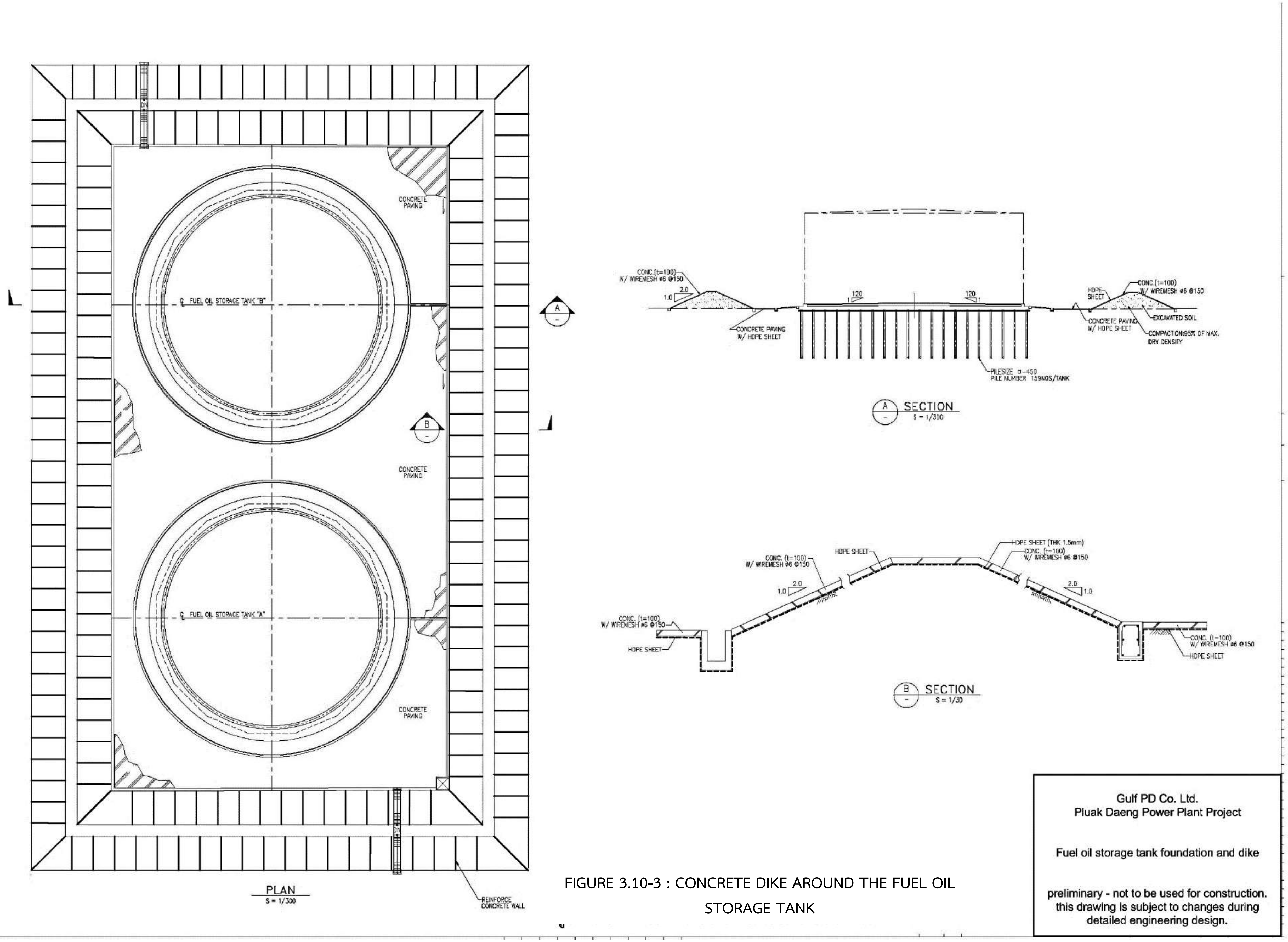


FIGURE 3.10-3 : CONCRETE DIKE AROUND THE FUEL OIL STORAGE TANK

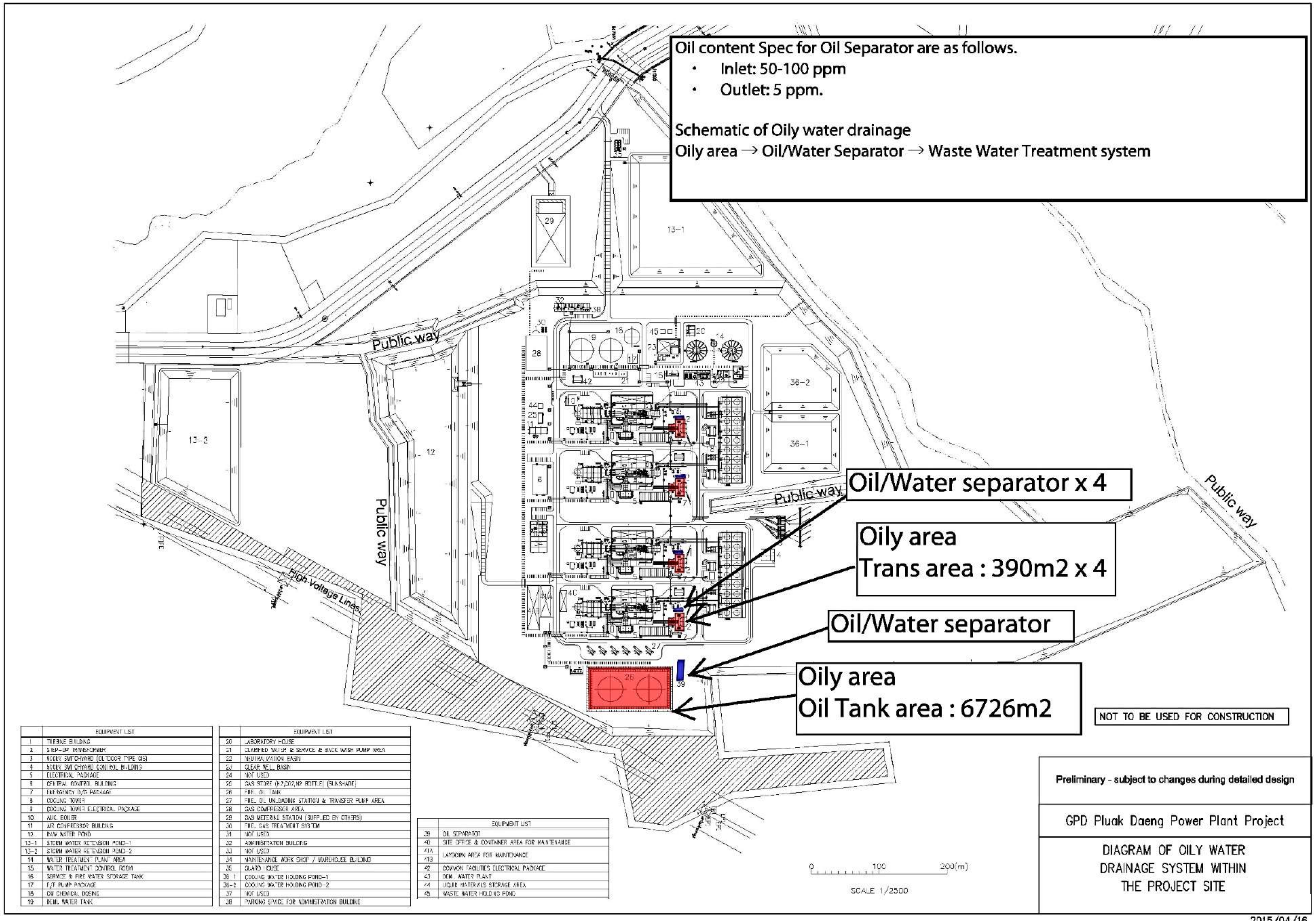


FIGURE 3.10-4 : LOCATIONS OF OILY AREAS AND OIL/WATER SEPARATOR

2.11 POLLUTION AND CONTROL

2.11.1 Air Pollution and Control

(1) Air Pollution Point Sources

During construction phase, activities causing environmental impacts are open excavation, stripping for foundation works and pond excavation, with total suspended particles (TSP) as the generated pollutant. Preliminary impact mitigation is to spray water over the construction area at least twice a day.

Air pollution during operation phase will be generated from natural gas combustion to drive the combustion turbines. In normal situation, exhaust gases will be released via stack of heat recovery steam generator (HRSG) of each turbine. Main pollutants in the exhaust gases are nitrogen oxides (NO_x), sulfur dioxide (SO_2) and total suspended particles (TSP). Air pollution emissions through the project' stacks during operation phase are presented in **Table 3.11-1**.

The criteria for air pollution emission control of Pluak Daeng Industrial Park show that pollution emission data of Pluak Daeng Power Plant are within the limits prescribed by Pluak Daeng Industrial Park (Certificate of capabilities for handling air pollution emission rates of Pluak Daeng Industrial Park is shown in **Appendix 3S**).

(2) NO_x Emission Control Technology

As the project site is located within Pluak Daeng Industrial Park, air pollution emission requirements for IPP power plants are stipulated in environmental impact prevention and mitigation measures and environmental monitoring measures in the Environmental Impact Assessment Report, Pluak Daeng Industrial Park Project, Expansion Phase 1, February 2016 (**Appendix 3T**), as shown in **Table 3.11-2**. As a result, Dry Low NO_x (DLN) combustion technology is selected for controlling NO_x emissions released via stacks in case of natural gas-fired operation while water injection technology is chosen for diesel-fuelled operation. This is to control NO_x emissions to be consistent with the air pollution emission requirements for IPP power plants of Pluak Daeng Industrial Park and air pollution emission standard for new power plants in accordance with the Notification of the Ministry of Natural Resources and Environment Regarding Air Pollution Emission Standard for New Power Plants announced on 20th December 2009 and the Notification of the Ministry of Industry B.E.2547 (2004) Regarding Emission Standards for Power Generation, Transmission or Distribution Plants. In case of natural gas-fired operation, NO_x emissions shall not exceed 59 ppm at 7% O_2 which is lower than the legal limit of 120 ppm at 7% O_2. In case of diesel-fuelled power generator, NO_x emissions shall not exceed 99 ppm at 7% O_2 which is lower than the legal limit of 180 ppm at 7% O_2.

TABLE 3.11-1
AIR POLLUTION EMISSION DURING PROJECT OPERATION

Description	Fuel Type	Unit	In Case of Normal Operation		
			Minimum Generation Load	Intermediate Load	Full Load
Production Data (in case of natural gas-fired operation)					
Net Output	Natural gas	MW/1 unit	375	537.5	700
Lower Heating Value (LHV)	Natural gas	kJ/kg	46,600	46,600	46,600
Fuel Consumption	Natural gas	MMscf/day/4 units	240	324	412
Production Data (in case of diesel-fuelled operation)					
Net Output	Diesel	MW/1 unit	375	437.5	500
Lower Heating Value (LHV)	Diesel	kJ/kg	43,148	43,148	43,148
Fuel Consumption	Diesel	Litre/day/4 units	7,003,000	7,839,000	8,631,000
Stack Data					
Stack diameter		m	8	8	8
Number of stacks		Stack	4	4	4
Stack height above ground level		m	60	60	60
Air Pollution Emission (in case of natural gas-fired operation)					
Net Output	Natural gas	MW/1 unit	375	537.5	700
SO_2 (20) */**		ppm	10	10	10
NO_2 (120) */**		ppm	59	59	59
Particulates (60) */**		mg/Nm^3	20	20	20
Emission velocity		m/s	15.8	19.5	23.1
Stack outlet temperature		°C	76	80	83
Air Pollution Emission (in case of diesel-fuelled operation)					
Net Output	Diesel	MW/1 unit	375	437.5	500
SO_2 (260*) (320**)		ppm	20	20	20
NO_2 (180)*/**		ppm	99	99	99
Particulates (120)*/**		mg/Nm^3	35	35	35
Emission velocity		m/s	17.2	19.0	21.1
Stack outlet temperature		°C	82	87	96

Remarks : (1) Figures in the above table were computed from 1 unit of combined cycle power plant (1 gas turbine unit) at local conditions with ambient temperature of 32.5°C, ambient pressure of 1000.9 mbar, and 76% relative humidity

(2) Emission concentration is at 25°C, pressure of 760 mmHg, 7% Oxygen on a dry basis.

(3) Oxides of sulphur concentration were calculated based on the assumption that hydrogen sulphide (H_2S) content in the natural gas does not exceed 50 ppm and sulfur content in diesel oil does not exceed 0.005%.

(4) Figures in ( ) mean emission standard for power plants according to (*) the Notification of the Ministry of Natural Resources and Environment Regarding Air Pollution Emission Standard for New Power Plants announced on 20th December 2009 and (**) the Notification of the Ministry of Industry B.E. 2547 (2004) Regarding Emission Standards for Power Generation, Transmission or Distribution Plants.

Source : Gulf PD Co., Ltd., 2016

TABLE 3.11-2
EMISSION RATE OF PLUAK DAENG POWER PLANT PROJECT

Description	Unit	Natural Gas at Full Load	Diesel Oil at Full Load	Standard Value[(1),(2)]		Requirements of Pluak Daeng Industrial Park[(3)]	
				Natural Gas	Diesel Oil	Natural Gas	Diesel Oil
Pollution Concentration							
– NOx as NO_2 @ 7%O_2	ppmvd	59	99	120	180	80	110
– SOx as SO_2 @ 7%O_2	ppmvd	10	20	20	260	14	28
– TSP @ 7%O_2	mg/m^3	20	35	60	120	32	44
Emission Rate/Stack							
– NO_2	g/s	58.6	74.0	-	-	66.36	75.00
– SO_2	g/s	13.9	21	-	-	15.79	25.79
– TSP	g/s	9.7	12.9	-	-	12.35	14.22

Remarks : (1) Emission standard values for power plants according to the Notification of the Ministry of Natural Resources and Environment on Emission Standards for New Power Plants, announced on 20th December 2009.

(2) Emission standard values for power plants according to the Notification of the Ministry of Industry B.E. 2547 (2004) Regarding Emission Standards for Power Generation, Transmission or Distribution Plants.

(3) Air pollution emission requirements for IPP power plants as stipulated in environmental impact prevention and mitigation measures and environmental monitoring measures in the Environmental Impact Assessment Report, Pluak Daeng Industrial Park Project, Expansion Phase 1, February 2016 (Appendix 3T).

Source : Gulf PD Co., Ltd., 2016

Details of Dry Low NO_x (DLN) combustion and water injection technologies are provided in **Appendix 3U.** A certificate of air pollution abatement efficiency from the manufacturer is presented in **Appendix 3V**.

Moreover, the project has specified continuous air quality monitoring by measuring NO_2, SO_2 and TSP emissions from the stacks and controlling them to be within the standard limits in order to prevent probable adverse impacts on people's health and agricultural products in the project vicinity.

(3) Installation of Continuous Emission Monitoring System

Continuous Emission Monitoring System (CEMS) will be installed, comprising equipment for NO_x, SO_2 and TSP concentration measurement. The monitoring will be consistent with U.S. EPA standards, etc., and Oxygen (O_2), flow rate, and temperature will also be measured. CEMS equipment will be installed at each stack outlet of heat recovery steam generator (HRSG) to continuously monitor and display emission data. Furthermore, a manual sampling port is provided on each HRSG stack in addition to monitoring by CEM system.

(4) Monitoring Plan for Prevention of Excessive NO_x Emission

A monitoring plan has been put in place to prevent NO_x emissions that may exceed the set limits of 59 and 99 ppm on a dry basis and 7% excess oxygen in case of natural gas-fired operation and diesel-fuelled operation, respectively. In the event of abnormal CEMS results, the system will send an alarm signal to the control room to notify the operator so that root cause analysis can be performed and solutions implemented.

In addition, a preventive inspection and maintenance plan has been established to ensure full efficiency of emission control device operation at all times and to prevent any abnormal event that may occur in the system operation. Details of the preventive inspection and maintenance plan will be consistent with the machinery manufacturers' manuals. Besides, necessary spare parts will be sufficiently available for immediate response in emergency cases.

3.11.2 Noise Pollution and Control

3.11.2.1 Construction Phase

(1) Noise Sources and Noise Levels

During construction phase of Pluak Daeng Power Plant Project, excavation machinery or stripping equipment for foundation works, and furnishing/inspection typically produce high noise levels. The maximum noise level produced by excavation activities for foundation works will be 89 dB (A) at a reference distance of 15 meters from noise source.

(2) Noise Level Control and Prevention

- Contractors are required to use appropriate low noise machines and equipment which must be maintained in good condition.
- Noisy construction activities will not be carried out during 18.00-07.00 hrs. If it is necessary to carry out such activities during the aforesaid period, coordination with relevant agencies and communities must be undertaken to inform them in advance.

3.11.2.2 Operation Phase

(1) Noise Sources and Noise Levels

Noise level of machines and equipment used in the project shall not exceed 85 decibels (A) at a distance of 1 meter from machinery. The project machines and equipment consist of the following.

- Gas turbines (GTs)
- Heat recovery steam generators (HRSGs)
- Steam turbines (STs)
- Generators

- Cooling tower machines
- Circulating water pumps
- Feed water pumps
- Electric motors
- Air compressors
- Control valves and associated pipe work
- Gas compressors
- Cooling fans for transformers

For some equipment that may produce loud noise, e.g. safety valves, and start up vent valves, etc., silencers will be installed to reduce noise levels. Besides, the general noise level at the project fence area will not exceed 70 decibels (A).

However, the aforementioned noise level is expected to occur during normal operations excluding abnormal events such as:

- Operation startup
- Operation shutdown
- Abnormal equipment performance during operation

In case of non-emergency incidents or if an implementation plan is known in advance, the project's public relations unit will inform communities around the project area prior to commencement of activities that may produce very high noise levels.

(2) Noise Control and Prevention

- For noisy machines and equipment, e.g. gas turbine, steam turbine, HRSG, gas compressor, etc., noise levels shall not exceed 85 decibels (A) at a distance of 1 meter from machinery or sound absorbing materials.
- When installing noisy machines for Pluak Daeng Power Plant Project, noise abatement devices such as silencers shall be installed at the end of the pipe that may produce noise.
- A warning sign or symbol shall be put up in areas with noise level exceeding 80 decibels (A) such as heat recovery steam generator (HRSG), combustion chamber of gas turbine, etc. Workers working in noisy areas shall wear noise abatement devices such as ear plugs, ear muffs, etc.
- Personal protective equipment, e.g. ear plugs, ear muffs, etc., shall be provided for employees working in areas with noise level exceeding 80 decibels (A).

3.11.3 Wastewater and Wastewater Management

(1) Construction Wastewater (as shown in Table 3.11-3)

Wastewater from workers' consumption is estimated at 179.2 m^3/day or about 80% of water consumption (Thongchai Panswad, 1987). The maximum number of workers is anticipated to be 3,200 persons, with 224 m^3/day of water demand based on a water use rate of 70 litres/person/day. Wastewater will be treated by septic tank installed in the project's office building area. Treated effluents will be discharged to a polishing pond (with 1-day storage capacity) to ensure that the effluent quality is in compliance with the Building Effluent Standard for Building Category C according to the Notification of Ministry of Natural Resources and Environment Prescribing Effluent Standards for Some Building Types or Sizes Before Discharging outside the Project Area. Effluent quality monitoring must be performed once a month during construction phase. Contractors are required to provide bathrooms and toilets in a ratio of 15 persons per unit for workers and construction supervision staff (Source: Ministerial Regulation No. 63, B.E.2551 (2008) issued pursuant to the Building Control Act B.E.2552 (2009).

TABLE 3.11-3
WASTEWATER POINT SOURCES AND WASTEWATER MANAGEMENT METHODS DURING THE PROJECT CONSTRUCTION PHASE

Activity	Wastewater Volume (m^3/day)	Treatment Method
1. Wastewater from workers' consumption (computed based on a water use rate of 70 litres/person/day and 3,200 workers)	179.2	– Septic tank -> central wastewater treatment system of the Industrial Park
2. Wastewater from construction activities – Wastewater from construction activities	55	– Non-contaminated wastewater from construction activities will be conveyed to a temporary sedimentation pond. Clear water will be used for spraying the project area while the remaining water will be drained to drainage ditches of the Industrial Park.
– Water discharge from hydrostatic testing of natural gas and oil pipelines [1/]	250[1/]	– The discharge will be directed to the central wastewater treatment system of the Industrial Park
Total	**234.2**	

Remarks : [1/] Water for hydrostatic test is required for pipeline testing only which does not occur every day.
Source : Gulf PD Co., Ltd., 2016

Wastewater from construction activities, about 55 m^3/day, is primarily generated by cleaning of construction equipment,

Additionally, 250 m^3 of water will be discharged from hydrostatic test of natural gas and oil transmission pipelines. The discharge will occur only once during the test-not an everyday occurrence (A written enquiry and a certificate of capabilities for water supply and treatment of hydrostatic test water discharges are provided in **Appendix 3D**). The project wastewater will be directed to the central wastewater treatment system of Pluak Daeng Industrial Park which has set out requirements for hydrostatic test water discharges as follows:

- Installation of fine mesh screen or net to trap debris and solids in the hydrostatic test water discharge at the end of drain pipes before discharging to the central wastewater treatment system of the Industrial Park;
- Checking of hydrostatic test water discharge covering pH value, temperature, suspended solids, oil and grease to ensure that the effluent characteristics are in compliance with the effluent requirements of Pluak Daeng Industrial Park before discharging to the central wastewater treatment system of the Industrial Park;
- When the project is ready to start operations, the Industrial Park management will be informed of the details of operation schedule prior to commencement.

(2) Wastewater from Project Operation

The point sources of wastewater from project operation can be considered from the water balance schematic diagram (**Figures 3.9-6** to **Figure 3.9-11**). A summary of wastewater point sources is presented in **Table 3.11-4**. Wastewater generated by the project can be classified into the following 2 types.

(a) Cooling water blowdown (12,232 m^3/day): Cooling water blowdown with reduced temperature will be discharged from cooling water system and kept in the cooling tower basin. This basin will have a storage capacity greater than 12,232 m^3-sufficient for accommodating 1-day cooling water blowdown. After that, blowdown water will be discharged to 2 cooling water holding ponds, with a capacity of 19,000 m^3 each, to hold water for at least 1 day. While one pond is in use, the other will serve as an emergency pond before discharging to the Industrial Park's cooling water holding pond with a capacity for storing 1-day cooling water blowdown. These are cooling water management measures according to the Environmental Impact Assessment Report, Pluak Daeng Industrial Park Project, Expansion Phase 1 (February 2016). The effluent characteristics shall comply with the standards of relevant agencies such as Notification of the Ministry of Industry No.2, B.E.2539 (1996) Regarding Industrial Effluent Standards. The value of total dissolved solid (TDS) shall be in accordance with the standard for effluents discharged into irrigation systems of the Royal Irrigation Department (TDS shall not exceed 1,300 milligrams/litre) and temperature shall not exceed 34°C.

Water Quality Parameters	Characteristics of Cooling Water Effluents Discharged to Cooling Water Holding Pond of Pluak Daeng Industrial Park	
	Pluak Daeng Power Plant	Ministry of Industry [1/]
Temperature	34°C	40°C
pH	5.5 - 9.0	5.5 - 9.0
Total Dissolved Solid (TDS)	1,300 mg/l[2/]	3,000 mg/l

Remarks : [1/] Notification of the Ministry of Industry No. 2, B.E. 2539 (1996) Regarding Industrial Effluent Standards
[2/] Effluent Characteristics discharged into irrigation systems of Royal Irrigation Department

TABLE 3.11-4
WASTEWATER POINT SOURCES, GENERATION RATE AND WASTEWATER MANAGEMENT METHODS OF THE PROJECT

Wastewater Point Sources	Maximum Generation Rate (m^3/day)[1/]	Management Method	Wastewater Generation (Continuous/ Non-continuous)
a. Wastewater from cooling system			
1. Cooling tower blowdown	12,232	– Cooling water holding pond of the power plant → cooling water holding pond of Pluak Daeng Industrial Park	Continuous
Total	**12,232**		
b. Wastewater from generation process			
1. Water treatment system (demineralization system) – wastewater from Mixed Bed Regeneration	13	– Neutralization pond → wastewater holding pond of the power plant → central wastewater treatment system of the Industrial Park	Non-continuous
2. Laboratory wastewater	5	– Neutralization pond → wastewater holding pond of the power plant → central wastewater treatment system of the Industrial Park	Non-continuous
3. Wastewater from consumption	30	– Septic tank (10 m^3/day) → wastewater holding pond of the power plant → central wastewater treatment system of the Industrial Park	Continuous
Total	**48**		
Total wastewater from (a) and (b)	**12,280**		

Remarks : [1/] Wastewater volume was calculated in case of operation at full load (100% load) using natural gas fuel.
Source : Gulf PD Co., Ltd., 2016

Online monitoring system has been installed to measure temperature, pH value, dissolved oxygen, and conductivity (to check the total volume of total dissolved solids) in the cooling water holding pond to comply with the Notification of the Ministry of Industry No.2, B.E.2539 (1996) Regarding Industrial Effluent Standards with the exception of total dissolved solids which must be in compliance with the Royal Irrigation Department's standard for effluents discharged into irrigation systems (TDS shall not exceed 1,300 milligrams/litre), as depicted in **Figure 3.11-1**. Furthermore, the project must adhere to with the measures recommended in the EIA Report of Pluak Daeng Industrial Park Project, Expansion Phase 1, which had been approved by ONEP according to the letter No. Thor Sor. 1009.3/15746 dated 29th December 2015. Pluak Daeng Industrial Park has set forth environmental impact prevention and mitigation measures and environmental monitoring measures (operation phase) for cooling tower blowdown from IPP plants, with details presented in **Appendix 3T**.

Management of cooling tower blowdown water in normal cases and in case of water quality non-compliance **(Figure 3.11-2)** is explained as follows:

– **Cooling Water Holding Pond and Emergency Water Pond**: Before discharging from the power plant, cooling water blowdown will be stored in the cooling water holding pond 1 which can hold the blowdown water for at least 1 day. For the cooling water holding ponds 2 and 3, each has a 1-day storage capacity. To prevent seepage, each pond will be lined with HDPE sheets. In normal operation, only one of the cooling water holding ponds 2 or 3 will be used, with the unused pond being kept dry to serve as an emergency pond.

– **Control Valve**: This part describes the system's main valves. The 1st valve will be closed when the cooling tower blowdown quality exceeds the set standard value. The 2nd valve and 3rd valve will manage water inflows into the cooling water holding ponds 2 and 3 respectively. The 6th valve and 7th valve will manage cooling tower blowdown prior to discharging to the cooling water holding pond of the Industrial Park in order to enhance the wastewater management capabilities.

– **Water Pumps**: Water pumps will be used to pump and deliver water from the cooling water holding ponds 2 and 3 to outside the power plant. Pump sizes will be designed to be capable of pumping all the water out of the pond within a short period of time so as to dry the pond for an emergency case.

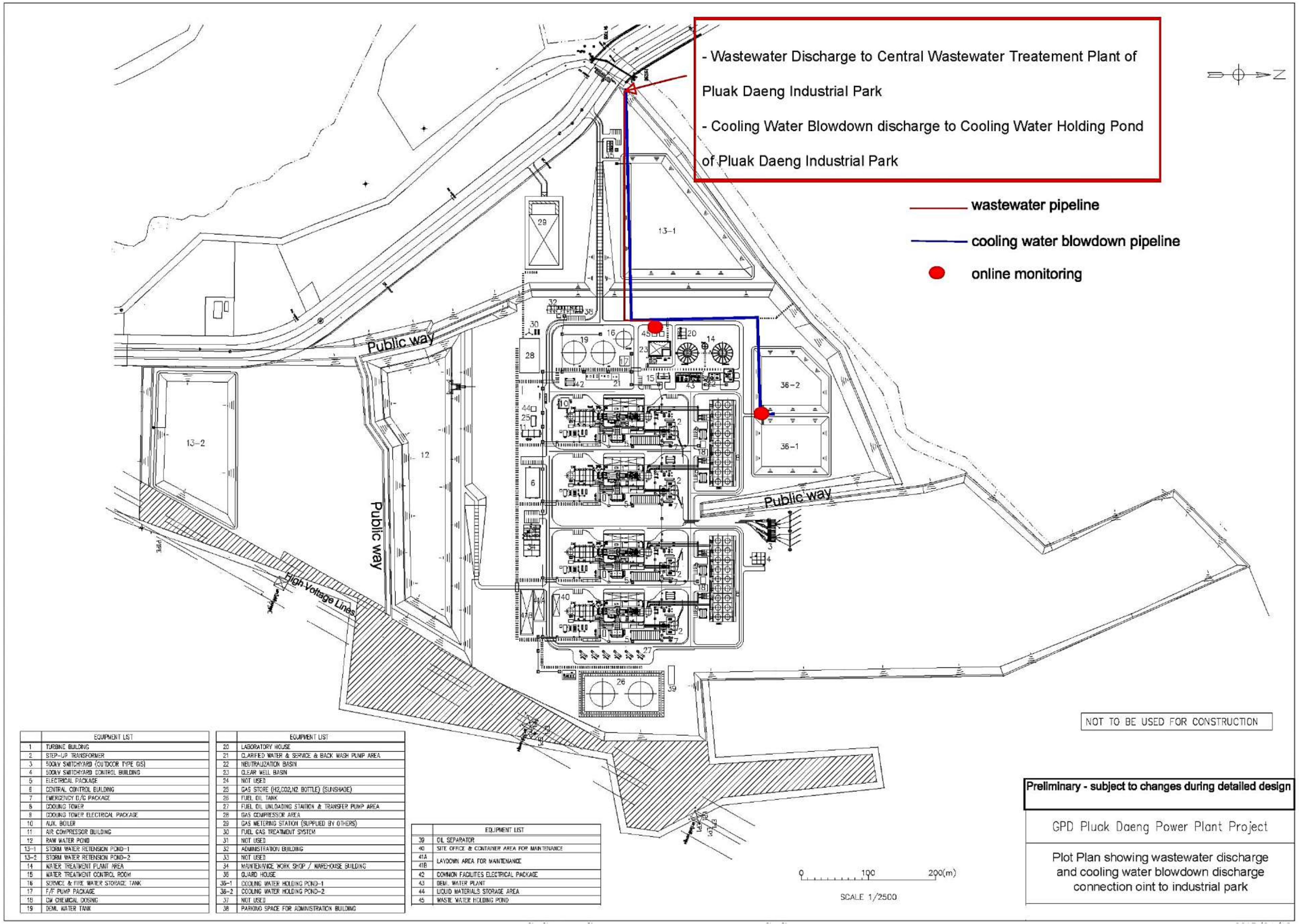
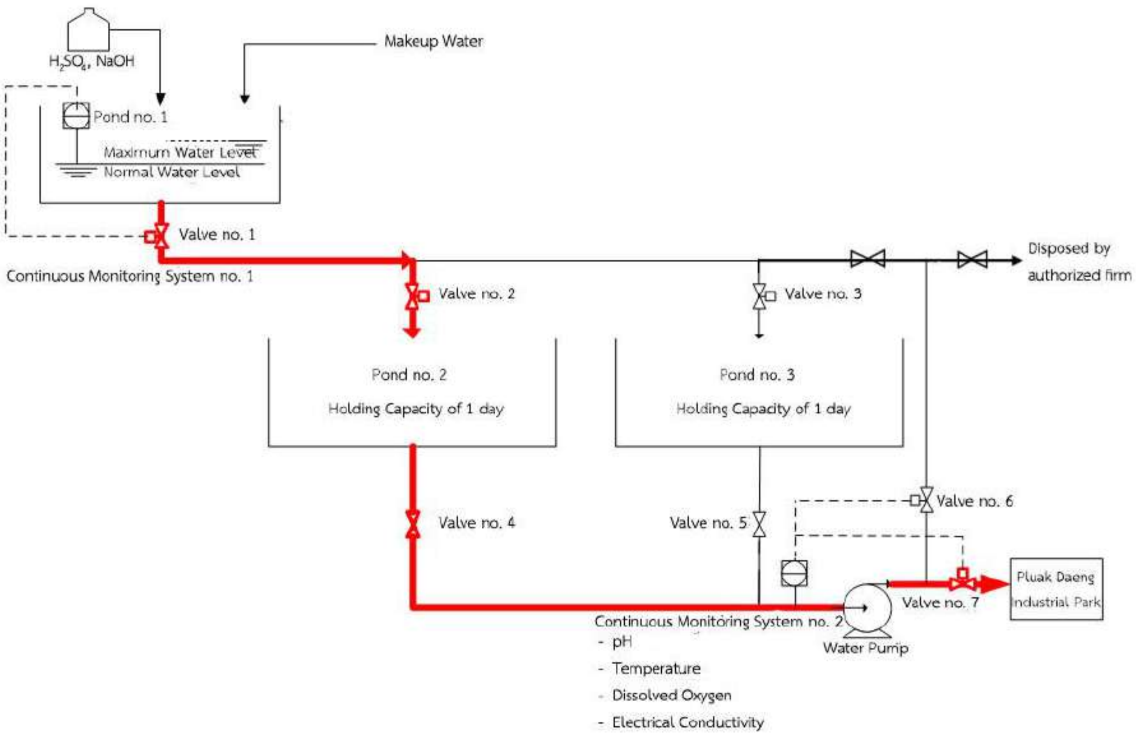
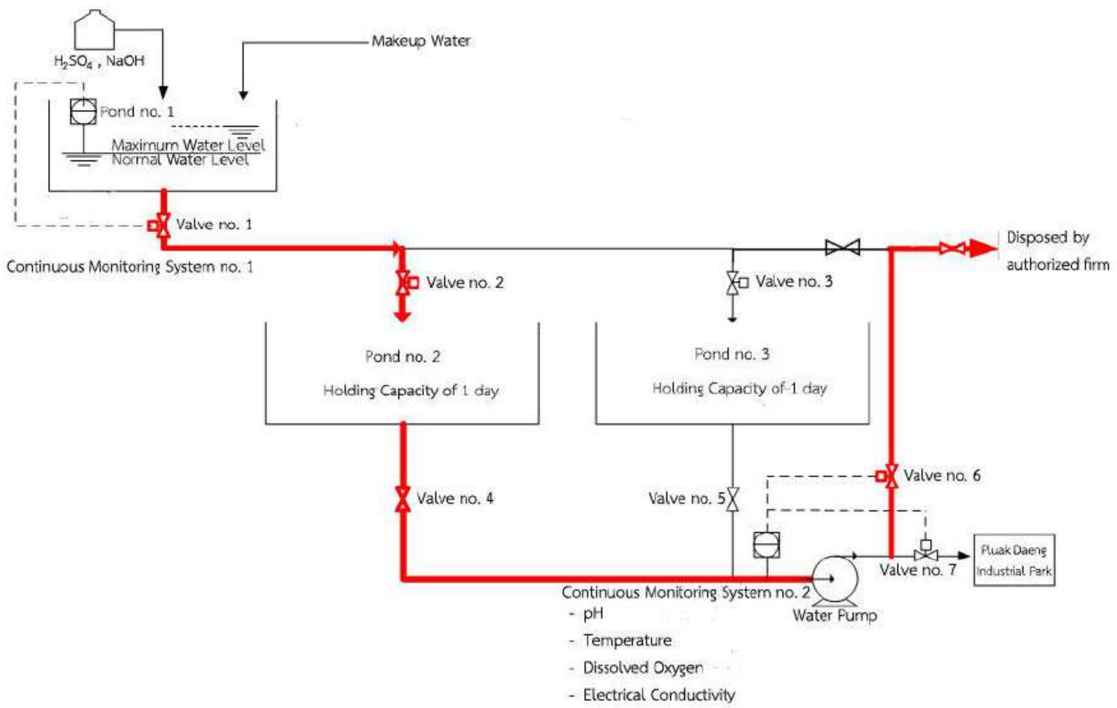


FIGURE 3.11-1 : WASTEWATER DISCHARGE POINTS WITH INSTALLED EFFLUENT QUALITY MONITORING SYSTEM



System diagram in case of blowdown water quality from cooling tower meets the standard.



System diagram in case of blowdown water quality from cooling tower does not meet the standard.

Source: Gulf PD Co.,Ltd., 2016

FIGURE 3.11-2 : COOLING TOWER BLOWDOWN WATER ,MANAGEMENT

TEAM

– **Water Quality Inspection and Monitoring System and Management for Cooling Water and Blowdown Water:** Circulating water in cooling system will be inspected and treated all the time to control the quality of circulating cooling water and blowdown water such as control of pH values, concentration, makeup water supply, and discharge of blowdown water, etc. Temperature, pH, dissolved oxygen, and conductivity will be continuously measured and monitored. Control signals will be transmitted to valves/pumps and the continuous measurement results will be sent to the control room. The characteristics of the project's cooling tower blowdown water are defined according to the Industrial Park's requirements.

In case the cooling blowdown and boiler blowdown do not meet the standards specified by the Industrial Park, the water quality monitoring equipment will send a signal to immediately close the 1st valve to prevent the blowdown water from flowing to the cooling water holding pond. The power plant will have a wastewater holding pond that can store the cooling blowdown and boiler blowdown for not less than 1st day, which is sufficient for dealing with the arisen problem. Whether it be a case of abnormal pH or conductivity, this management practice will enable the power plant operations to continue even though cooling blowdown and boiler blowdown cannot be discharged. For example, if pH of cooling system is lower than the standard value, wastewater in the power plant's holding pond will be neutralized. In case of wastewater from the power plant has higher conductivity than the specified limit, the power plant may apply various management methods, e.g. change of anticoagulants or increase the makeup water volume to reduce concentrations in the system, etc. The duration that the power plant can operate without effluent discharge is more than 1 day.

In case the power plant is unable to manage the situation by the aforementioned methods for more than 1st day, the power plant will prepare the cooling water holding ponds 2 and 3. One of the two ponds will be designated as a holding pond for poor quality cooling water or an emergency pond. The other will store cooling water when the situation returns to normal or cooling water that meets the established quality standard. For example, if the cooling water holding pond 2 is chosen to hold the poor quality effluent or to serve as an emergency pond, cooling blowdown water will be conveyed into this pond through the 2nd valve. Meanwhile, the 3rd valve will be closed so that the cooling water holding pond 3 is empty and ready for holding and draining the cooling water discharge that meets the standards. Nonetheless, if the cooling water holding pond 3 is selected for holding poor quality effluent, the same method will be applied to the cooling water holding pond 2. The power plant has several methods to manage the effluents that exceed the standard value, depending on the root cause of the problem. For example, poor quality effluent will be sent to neutralization system of the power plant or for disposal by the permitted company.

Moreover, the power plant will adopt additional prevention measures to check and monitor the quality of effluent after it is released from the cooling water holding pond 2 or 3 in case the water quality monitoring system at point 1 detects any error. If it is found that the effluent does not meet the standards, the system will close the 7th valve and open the 6th valve in order to convey the poor quality effluent back to the cooling water holding pond for treatment.

(b) Wastewater from Generation Process: A total volume of 48 m^3/day of wastewater is produced from the generation process, comprises as follows:

- Wastewater from mixed bed regeneration process in demineralization system (13 m^3/day) will be discharged to a neutralization pond for pH adjustment before being drained to the project's wastewater holding pond where wastewater will be collected and delivered to the central wastewater treatment system of Pluak Daeng Industrial Park (**Figure 3.11-1**).
- Laboratory wastewater (5 m^3/day) will be directed to the neutralization pond for pH adjustment before being discharged to the project's wastewater holding pond where wastewater will be collected and conveyed to the Industrial Park's central wastewater treatment system.
- Wastewater from consumption (Calculation sheets are provided in **Appendix 3L**), divided into:
  - Greywater from bathrooms (10 m^3/day) will be treated in septic tank or onsite wastewater treatment system before flowing into the project's wastewater holding pond where wastewater will be collected and conveyed to the Industrial Park's central wastewater treatment system ;
  - Wastewater from general consumption (20 m^3/day) will be directed to the project's wastewater holding pond where wastewater will be collected and conveyed to the Industrial Park's central wastewater treatment system.

All the wastewater from generation process as mentioned in (b) above will be stored in two wastewater holding ponds, with 75-m^3 storage capacity each (1.5-day storage capacity each), before being delivered to the Industrial Park's central wastewater treatment system for treatment. The effluent quality must comply with the allowable characteristics of effluents to be discharged to the Industrial Park's central wastewater treatment system, as shown in **Table 3.11-5**. Online monitoring system has been installed to measure temperature, pH, dissolved oxygen, and conductivity in the wastewater holding pond prior to discharge outside the project area.

Pluak Daeng Industrial Park has provided a certificate of capabilities for wastewater management of Pluak Daeng Power Plant, as shown in **Appendix 3W**.

TABLE 3.11-5
|ALLOWABLE CHARACTERISTICS OF INDUSTRIAL EFFLUENT DISCHARGE TO THE CENTRAL WASTEWATER TREATMENT SYSTEM AND CHARACTERISTICS OF EFFLUENT FROM THE CENTRAL WASTEWATER TREATMENT SYSTEM OF PLUAK DAENG INDUSTRIAL PARK

No.	Water Quality Parameters	Unit	Maximum Allowance for Discharge to the Central wastewater treatment system 1/	Maximum Allowance for Discharge from the Central wastewater treatment system 2/
1	BOD_5 as 20 °C	mg/l	Not more than 500	Not exceed 20
2	COD	mg/l	Not more than 750	Not exceed 120
3	pH		5.5 – 9.0	5.5 - 9.0
4	Total Dissolved Solid (TDS)	mg/l	Not more than 3,000	Not exceed 3,000
				Not exceed 5,000 3/
5	Total Suspended Solids (TSS) 4/	mg/l	Not more than 200	Not exceed 50
6	Total Kjeldahl Nitrogen (TKN)	mg/l	Not more than 100	Not exceed 100
7	Heavy Metals			
	7.1 Mercury (Hg)	mg/l	Not more than 0.005	Not exceed 0.005
	7.2 Selenium (Se)	mg/l	Not more than 0.02	Not exceed 0.02
	7.3 Cadmium (Cd)	mg/l	Not more than 0.03	Not exceed 0.03
	7.4 Lead (Pb)	mg/l	Not more than 0.20	Not exceed 0.2
	7.5 Arsenic (As)	mg/l	Not more than 0.25	Not exceed 0.25
	7.6 Chromium Trivalent (Cr^{3+})	mg/l	Not more than 0.75	Not exceed 0.75
	7.7 Chromium Hexavalent (Cr^{6+})	mg/l	Not more than 0.25	Not exceed 0.25
	7.8 Barium (Ba)	mg/l	Not more than 1.0	Not exceed 1.0
	7.9 Nickel (Ni)	mg/l	Not more than 1.0	Not exceed 1.0
	7.10 Copper (Cu) 5/	mg/l	Not more than 2.0	Not exceed 2.0
	7.11 Zinc (Zn)	mg/l	Not more than 5.0	Not exceed 5.0
	7.12 Manganese (Mn)	mg/l	Not more than 5.0	Not exceed 5.0
	7.13 Silver (Ag)	mg/l	Not more than 1.0	-
	7.14 Total Iron	mg/l	Not more than 10.0	-
8	Sulphide as H_2S	mg/l	Not more than 1.0	Not exceed 1
9	Cyanide as HCN	mg/l	Not more than 0.2	Not exceed 0.2
10	Formaldehyde	mg/l	Not more than 1.0	Not exceed 1
11	Phenols Compound	mg/l	Not more than 1.0	Not exceed 1
12	Free Chlorine	mg/l	Not more than 1.0	Not exceed 1
13	Chloride as Chlorine	mg/l	Not more than 2,000	-
14	Fluoride	mg/l	Not more than 5.0	-
15	Pesticide	mg/l	None	None
16	Temperature	°C	Not more than 45	Not exceed 40
17	Color		120 Pt-Co	120 ADMI
18	Odor		Not objectionable	-

TABLE 3.11-5

|ALLOWABLE CHARACTERISTICS OF INDUSTRIAL EFFLUENT DISCHARGE TO THE CENTRAL WASTEWATER TREATMENT SYSTEM AND CHARACTERISTICS OF EFFLUENT FROM THE CENTRAL WASTEWATER TREATMENT SYSTEM OF PLUAK DAENG INDUSTRIAL PARK

No.	Water Quality Parameters	Unit	Maximum Allowance for Discharge to the Central wastewater treatment system 1/	Maximum Allowance for Discharge from the Central wastewater treatment system 2/
19	Oil & Grease	mg/l	Not more than 10.0	Not exceed 5
20	Surfactants	mg/l	Not more than 30.0	-

Remarks : 1/ Characteristics of industrial effluents allowed to be discharged to the central wastewater treatment system of Pluak Daeng Industrial Park

2/ Notification of the Ministry of Science, Technology and Environment, No.3, B.E.2539 (1996), dated 3 January 1996 Regarding Industrial Effluent Standards for Industrial Plants and Industrial Estates, published in the Royal Government Gazette, Vol. 113, Part 13, dated 13 February B.E.2539 (1996)

3/ In case effluent will be discharged into a receiving water source with TDS more than 3,000 mg/l, TDS in effluent shall not exceed TDS of the receiving water source by more than 5,000 mg/l.

4/ For TSS of the water discharge into Pluak Daeng Industrial Park's central wastewater plant, the project comply with Pluak Daeng Industrial Park's regulation of 200 mg/l. Anyway, Pluak Daeng Industrial Park central wastewater treatment plant will treat the water, and discharge from their wastewater treatment plant will have TSS<50 mg/l, as per requirement by WBG EHS guideline

5/ The project confirms that Copper (Cu) effluent standards for cooling water discharge will be complied with copper requirement of 0.5 mg/l

Source : EIA Report of Pluak Daeng Industrial Park Project, Expansion Phase 1, February 2016.

The floor of wastewater holding pond is designed to prevent seepage into underground layers (e.g. lining). Regular inspection and maintenance will be carried out to keep the pond in good condition. Repairing will be promptly conducted in case of any malfunction. Calculation sheets of wastewater holding pond are presented in **Appendix 3X**.

(3) Wastewater from the Project's Stormwater Drainage System

Wastewater from the project's stormwater drainage system will be managed as follows:

(a) Non-contaminated stormwater runoff from non-contaminated areas will be intercepted and drained into the project's stormwater retention pond with design capacity of 100 mm/hour for 3 hours. There will be no increase in stormwater discharge volume from the area, compared to pre-project conditions (C value of pre-project condition is 0.3 and that of post-project condition is 0.7). Stormwater in the stormwater retention pond can be reused as raw water supply or drain to storm drains of Pluak Daeng Industrial Park.

Calculation sheets of the project's storm drain system including retention pond and drain ditches in the project area are provided in **Appendix 3N**. Calculation sheets of stormwater discharge rate from the project area to outside areas and storm drain capacity of Pluak Daeng Industrial Park are presented in **Appendix 3O**.

(b) Oil-contaminated stormwater from cleaning of oil-contaminated areas will be collected to the oil separator for oil separation before being conveyed to the Industrial Park's central wastewater treatment system. The effluent quality must comply with the allowable characteristics of effluents to be discharged to the Industrial Park's central wastewater treatment system, as shown in **Table 3.11-5**.

Calculation sheets of oil-contaminated stormwater volume are shown in **Appendix 3P**.

(4) Wastewater Management System and Drainage and Flood Control System of Pluak Daeng Industrial Park

Pluak Daeng Industrial Park has anticipated that the maximum wastewater volume will be about 1,853 m^3/day, including 200 m^3/day of wastewater from IPP power plants. Activated sludge system was designed for the Industrial Park's central wastewater treatment system, with peak capacity of 2,000 m^3/day. Details of wastewater treatment process are shown in **Appendix 3Y**.

As for flood control system, 4 stormwater retention/raw water ponds are spatially located in the industrial park area, depending on the suitable topographic conditions. These ponds together with drainage areas of Pluak Daeng Industrial Park will have a total capacity of 288,273 m^3 for retaining stormwater for not less than 3 hours before discharging stormwater runoff to Huai Phu Sai. Details of the Industrial Park's drainage and flood control system are provided in **Appendix 3Z.**

3.11.4 Solid Waste Management

The project will comply with the Notification of the Ministry of Industry on Disposal of Waste or Unusable Materials, B.E.2548 (2005) as follows:

(1) Construction Waste/Debris

Solid waste generated from construction activities will comprise the following:

- Construction waste, e.g. structural parts or used or residual materials;
- Hazardous waste, e.g. batteries, engine oil, hydraulic oil, filter, mineral oil, used detergents or solvents including poor quality coating products or paints

- General waste, about 2,720 kilograms/day, is generated by a peak number of 3,200 workers (based on the set criteria, a person generally produces 0.85 kilograms/person/day of waste-reference to Kriangsak Udomsinroj, 1994).

Specific storage areas will be designated for each type of solid waste and appropriate containers will be provided for collection and separation of waste by type for convenience in transport and disposal by appropriate methods. The conditions of construction contracts will specify that contractors shall be responsible for disposal of all solid waste. As for construction wastes, it will be specified in the contract conditions that all construction wastes shall be removed by contractors and not allowed to be piled in the project area.

(2) Solid Waste/Garbage Generated during Operation Phase

(a) General Waste: Solid waste from office is estimated at 51 kg/day (based on the number of 60 employees and waste generation rate of 0.85 kilograms/ person day, with reference to Kriangsak Udomsinroj, 1994). It includes food waste, plastic bags, paper scraps, etc. General waste will be collected and sent for disposal. A waste disposal agency permitted by the government or a local agency will be engaged to collect and transport solid waste for disposal.

(b) Air Filter: It is used for filtering dust residue and other airborne residual debris before entering the power generation system. Filter is synthetic fabric which can be used only once. It cannot be reused because a dense dust layer will accumulate on filter surface. As dust is damp, it cannot be blown or cleaned. After a period of use, fully loaded air filter needs to be replaced. The total usage rate is about 47,040 kilograms/1.5 years. The removed air filters will be sent to an industrial waste disposal company authorized by the Department of Industrial Works for disposal.

(c) Used Engine Oil and Oil from Oil Separator: Deteriorated engine oil and oil from oil separator will be about 800 litres/month which will be stored in 200-litre drums and sent to an industrial waste disposal company authorized by the Department of Industrial Works for disposal.

(d) Resin for Water Purification for Power Plant: Part of resin, about 1 cu.m., will need to be changed in each year. Suppliers will be required to collect the removed resin or it will be collected in plastic bags and kept in covered 200-litre drums inside the building. It will be transported to an industrial waste disposal company authorized by the Department of Industrial Works for disposal.

(e) Sediment from Dewatering Process in Water Treatment System: The project's water pre-treatment system will produce a maximum sediment volume of 5 tons/day, with the calculation details presented herein.

- **In Case of Natural Gas Fuel**
  - 62,618 m^3/day of raw water supply to water pre-treatment system;
  - The maximum volume of Total Suspended Solids (TSS) is 16 mg/litre (Data from Eastern Water Resources Development and Management Plc);
  - TSS concentration in raw water that will settle in a day is equal to 16 mg/litre x 62,618 m^3/day x 1,000,000,000 mg/ton x 1,000 litres/m^3 = 1.00 ton/day;
  - Chemicals applied to sedimentation in water pre-treatment system are ferric chloride and polymer, with a maximum use of 3.2 m^3/day or about 3.2 tons/day.

As a result, the sediment volume generated in water pre-treatment system and discharged as sludge cake is equal to 4.2 tons/day or about 5 tons/day.

- **In Case of Diesel Fuel**
  - 46,857 m^3/day of raw water supply to water pre-treatment system;
  - The maximum TSS volume = 16 mg/litre (Data from Eastern Water Resources Development and Management Plc);
  - TSS concentration in raw water that will settle in a day is equal to 16 mg/litre x 46,857 m^3/day x 1,000,000,000 mg/ton x 1,000 litres/m^3 = 0.75 tons/day;
  - Chemicals applied to sedimentation in water pre-treatment system are ferric chloride and polymer, with a maximum use of 3.2 m^3/day or about 3.2 tons/day.

Consequently, the sediment volume generated in water pre-treatment system and discharged as sludge cake is equal to 3.95 tons/day or about 4 tons/day.

Sediment will be stored in 20-ton sludge hoppers inside the water pre-treatment plant. The sludge hopper’s capacity will be sufficient for holding sludge cakes from water pre-treatment system while waiting for delivery to a disposal site in accordance with the Notification of the Ministry of Industry on Disposal of Waste or Unusable Materials, B.E.2548 (2005) by an industrial waste disposal company authorized by the Department of Industrial Works.

When considering the aforesaid sludge disposal, it is found that the highest sludge volume from water pre-treatment system during water use in the natural gas fired operation will be about 35 tons/week. About three 15-ton trucks/week will be used to transport sludge for disposal and this arrangement will be capable of adequately handling sludge volume produced from the process, without any sludge left over in the project area.

Solid waste types, quantities and management methods of the project during both construction and operation phases are summarized in **Table 3.11-6**.

3.12 WORKER MANAGEMENT PLAN

(1) Construction Period

Construction period is approximately 48 months which expected to have maximum workers and employees approximate 3,200 persons. The amount of maximum worker (3,200 persons) will work for 6 months.

The project will request the Contractor to consider hiring local people first. During project execution, the project will monitor Contractor's hiring process to ensure that the Contractor will hire local workers as much as possible and available. In addition, the Contractor will report the numbers of workers to the project every month. Before hiring workers, Contractor has the process to interview and carry out health & physical check-up and request for medical check certificate to confirm that the person has no incurable disease and congenital disease which obstruct to work. Contractor will provide first aid facility at Project site and worker's accommodation. Local hospitals are used in case of emergency. All medical record will be maintained by Contractor at the project.

Contractor will build temporary accommodation for workers near to GSRC Project location and away from local communities. Their accommodation will be outside project area and industrial estate area in 4 to 5 km radius of project area, therefore there will be very minimal impact to the local communities. All workers are required to follow standard rule and regulation set up (Example of regulation of workers camp as shown in **Appendix 3R**) by contractor in compliance with national Laws. All workers are subject to random check for alcohol & urine testing for use of illegal drugs periodically.

The project will monitor performance of the Contractor to enforce their rule and regulation on project site and worker accommodation area. Periodical meeting will be held with Contractor to communicate and emphasize the requirements for safety and security of the community. Regular audit and random audit are means to be used by the project to ensure the Contractor enforce their rule and regulation appropriately.

For worker management during construction period, the project's human resource management policy and EPC will be in compliance with national requirements and core labor standards. Moreover, project has set up mitigation measurements regarding to worker management as follow:

TABLE 3.11-6
TYPES, QUANTITIES AND MANAGEMENT METHODS FOR WASTE FROM POWER PLANT PROJECT

Type	Quantity	Management Method	Sources/Frequency/Storage Methods and Places
Construction Phase			
1. General Waste	2,720 kg/day	- Specific storage areas will be designated for each type of waste and appropriate containers will be provided for waste collection and separation by type for convenience in transport and disposal by appropriate methods	- The project construction contracts will specify that contractors shall be responsible for disposal of all solid waste. As for construction wastes, the contract conditions will specify that all construction wastes shall be removed by contractors and not allowed to be piled in the project area.
Operation Phase			
1. Office Waste	51 kg/day	- A waste disposal agency permitted by the government or a local agency will be engaged to collect and transport solid waste for disposal.	- Office waste can be reduced by reuse (e.g. one side used paper) and recycle - Office waste will be collected in waste bins near the administrative office building, waiting to be collected and disposed every 2 days by a waste disposal agency permitted by the government or a local agency.
2. Air Filter	47,040 kg/ 1.5 years	- Deteriorated air filters will be sent to an industrial waste disposal company authorized by the Department of Industrial Works for disposal	- It is used for filtering dust residue and other airborne residual debris before entering gas turbines because dust and residual debris can reduce the efficiency of gas turbines. The unfiltered dust can also contaminate the combustion exhaust. - Air filter must be replaced according to its lifespan of 1.5 years. The removed filters will be kept in the gas turbine building and quickly delivered for disposal.

TABLE 3.11-6

TYPES, QUANTITIES AND MANAGEMENT METHODS FOR WASTE FROM POWER PLANT PROJECT (CONT'D)

Type	Quantity	Management Method	Sources/Frequency/Storage Methods and Places
3. Used Engine Oil and Oil from Oil Separator	800 litres/ month	– Used engine oil and oil from oil separator will be stored in 200-litre steel oil drums and sent to an industrial waste disposal company authorized by the Department of Industrial Works for disposal	– Used engine oil after reaching the end of useful life or oil from oil/water separator will be collected in 200-litre drums, kept in the workshop building and then quickly delivered for disposal.
4. Exhausted Resin	1 m^3/year	– Exhausted resin will be returned to suppliers or stored in plastic bags and kept in covered 200-litre oil drums which will be sent to an industrial waste disposal company authorized by the Department of Industrial Works for disposal.	– Resin in the mixed bed regeneration tank of demineralization system will need to be changed after reaching the end of its 1-year life. The exhausted resin will be returned to suppliers who will replace the resin or send it for disposal. It will be kept in 200-litre drums in the workshop building and quickly delivered for disposal.
5. Sediment from Water Pre-Treatment System – Natural Gas Fuel – Diesel Fuel	 5 tons/day 4 tons/day	– Sludge will be collected for delivery to a disposal site in accordance with the Notification of the Ministry of Industry on Disposal of Waste or Unusable Materials, B.E.2548 (2005) or for disposal by an industrial waste disposal company authorized by the Department of Industrial Works	– Water pre-treatment system will separate sediment from raw water, thereby producing sediment which will be collected and sent for disposal. Sediment will be stored in a sludge hopper located in the water pre-treatment plant, waiting to be transported to the disposal site about 3 times/ week.

Source : Gulf PD Co., Ltd., 2016

- Provide for a ready-made wastewater treatment system in the area of the workers' living quarters including a discharged water retention pond with holding capacity for at least one day to inspect the quality of the discharged water to ensure that it meets the requirement for Building Type C according to the standards prescribed in Ministry of Natural Resources and Environment's Notification Prescribing Standards for Discharged Water from Building of Certain Types and Sizes Prior to Draining Outside.
- Require the contractors to provide adequate and hygienic drinking water for construction workers.
- Monitor and control workers' behaviors closely if their living quarters are near local communities so as not to disturb the nearby communities.
- Ensure the contractors comply with labor laws regarding physical health check and risk-based heath check. This law is in accordance with Ministerial Regulation on the Prescribing of Criteria and Method of Conducting Health Check Up of Employees and Forwarding the Results of Health Check Up to Labour Inspector B.E. 2547 (A.D.2004)
- **Measures Regarding Safety of Life and Property**
  - Give priority of hiring qualified local residents.
  - Keep records of non-local and foreign workers.
  - Assign the head of the project to supervise workers. Assign employees to monitor entry into and exit from the project strictly.
  - Control the construction activities and the workers' behaviors to prevent impacts to people in the vicinity.
  - Provide the rest area for the construction worker. The rest area should be sited in safe location and away the work in progress area.
  - Issue work regulation and ensure that construction worker strictly comply with the regulations.
  - Monitor and control workers' behaviors closely if their living quarters are near local communities so as not to disturb the nearby communities.
  - Publicize and clarify facts to the public urgently, in case of misunderstanding between the power plant, and the community through various channels or media so people receive factual information. Be prepared to demonstrate that the project will take responsibility and care about people's feeling.
  - Take corrective action urgently where it is proved that the power plant is the cause of such impacts. Set up a register of individuals or groups being affected and use the data to implement stricter measures to prevent the problems.
  - Prepare a register of people affected, recording issues from the complaints or from the event as evidence. Record information related to proof of facts, solutions, negotiations, and arrangements as evidence of the power plant operation.

(2) Operational Period

The maximum number of worker in operation period is 60 persons as shown in organization chart in **Figure 3.12-1**.

3.13 TRANSPORTATION

(1) Construction Phase

The vehicular volume expected to be used in the project's construction activities and in transporting workers is presented in **Table 3.13-1**.

Transport mode, traffic plan, traffic flow, and parking spaces in the project area during construction phase are exhibited in **Figure 3.13-1**.

(2) Operation Phase

Private car data of Uthai Power Plant (IPP Plant of Gulf Group) were reviewed as its number of staff is similar to that of Pluak Daeng Power Plant Project. The results show that the average maximum number of staff cars plus visitors' cars is 84 cars per day, and there is one garbage truck/day. Moreover, about 5 tons/day of sludge cakes from water pre-treatment system will be stored in sludge hoppers in the water pre-treatment plant area. Hence the sludge cake volume will be about 35 tons/week. Three 10-wheel trucks/week, with 15-ton capacity each, will be used to transport sludge for disposal. This arrangement can sufficiently handle sludge cake volume produced from the process, without any sludge left over in the project area. Furthermore, a total of 140 trips/year or equivalent to 3 trips/week will be needed for transporting chemicals for project use. One truck per day will be used for chemicals transport.

TABLE 3.13-1

FORECAST MAXIMUM VEHICULAR VOLUME DURING CONSTRUCTION PHASE

Transport Activity	Vehicular Type	Vehicular Volume (cars/day)	No. of Trips (trips/day)
Machines	Trailers	10	20
Workers	Small trucks	48	96
Materials and equipment	Trailers	30	60
Total		**88**	**176**

Source : Gulf PD Co., Ltd., 2016

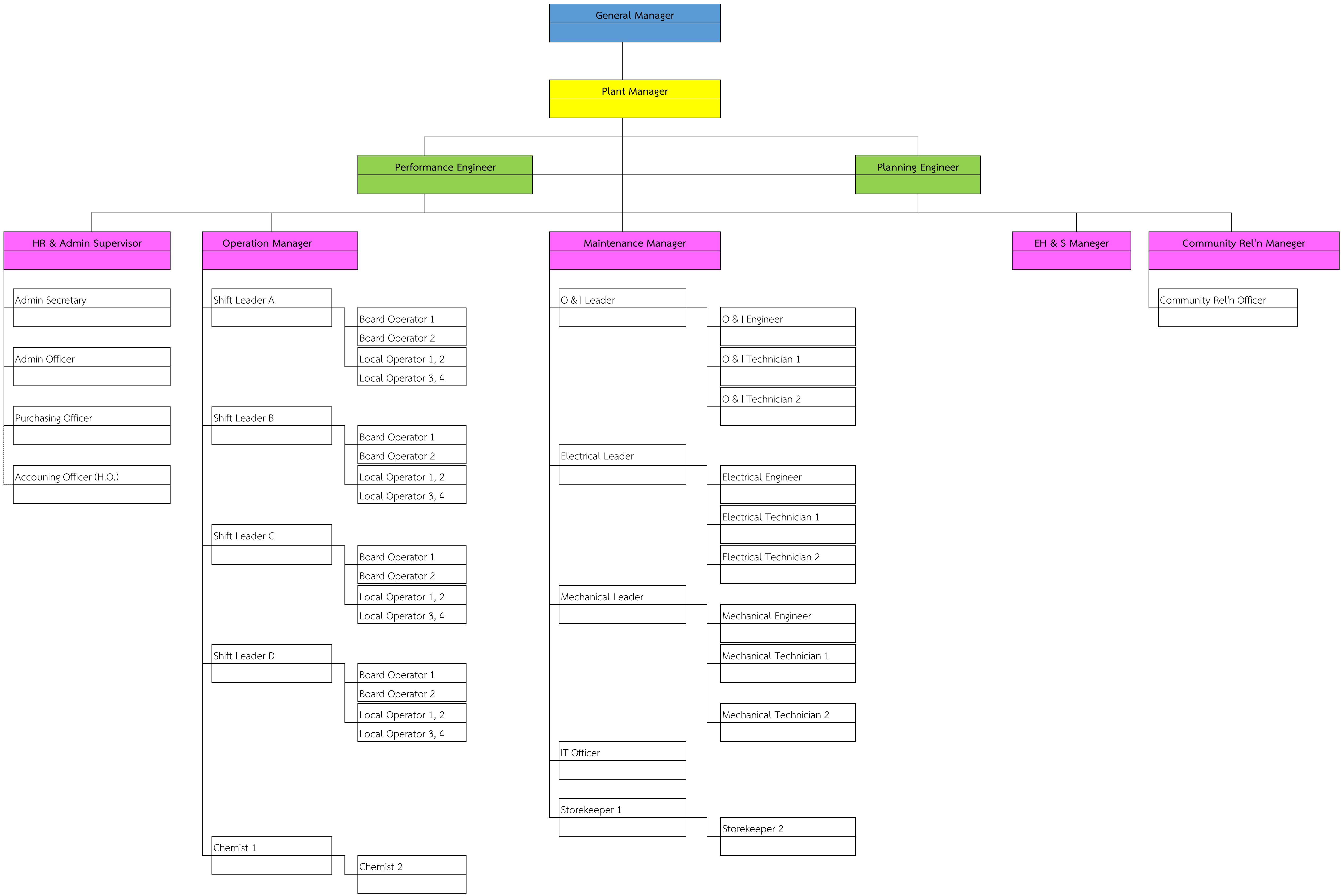


FIGURE 3.12-1 : ORGANIZATIONAL STRUCTURE

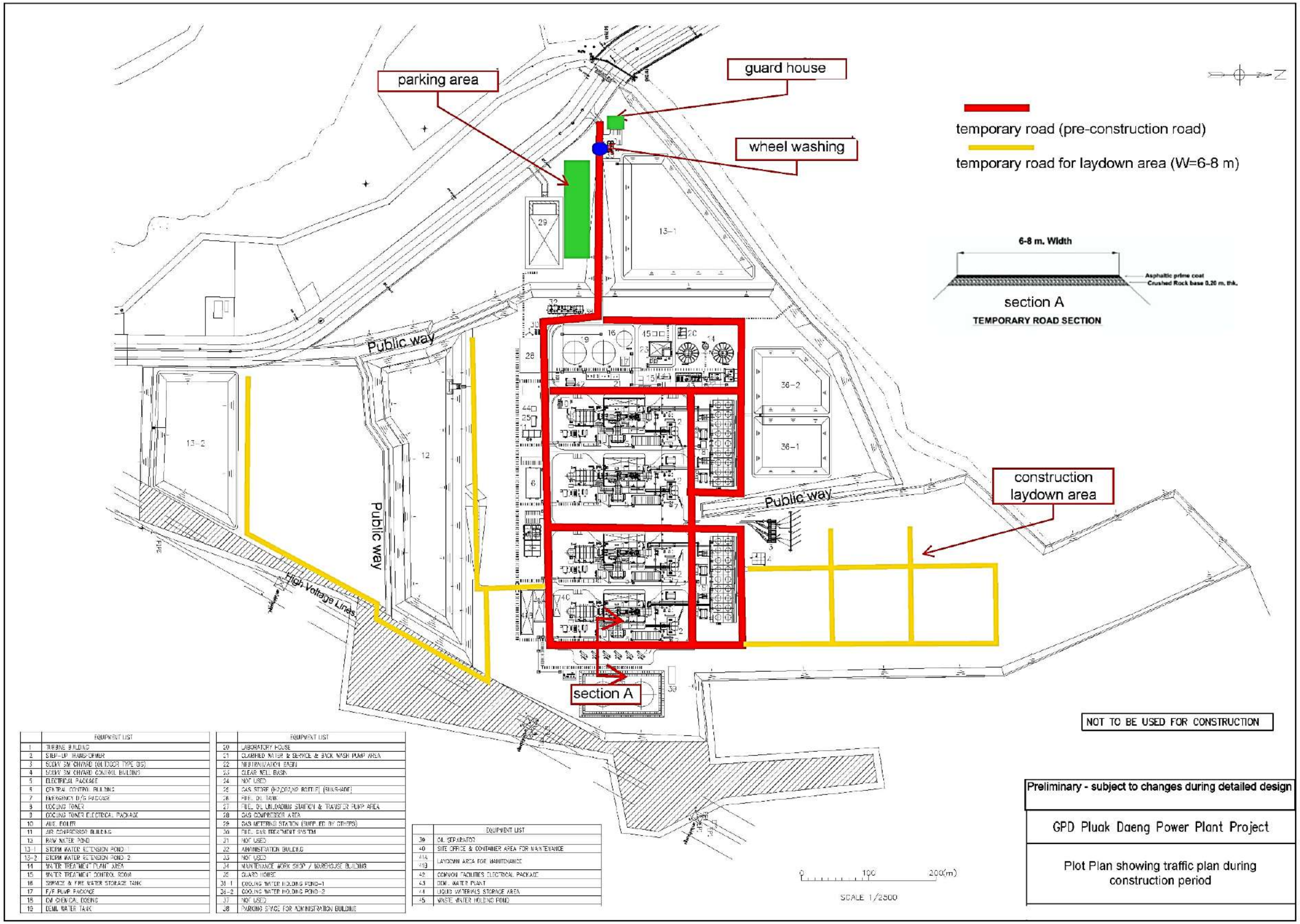


FIGURE 3.13-1 : TRAFFIC PLAN DURING CONSTRUCTION PHASE

When the project becomes operational, traffic volume will be higher, with the maximum vehicular volume during operation phase totaling 87 cars/day or 174 trips/day. **Table 3.13-2** shows the details of traffic volume during operation phase.

TABLE 3.13-2
FORECAST MAXIMUM VEHICULAR VOLUME DURING OPERATION PHASE

Transport Activity	Vehicular Type	Vehicular Volume (cars/day)	No. of Trips (trips/day)
Travel by power plant staff and visitors*	Private cars	84	168
Waste transport*	Garbage trucks	1	2
Transport of sludge from water pre-treatment system	10-wheel trucks	1	2
Chemicals transport	Trailers	1	2
Total		**87**	**174**

Source : *Environmental Compliance Monitoring Report of Uthai Power Plant Project (January-June 2016), Gulf JP UT Co., Ltd.

3.14 OCCUPATIONAL HEALTH AND SAFETY

The project place great emphasis on safety and has devised an occupational health and safety in conformity with applicable standards and laws such as:

(1) Ministerial Regulation re: Prescribing Standards for Management, Administration and Implementation of Occupational Health, Safety and Working Environment in working conditions with hazardous chemicals B.E. 2556;

(2) Department of Labour Welfare & Protection's Notification re: Prescribing Personal Protective Equipment Standards B.E. 2554;

(3) Guideline of hazardous material transportation of Pollution Control Depart, September 2011.

(4) Hazardous Chemicals Management and Administration in Work Places Manual, April 2011;

(5) Department of Industrial Works' Notification re: Hazardous Chemicals and Storage Manual B.E.2550.

(6) Department of Industrial Works' Notification re: Manual on Storage of Hazardous Chemicals and Substances B.E. 2550;

(7) Ministerial Regulation re: Prescribing Standards on Management, Administration and Implementation of Occupational Health and Safety in Workplaces B.E. 2549;

(8) Ministerial Regulations No. 33 B.E. 2535 issued by virtue of the Building Control Act B.E. 2522 on high rise buildings.

(9) Ministry of Interior's Notification re: Fire Prevention and Suppression in Work Places for the Safety of Employees B.E. 2539.

(10) Department of Industrial Works' Notification re: Fire Prevention and Suppression in Factory B.E. 2552.

(11) Ministerial Regulation on the Prescribing of Criteria and Method of Conducting Health Check Up of Employees and Forwarding the Results of Health Check Up to Labour Inspector B.E. 2547 (A.D.2004)

(12) OSHA Standard, Part title: Safety and health regulations for construction, Subpart title: Occupational health and environmental controls, Standard number 1926.55 App A

(13) General Environmental, Health, and Safety Guidelines, International Finance Corporation (IFC), 2007

(14) ADB's safeguard policy statement (SPS), 2009

3.14.1 Occupational Health and Safety Control during Construction Phase

An action plan and a monitoring plan have been established for occupational safety, health and working environment during construction phase so as to control the project execution to be consistent with the project's standards and rules on general safety, with details explained herein.

(1) All construction contracts must explicitly stipulate occupational health and safety measures as follows:

- Conditions have been specified for contractors and teams working in the power plant area under construction contracts. Occupational safety, health and environment measures will be enforced for both design and construction works to be consistent with occupational health and safety standards and regulations.
- Qualified personnel will be assigned to be responsible for safety.
- The project and the main contractor will set up an occupational safety, health and environment committee which will include supervisors of the project's subcontractors. Occupational Safety, Health and Environment Manager will directly report to Project Manager.
- First aid kits and basic medical supplies will be provided including an emergency car according to the Ministry of Labour's Ministerial Regulation on Labour Welfare in Workplaces, B.E. 2548 (2005);

- Utilities will be sufficiently provided for workers in accordance with sanitation principles such as clean drinking water, bathrooms, toilets, etc.
- Warning signs will be put up in construction zones, danger areas, and areas that require personal protective equipment (PPE).
- The main contractor will prepare a plan for coordination with local firefighting units to ensure preparedness for an emergency.
- Entry permit system will be put in place for entering some spaces as stipulated by law.
- Personal protective equipment (PPE) will be regularly inspected.
- Occupational safety, health and environment committee meetings will be held at least once a month for evaluation and problem-solving recommendation.

Furthermore, contractors are required to take out third party insurance covering any damage to life and property of third parties that may arise due to the project execution.

(2) Construction safety measures must cover every construction activity such as:

- Fire Prevention and Suppression System
  - The main contractor will provide firefighting equipment for ready use and in sufficient quantity for workers working in danger areas or hot work operations with fire risks such as metal welding. Every welder team must always keep firefighting chemicals near the welding area. For welding works at height, fire-proof blankets must be placed under the welding area to prevent sparks from falling onto workers working below, etc.
  - The main contractor will prepare a plan for coordination with local firefighting units to ensure preparedness for an emergency.
  - Entry-exit to danger areas and traffic will be controlled and danger warning signs will be visibly displayed by supervisors or safety officers.
  - Work conditions and construction equipment will be regularly inspected, particularly danger or fire risk areas.
  - Fire suppression equipment will be regularly inspected in accordance with the project safety procedure.

3.14.2 Occupational Health and Safety Management during Operation Phase

3.14.2.1 Occupational Safety, Health and Environment Management Policy

The project will set a policy on occupational health, safety and environment management and prepare a safety procedure to be a guideline for the company's implementation and development in occupational safety, health and environment aspects to be consistent with relevant laws and requirements. This is to ensure safety in life and good health of every staff.

(1) Summary of Work Plans to Ensure the Project Execution in Accordance with the Established Policy

Annual work plans have been determined for occupational safety, health and environment aspects to ensure the implementation to reach full potential in various aspects such as:

- Training Plan for Safe Work Practice, Use of Personal Protective Equipment, Safety Procedure in Risky Works;
- Fire Prevention and Control Drill Plan for employees;
- Employee Health Check-up Plan;
- Plan for Safety Promotion Activities
- Fire Suppression Equipment and Warning Signal System Inspection Plan
- Safety Compliance Monitoring Plan, e.g.
  - 1 electrical system test per year
  - Report to the Occupational Safety, Health And Environment Committee's meeting every month
  - Employee health check-up report once a year according to the Labour Protection Act
  - Notification of machinery (crane) register once a year
  - Preparation and exercise of Fire Prevention and Control Plan once a year including performance report
  - Fire drill report once a year

(2) Occupational Safety, Health and Environment Committee

An occupational safety, health and environment committee has been established in accordance with the Ministerial Regulation on Prescribing Standard for Administration and Management of Occupational Safety, Health and Environment, B.E. 2549 (2006) dated 16th May 2006, Clause 23: The workplace shall set up an occupational safety, health and environment committee, comprising the employer or one representative of the employer in management level acting as Chairman of the Committee, at least one representative of the employer in supervisory level, two representatives of the employee acting as committee members, and one committee member and secretary (The committee's organizational structure is shown in **Figure 3.14-1**) or as specified in the project safety procedure. The committee's duties and responsibilities are as follows:

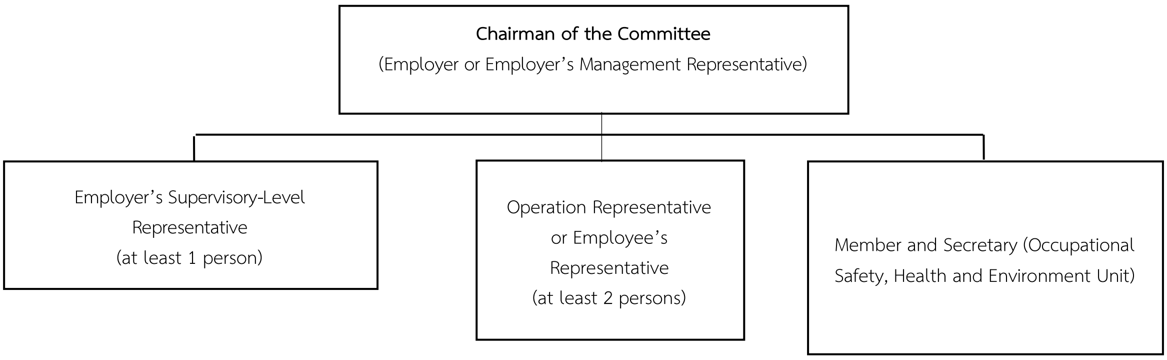


FIGURE 3.14-1 : ORGANIZATIONAL STRUCTURE OF OCCUPATIONAL SAFETY, HEALTH AND ENVIRONMENT COMMITTEE

- To consider the policy and work plan on occupational safety and non-work safety so as to prevent and reduce accidents, dangers, sickness or annoyance resulting from work or unsafe working conditions for presenting to the project;
- To report and give recommendations or measures for improvement and rectification to comply with the law on occupational safety or occupational safety standards for safety of employees, contractors, and third parties who enter the workplace to work or use services in the project;
- To promote and support occupational safety, health and environment activities of the project works;
- To consider regulations and guidance stated in the Ministerial Regulation on Prescribing Standard for Administration and Management of Occupational Safety, Health and Environment, B.E. 2549 including occupational safety standards of the project for presenting to the management;
- To survey, at least once a month, occupational safety performance and examine the statistics of dangers that occurred in the project;
- To prepare a project or training plan relating to occupational safety, health and environment as well as training on roles and responsibilities for safety of employees, supervisors and staff in every level to be proposed to the management;

- To systemize the reporting on unsafe working conditions to be a duty of all employees;
- To follow up the progress of matters submitted to the management;
- To prepare an annual report on the operational performance including specifying problems, obstacles, and suggestions on the performance of the committee when completing one-year period of service to be presented to the management; and
- To assess the occupational safety performance of the project.

3.14.2.2 Occupation Health Management

Occupation health management shall comply with the project safety procedure to ensure employees' good health, suitable working environment and workplace safety. The management approach is presented as follows:

(1) Industrial Hygiene Survey: Safety Officer will survey the workplace so as to consider the workplace environment that may affect workers' occupational safety and health.

(2) Preparation of Industrial Hygiene Monitoring Plan: Safety Officer will review the survey results along with legal requirements, EIA report or other relevant requirements. An annual industrial hygiene monitoring plan will be prepared, stipulating that Safety Officer will conduct industrial hygiene monitoring according to the Safety Procedure regarding industrial hygiene, e.g. heat, light, noise, dust levels, etc.

(3) Analysis and Follow-up of Monitoring Results: Safety Officer will analyze the monitoring results in comparison with Thai or international standards and prepare and a monitoring report for submission to supervisors of such work area. In case the results do not conform to the standard criteria, relevant supervisors of such work area will be notified so that corrective action can be taken.

(4) Identification of Risk Groups for Health Check-up According to Risk Factors: Safety Officer will consider the monitoring results together with legal requirements or other relevant requirements in order to identify groups of employees who may be subject to health risks arising from the nature of work and work environment.

(5) Preparation of Annual Health Check-up Plan According to Risk Factors: Safety Officer will work jointly with nursing officer to formulate an annual health check-up plan according to risk factors.

(6) Health Check-up According to Risk Factors: Nursing Officer together with the hospital will perform annual health check-ups according to risk factors as planned. In case of health check-up prior to employment and staff transfer, a list of new/transferred employees and their sections shall be sent to the Safety Officer for consideration of health check-ups according to risk factors. Consideration will be given to the nature of work and workplace. The Safety Officer will take into account health check-up results and prepare staff health baseline data before forwarding to the human resources officers for consideration in line with the human resources management process.

(7) Verification of Health Check-up Results: After receiving health check-up results from hospital compared with standard values and/or baseline data, the Nursing Officer will send health check-up results to the sections/staff that had been examined and the overall examination results to the Safety Officer. In case the results do not meet the standard criteria, the Nursing Officer will coordinate with such section/staff for an immediate health re-examination, the results of which will be sent to the concerned section/staff and the Safety Officer for information. If the re-examination results reveal an abnormal condition that may be work related, the project will adjust the work operation of that staff and implement prevention and mitigation measures. Health monitoring will be continuously carried out.

(8) Finalization of Occupational Health Performance Results: Results of occupation health performance will be reported to the management review meeting for finalization of results and/or seeking a corrective action policy in case the monitoring results do not meet the set criteria. Additionally, occupational health management entails proactive industrial hygiene monitoring to build knowledge and awareness of health care and safe work environment. It also encompasses detailed measurement of work environment and identification of hazard sources to bring about mitigation and prevention in a concrete manner.

3.14.2.3 Occupation Health and Safety Assessment, Evaluation and Monitoring

(1) Safety Inspection

The following personnel have been assigned to be responsible for safety.

- Work supervisors/shift leaders in each section will conduct a safety inspection in their area of responsibility every day or according to the Safety Procedure.
- Safety Officer will regularly conduct safety inspections in all areas of the power plant according to the Safety Procedure.

The project will also conduct a hazard survey of the workplace. Every employee can report on any dangerous practice encountered which will lead to improvement process to risk mitigation.

(2) Working Environment Monitoring and Assessment

Monitoring and assessment of the work environment will be continuously performed both in normal working conditions and danger zones. Measurements will be made of heat, light, noise and dust levels in order to protect employees from harm in compliance with the law. In addition, work environment improvement measures have been put in place according to the Notification of the Ministry of Industry on Safety Protection Measures for Factory Operations Relating to the Work Environment, B.E. 2546 (2003) and the Ministerial Regulation on Labour Welfare in Workplaces, B.E. 2548 (2005).

(3) Employee Health Check-up

The project will provide health check-ups for employees exposed to risk factors which will be performed by a medical doctor holding a license to practice occupational medicine. Each employee will receive a pre-employment health check-up and then an annual check-up.

3.14.2.4 Personal Protective Equipment

The project requires all personnel entering health hazard areas to wear appropriate personal protective equipment according to type of work and impact as detailed in **Table 3.14-1**. The project will also conduct regular inspection of the personal protective equipment or according to the project safety procedure.

TABLE 3.14-1

PERSONAL PROTECTIVE EQUIPMENT BY WORK AREA

Work Area	Personal Protective Equipment
1. Boilers & Turbines	- Safety helmet, safety shoes, ear plugs, ear muffs, safety goggles.
2. Maintenance work	- Safety helmet, safety shoes, safety goggles, safety gloves, ear plugs or ear muffs for noise reduction
3. Chemical handling	- Chemical safety goggles, laboratory coat/coverall, safety face shield, chemical resistant gloves, rubber boots, and respirators.

Remarks : Basic Personal Protective Equipment (PPE) provided to each employee: safety helmet and safety shoes. Other PPE will be specifically provided according to the nature of work in the work area.

Source: Gulf PD Co., Ltd., 2016

3.14.2.5 Work Environment Protection Plan

The project has established a work environment protection plan, covering noise level, heat, chemicals and risks to prevent any harm that may happen to workers during their work. This is in compliance with applicable laws, with details as follows:

(1) Noise

The project's design maximum noise level is at 85 dB(A), which meets the safety standards prescribed in the Notification of the Ministry of Industry on Safety Protection Measures for Factory Operations Relating to the Work Environment, B.E. 2546 (2003). However, the factor to be considered for mitigation of long-term impacts is wear and tear due to long-term operations which may lead to higher noise level than the specified limit of the power plant if proper maintenance is not carried out. Therefore, noise impact prevention and mitigation measures have been set out as follows:

- A preventive maintenance plan has been formulated for continual maintenance of process machinery and equipment;
- Hearing protection equipment will be sufficiently provided to workers, e.g. ear plugs or ear muffs;
- Warning signs will be put up in noisy areas in order to warn workers to use ear plugs or ear muffs as appropriate. Training will be provided to workers on work procedure and proper and regular use of protective equipment.
- Silencers will be installed and noisy machinery will be covered.

(2) Heat

Even though the nature of work and the duration of exposure to heat may not have direct impact on workers, the project has put in place impact mitigation measures for operational phase such as installing insulation and enclosures of heat sources based on the nature of the production unit.

(3) Chemicals

Chemical Transportation Safety Measures

Hazardous substance transportation with community, property and environmental safety must comply with the project safety procedure, applicable laws and standards such as Guideline on Hazardous Substance Transportation, the Pollution Control Department, September 2011; Guideline on Hazardous Chemicals Management and Administration in Workplaces, July 2013; and Notification of the Department of Industrial Works on Guideline on Chemicals and Hazardous Substance Storage, B.E. 2550 (2007); and Notification of the Ministry of Industry on Guideline on Transportation of Hazardous Substances under the Responsibility of Department of Industrial Works, B.E. 2558 (2015), e.g.

- Apply for transportation license;

- Labels and placards must be properly affixed on chemical transport trucks according to the Department of Land Transport's requirements;
- Chemical classification and transfer will be properly and safely carried out;
- Preparation of shipping papers;
- Preparation of material safety data sheets (MSDS) concerning potential hazards according to the characteristics of such substance, both in Thai and English;
- Provision of personal protective equipment (PPE) on chemical transport trucks;
- Training of truck drivers to be aware and understand the hazards of chemicals being transported, and to have safe driving skills and ability to preliminarily solve problems in case of an emergency.

Chemical Storage Safety Measures

The project's chemical storage safety measures will comply with the Notification of the Department of Industrial Works Regarding Guideline on Chemicals and Hazardous Substance Storage, B.E. 2550 (2007); and Guideline on Hazardous Chemicals Management and Administration in Workplaces, April 2011, e.g.

- Preparation of material safety data sheets (MSDS) concerning potential hazards according to the characteristics of such substance, both in Thai and English;
- Classification of hazardous substances into: Category 1 (required to comply with the prescribed criteria and procedure), Category 2 (an advance notification must be made to the competent official according to the prescribed criteria and procedure), Category 3 (license is required), and Category 4 (production, importation or exportation or possession is prohibited).
- Hazardous chemical storage and method shall be safe according to the condition and characteristics of hazardous chemicals.

Safety Measures for Chemical Usage

The project's safety measures for chemical usage are based on the Occupational Safety and Health Administration (OSHA) Standard and Ministerial Regulation on Prescribing Standards for Administration and Management of Occupational Safety, Health and Environment in Relation to Hazardous Chemicals, B.E. 2556 (2013). Details of the measures will be included in the project safety procedure, consisting of:

- Material safety data sheets (MSDS) concerning potential hazards will be prepared according to the characteristics of such substance together with Thai translation, displayed at the work areas;
- Prohibition signs, mandatory signs or warning signs relating to hazardous chemical handling and use will be installed in clearly visible places;

- Safety protection places and equipment will be provided in the work areas where hazardous chemicals are used, e.g. eye wash stations, hand and face wash stations, and safety showers;
- Personal protective equipment (PPE) will be provided for workers according to the nature and severity level of hazard or nature of work;
- Chemical hazard prevention measures will be put in place for hazardous chemical storage. In addition, preliminary measures will be implemented for mitigation of hazardous incidents such as suitable ventilation system, prevention of potential causes of fire, dike construction to contain chemicals within the hazardous chemical storage, drainage ditches, which must be separate from stormwater drainage system, to drain the spilled hazardous chemicals for safe disposal;
- Prevention and control system will be installed to control atmospheric concentration of hazardous chemicals in the workplace or hazardous chemical storage to be within the specified limit;
- Measurement and analysis will be carried out for atmospheric concentration of hazardous chemicals in the workplace and hazardous chemical storage;
- Firefighting together with first aid equipment and supplies will be appropriately provided to workers;
- Personnel responsibilities will be defined for revision of the chemical usage safety plan (chemist);
- Chemist and safety officer must inspect and prepare a hazardous chemicals inspection plan for each work area where chemicals are used. Review and revision of the plan will be undertaken at least once a year.
- Train staff working with chemicals to know safe use of chemicals including practical guidance for chemical leak prevention and inspection.

(4) Risks

(a) Natural Gas

Safety control and impact mitigation measures for use of natural gas are as follows:

- Establish perimeter of danger zones and strict safety control and protection measures such as no smoking zone, hot work and authorized personnel only areas, etc.;
- Install a gas monitoring system to detect natural gas leakage;
- Regularly test the thickness and corrosion of natural gas pipelines;
- Install pipeline marker posts together with warnings to prevent any action to the ground above the pipeline alignment that may have impact on the gas pipeline and to provide contact information if any abnormalities are found by passerby;

- Develop and implement safety procedures for works relating to natural gas pipelines;
- Install shutdown control and relief valve systems to quickly and accurately check for pipeline pressure anomalies.

(b) Diesel Oil

As the project will use diesel oil as auxiliary fuel in the power generation, the project has decided on setting up fuel storage facilities according to the following relevant laws.

- Fuel oil storage according to the Ministerial Regulation on Fuel Oils Storage, B.E. 2556 (2013) of the Ministry of Energy;
- Oil storage tanks to be considered according to API 650 standard;
- Oil piping design standard according to ASME B31.1;
- Classification of hazardous locations according to API RP 500;
- Provision of fire protection and suppression equipment in accordance with NFPA 850, and NFPA 11 standards

3.14.2.6 Safety Monitoring Systems

The project will be equipped with automatic safety monitoring systems, sending warning signals to the control room to warn personnel working in other relevant work areas of danger such as fire, gas leak, explosion, other emergencies, etc. Two types of safety monitoring systems will be deployed:

(1) Smoke Detectors: They will be installed in the control room along with Automatic Fire Suppression Systems according to the standard of U.S. National Fire Protection Association (NFPA72).

(2) Fire Suppression Equipment: The project will install fire suppression systems in the control room, office building, and work areas such as portable fire extinguishers, Deluge Water Spray, including fire hydrants in all work areas according to NFPA72 standard.

3.14.2.7 Fire Prevention and Suppression Equipment

(1) Fire Suppression Equipment

The project is to install a sufficient number of fire prevention and suppression equipment in accordance with the NFPA standards and applicable laws, standards and regulations as follows:

- Ministerial Regulation No. 33 (B.E. 2535) issued pursuant to the Building Control Act, B.E. 2522 (1979) Regarding High Rise Buildings;
- Notification of the Ministry of Interior on Fire Prevention and Control in Workplaces, published in the Government Gazette on 21st May 1996;

- Notification of the Ministry of Industry on Factory Fire Prevention and Control, B.E. 2552 (2009).

Fire protection system is to be installed in the power plant area, covering power plant buildings, workshop, administrative office buildings and other areas **(Figure 3.14-2** and **Figure 3.14-3)**. **Tables 3.14-2** and **Table 3.14-3** present the details of fire protection system, comprising quantity and size of fire protection and suppression equipment in the area and standards applicable to such systems. The project's computer server room and power control building will be equipped with portable extinguishers.

Installation of fire protection equipment and firefighting system of the project will be defined and detailed design carried out during construction in accordance with the specified standards. Initially, type and nature of the installation of fire protection equipment, and firefighting system will be of the same standard as those of the Gulf Group's power plants, both in operation and under construction. Furthermore, great importance has been given to fire prevention and suppression system, and annual inspection system by insurance firms has been put in place.

(2) Fire Water System

(a) Fire Water Reserve

A combined service/fire water tank is designed to have a storage capacity of 4,200 m^3. Water pumping will be conducted in 2 modes. Service water will be drawn from the upper part of the tank while fire water will be pumped from the lower part of the tank. It is therefore ensured that the remaining water volume in the tank for firefighting will be more than 1,500 m^3, sufficient for maximum 2-hour fire suppression (in case of fire at the diesel oil storage tank with water requirement of 1,364 m^3). This is in accordance with NFPA 850 Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations.

(b) Fire Pump

Details of the project's fire pumps are presented herein.

- 1 set of electric motor pump: 3,000 gallons/minutes, head of 90 meters and capacity of 250 kW, designed according to NFPA 20 (Standard for the Installation of Stationary Pumps for Fire Protection).
- 1 set of diesel motor pump: 3,000 gallons/minutes, head of 90 meters and capacity of 250 kW, designed according to NFPA 20 (Standard for the Installation of Stationary Pumps for Fire Protection).

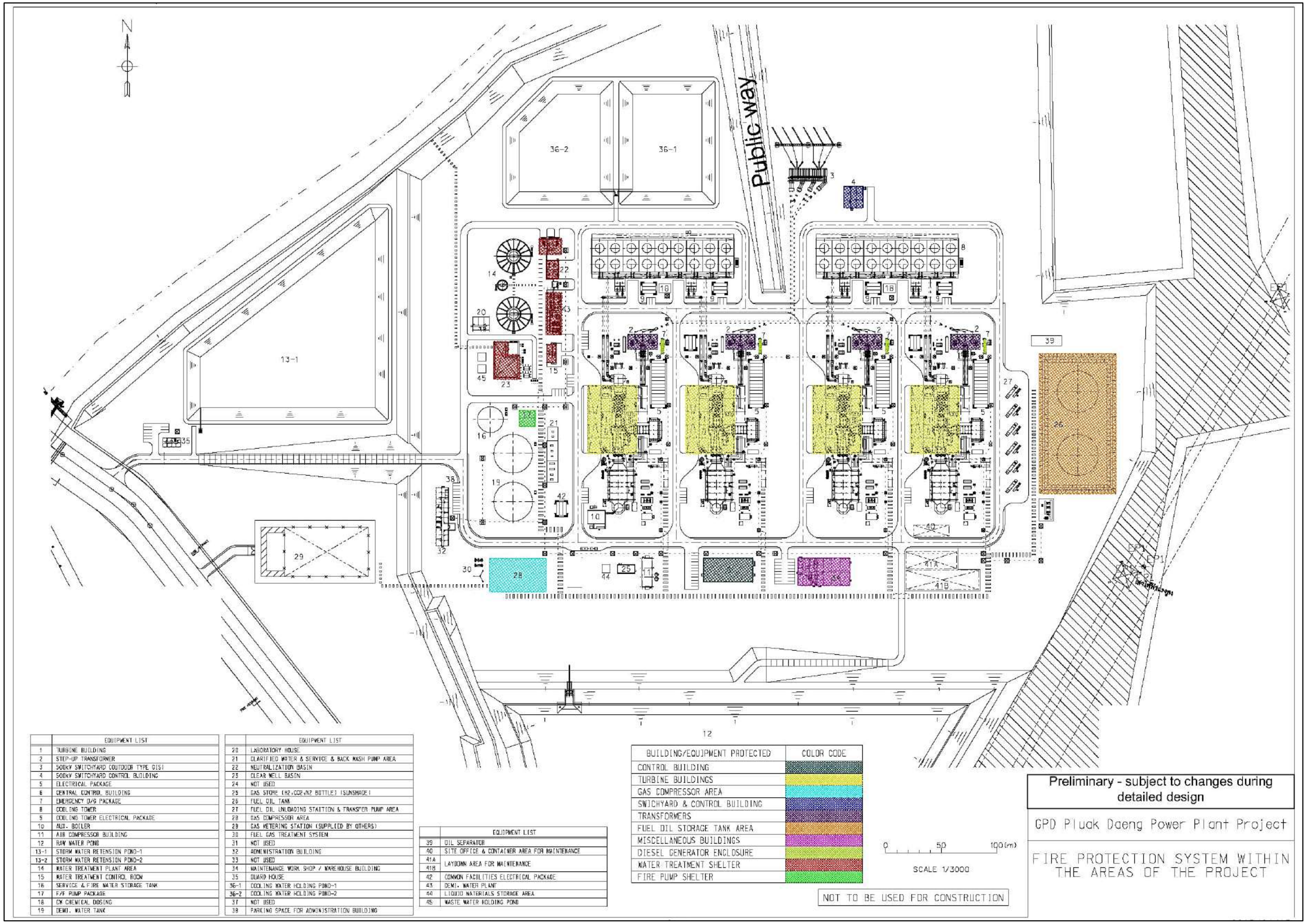


FIGURE 3.14-2 : FIRE PROTECTION SYSTEM WITHIN THE PROJECT AREA

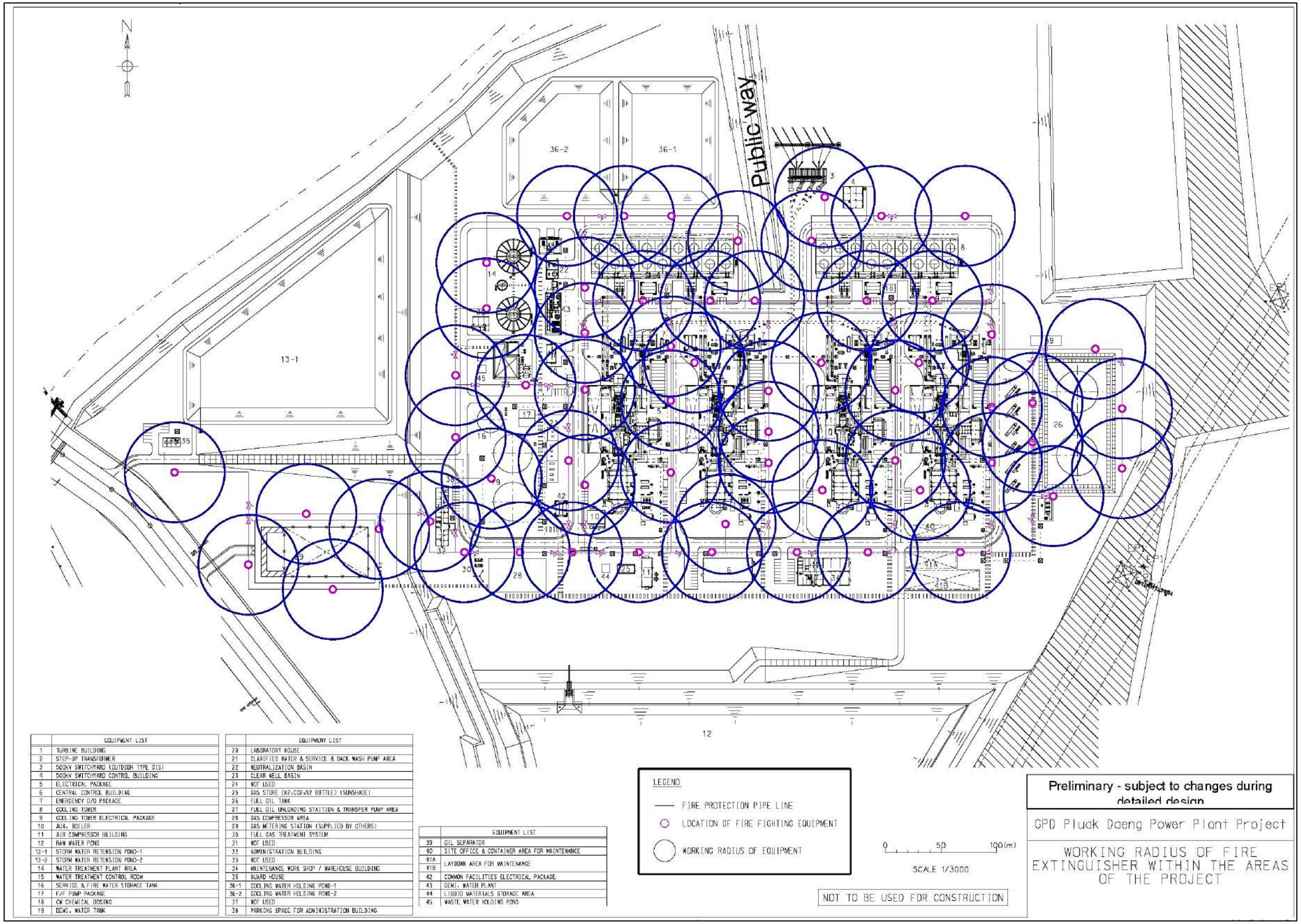


FIGURE 3.14-3 : WORKING RADIUS OF FIRE SUPPRESSION WITHIN THE PROJECT AREA

TABLE 3.14-2

FIRE SUPPRESSION EQUIPMENT AND STANDARDS FOR FIRE PROTECTION SYSTEM DESIGN OF THE PROJECT'S POWER PLANT BUILDINGS

Area	Monitoring System	Fire Suppression System	Operating Mode	Quantity (1)	Design/Equipment Standard	Area (m^2)/ Volume (m^3)
Control Buildings						
Control Building Office Areas		• Pre-Action Sprinkler	Automatic	60	NFPA 13 NFPA 850	556 / 1,668
	• Smoke Detection		Automatic	20	NFPA 72 NFPA 850	-
		• Portable Extinguishers	Manual	10	NFPA 10	-
Toilets	• Smoke Detection		Automatic	2	NFPA 72 NFPA 850	22.5/67.5
		• Portable Extinguishers	Manual	2	NFPA 10	
Computer Server Room	• Smoke Detection		Automatic	1	NFPA 72 NFPA 850	30/90
		• Portable Extinguishers	Manual	2	NFPA 10	
Electrical Package Area						
Electrical Package Area	• Smoke Detection		Automatic	2 sets/generating unit	NFPA 72 NFPA 850	504/1,612
		• Portable Extinguishers	Manual	2 sets/generating unit	NFPA 10	
Turbine Buildings						
Gas Turbine Room and Steam Turbine Room		• Portable Extinguishers	Manual	10 sets/generating unit	NFPA 10	10,080 / 282,240
Turbine Lube Oil Unit of Gas Turbines and Steam Turbines	• Deluge Water Spray with Wet-Pilot Sprinkler Head	• Deluge Water Spray with Wet-Pilot Sprinkler Head	Automatic	4 sets/generating unit	NFPA 15 NFPA 850	-
Turbine Lube Oil Piping and Grade Level under Pedestal	• Wet-pipe Sprinkler	• Wet-pipe Sprinkler	Automatic	50 sets/generating unit	NFPA 13 NFPA 850	-

TABLE 3.14-2

FIRE SUPPRESSION EQUIPMENT AND STANDARDS FOR FIRE PROTECTION SYSTEM DESIGN OF THE PROJECT'S POWER PLANT BUILDINGS (CONT'D)

Area	Monitoring System	Fire Suppression System	Operating Mode	Quantity (1)	Design/Equipment Standard	Area (m^2)/ Volume (m^3)
Generator Bearings	• Heat Detection		Automatic	2 sets/generating unit	NFPA 72 NFPA 850	-
		• Pre-Action Close-head Sprinkler	Automatic	4 sets/generating unit	NFPA 13 NFPA 850	-
Generator Hydrogen Seal Oil Units	• Deluge Water Spray with Wet-Pilot Sprinkler Head	• Deluge Water Spray with Wet-Pilot Sprinkler Head	Automatic	2 sets/generating unit	NFPA 15 NFPA 850	-
Combustion Turbine Enclosures including Combustion Turbine Exhaust End Bearing Tunnel	• Heat Detection		Automatic	8 sets/generating unit	NFPA 72	-
		• Carbon Dioxide Fire Protection	Automatic	1 set/generating unit	NFPA 72	-
Fuel Gas Compressor Area						
Gas Compressor	• Heat Detection		Automatic	4 sets	NFPA 72 NFPA 850	-
		• Portable Extinguishers	Manual	2 sets	NFPA 10	
Electrical Equipment Room	• Smoke Detection		Automatic	6 sets	NFPA 72 NFPA 850	108/345
		• Portable Extinguishers	Manual	2 sets	NFPA 10	
Diesel Generator						
Diesel Generator Enclosure	• Wet-pipe Sprinkler or Pre-Action Close-head Sprinkler)	• Wet-pipe Sprinkler or Pre-Action Close-head Sprinkler	Automatic	8 sets/generating unit	NFPA 13 NFPA 850	-
	• Water Treatment Control House					
Control Room	• Smoke Detection		Automatic	4 sets	NFPA 72 NFPA 850	128/448

TABLE 3.14-2

FIRE SUPPRESSION EQUIPMENT AND STANDARDS FOR FIRE PROTECTION SYSTEM DESIGN OF THE PROJECT'S POWER PLANT BUILDINGS (CONT'D)

Area	Monitoring System	Fire Suppression System	Operating Mode	Quantity (1)	Design/Equipment Standard	Area (m^2)/ Volume (m^3)
		• Portable Extinguishers	Manual	2 sets	NFPA 10	-
	Fire Pump Package					
Fire Pump Package		• Wet-pipe Sprinkler	Automatic	8 sets	NFPA 13 NFPA 850	-
	• Heat Detection		Automatic	4 sets	NFPA 72 NFPA 850	-
500 kV Switchyard Control Building						
Electrical and Electronic Equipment Control Room	• Smoke Detection		Automatic	4 sets	NFPA 72 NFPA 850	209/836
		• Portable Extinguishers	Manual	2 sets	NFPA 10	
Transformers						
Step-up Transformers	• Deluge Water Spray with Wet-Pilot Sprinkler Head	• Deluge Water Spray with Wet-Pilot Sprinkler Head	Automatic	60 sets/generating unit	NFPA 15 NFPA 850	1,200 m^2
Unit Transformers	• Deluge Water Spray with Wet-Pilot Sprinkler Head	• Deluge Water Spray with Wet-Pilot Sprinkler Head	Automatic	20 sets/generating unit	NFPA 15 NFPA 850	360 m^2
Fuel Oil Storage Tank Area						
Fuel Oil Storage Tank		• Foam hydrant	Manual	6 sets	NFPA 11	6,726 m^2
	• Heat Detection		Automatic	4 sets	NFPA 72 NFPA 850	-

Remarks: (1) Quantity of fire suppression equipment will be rechecked during detailed design of each building to be consistent with the standards of U.S. National Fire Protection Association (NFPA).

Source: Gulf PD Co., Ltd., 2016

TABLE 3.14-3

FIRE SUPPRESSION EQUIPMENT AND STANDARDS FOR FIRE PROTECTION SYSTEM DESIGN OF THE PROJECT'S ADMINISTRATIVE OFFICE BUILDINGS, WORKSHOP AND WAREHOUSE

Area	Fire Suppression System	Operating Mode	Quantity[1]	Design/ Equipment Standard	Area (m^2)/ Volume (m^3)
Administrative Offices and Common Areas	• Wet-pipe Sprinkler	Automatic	30 units	NFPA 13	572/1,716
Workshop and Warehouse	• Wet-pipe Sprinkler	Automatic	40 units	NFPA 13	1,104/8,016
Guard House	• Portable Extinguishers	Manual	3 units	NFPA 11	124/298

Remarks : [1] Quantity of fire suppression equipment will be rechecked during detailed design of each building to be consistent with the standards of U.S. National Fire Protection Association (NFPA).

Source : Gulf PD Co., Ltd., 2016

- 1 set of jockey pump: 50 gallons/minutes, head of 90 meters and capacity of 5 kW, designed according to NFPA 20 (Standard for the Installation of Stationary Pumps for Fire Protection).

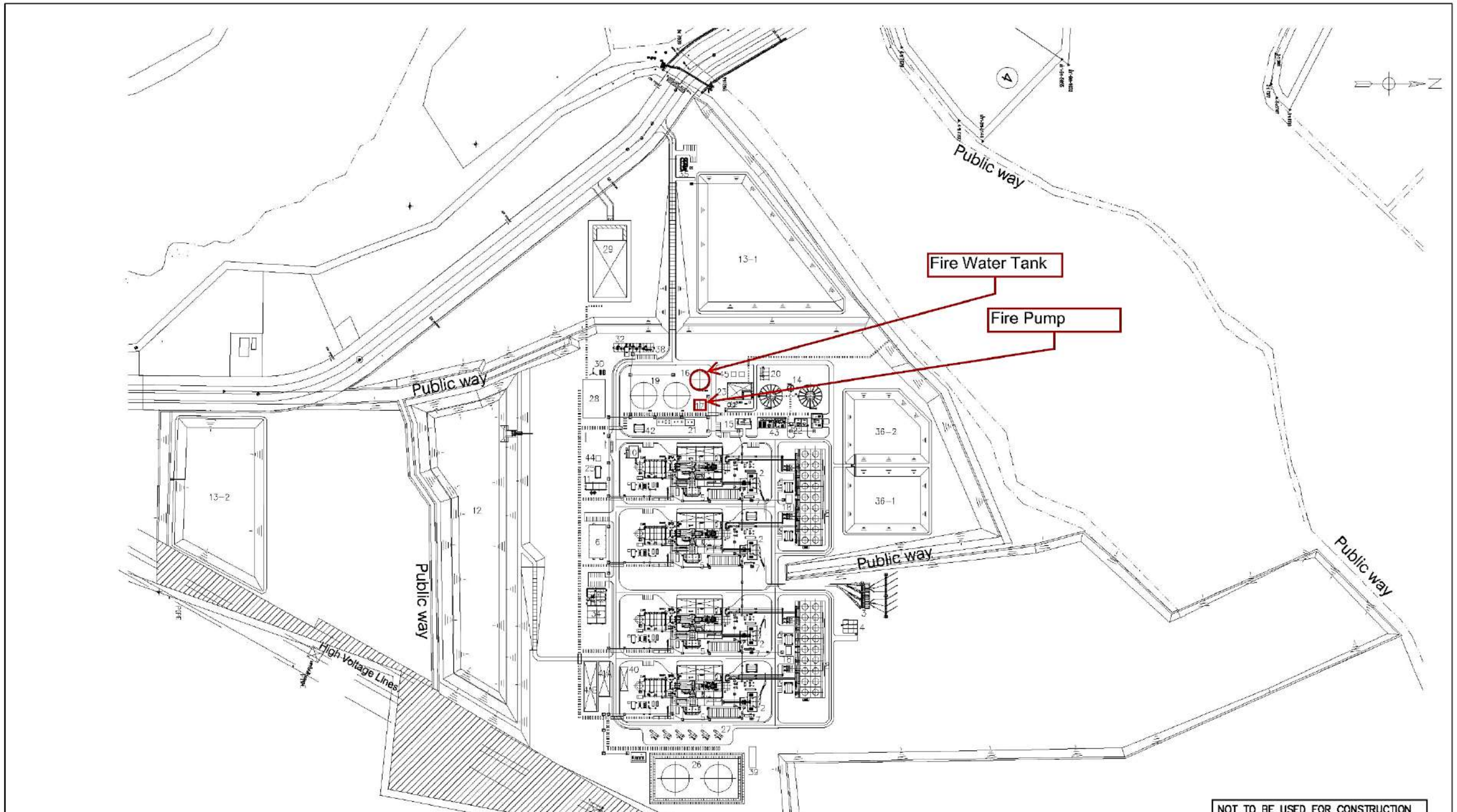
Locations of fire pumps and fire water tank are depicted in **Figure 3.14-4.** Calculation sheets of fire water tank sizing and pumping rate of fire pumps are provided in **Appendix 3AA**.

For about 60 fire hose cabinets in the project area, the design will follow NFPA 24 (Standard for the Installation of Private Fire Service Mains and Their Appurtenances) and NFPA 850 (Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations).

(3) Safety Shower and Eye Wash Equipment

Chemicals used in the project are mentioned earlier in **Item 3.5**. Each type of chemical will be stored in an appropriate container, as given in **Table 3.5-1**. Such container will be surrounded by concrete dike or drip pan. In case of chemical spill, the chemicals will be contained within the concrete dike or drip pan. In addition, chemical storage will be roofed to prevent rain from falling inside the dike area or drip pan.

The project also has incorporated a chemical spill prevention and control plan and a vapour control plan in the Safety Procedure regarding spill prevention and control plan, as shown in **Appendix 3AB.**



	EQUIPMENT LIST
1	TURBINE BUILDING
2	STEP-UP TRANSFORMER
3	500kV SWITCHYARD (OUTDOOR TYPE GIS)
4	500kV SWITCHYARD CONTROL BUILDING
5	ELECTRICAL PACKAGE
6	CENTRAL CONTROL BUILDING
7	EMERGENCY D/G PACKAGE
8	COOLING TOWER
9	COOLING TOWER ELECTRICAL PACKAGE
10	AUX. BOILER
11	AIR COMPRESSOR BUILDING
12	RAW WATER POND
13-1	STORM WATER RETENSION POND-1
13-2	STORM WATER RETENSION POND-2
14	WATER TREATMENT PLANT AREA
15	WATER TREATMENT CONTROL ROOM
16	SERVICE & FIRE WATER STORAGE TANK
17	F/F PUMP PACKAGE
18	CW CHEMICAL DOSING
19	DEMI. WATER TANK

	EQUIPMENT LIST
20	LABORATORY HOUSE
21	CLARIFIED WATER & SERVICE & BACK WASH PUMP AREA
22	NEUTRALIZATION BASIN
23	CLEAR WELL BASIN
24	NOT USED
25	GAS STORE (H2,CO2,N2 BOTTLE) (SUNSHADE)
26	FUEL OIL TANK
27	FUEL OIL UNLOADING STATION & TRANSFER PUMP AREA
28	GAS COMPRESSOR AREA
29	GAS METERING STATION (SUPPLIED BY OTHERS)
30	FUEL GAS TREATMENT SYSTEM
31	NOT USED
32	ADMINISTRATION BUILDING
33	NOT USED
34	MAINTENANCE WORK SHOP / WAREHOUSE BUILDING
35	GUARD HOUSE
36-1	COOLING WATER HOLDING POND-1
36-2	COOLING WATER HOLDING POND-2
37	NOT USED
38	PARKING SPACE FOR ADMINISTRATION BUILDING

	EQUIPMENT LIST
39	OIL SEPARATOR
40	SITE OFFICE & CONTAINER AREA FOR MAINTENANCE
41A	LAYDOWN AREA FOR MAINTENANCE
41B	
42	COMMON FACILITIES ELECTRICAL PACKAGE
43	DEMI. WATER PLANT
44	LIQUID MATERIALS STORAGE AREA
45	WASTE WATER HOLDING POND

FIGURE 3.14-4 : LOCATIONS OF FIRE PUMPS AND FIRE WATER TANK

Safety showers and eye washers will be installed in the chemical storage area or areas where chemicals are used so that workers exposed to a chemical spill can take a safety shower and eye wash. Locations of safety showers and eye washers are illustrated in **Figure 3.14-5**.

2.14.2.8 Emergency Action Plan

The project has developed an emergency plan for various scenarios that might occur. The main aim is to mitigate any impact on personnel working on site and minimize damage to machinery and equipment. The emergency plan consists of:

(a) Building map and plan indicating all exits of each building

(b) Safety areas, evacuation routes and assembly points

(c) Firefighting equipment layout plan indicating location of the equipment, e.g. fire hydrant, fire hose cabinets, fire extinguishers, etc., in each building.

(d) Emergency response procedures for a range of emergencies such as fire, electrical leakage, storm, flood, accident, chemical spill, riot, etc.

(e) Evacuation plan

(f) First aid treatment

Training on proper use of firefighting equipment

During normal operational hours, the power plant manager is designated as emergency director. In case of emergency outside normal hours, the shift leader will be designated as emergency director. The emergency director will be responsible for controlling and directing all actions during an emergency to evacuate all personnel into a safe place. The emergency director is knowledgeable about all emergency plans, able to assess situations and determine the level of emergency whether to evacuate all or part of personnel. He/she will decide which area to be blocked to contain the situation. When the situation returns to normal, the emergency director can order all or only specific group of personnel back to work. He/she will also be responsible for reporting on the incident in detail, specifying date, time, location, cause, severity, any casualties, damages or losses to personnel and machinery as well as working hours lost. The report will also detail the orders made, rehabilitation plan, machinery repair plan, expected time of repair, number of personnel involved, and cost estimates for repair and parts procurement, etc.

The project has stipulated an emergency drill once per year including employee training for emergency response. Inspection of all fire suppression equipment is required to be performed every week or as specified in the project safety procedure.

The project has also developed the project's emergency preparedness measures in 3 phases as follows:

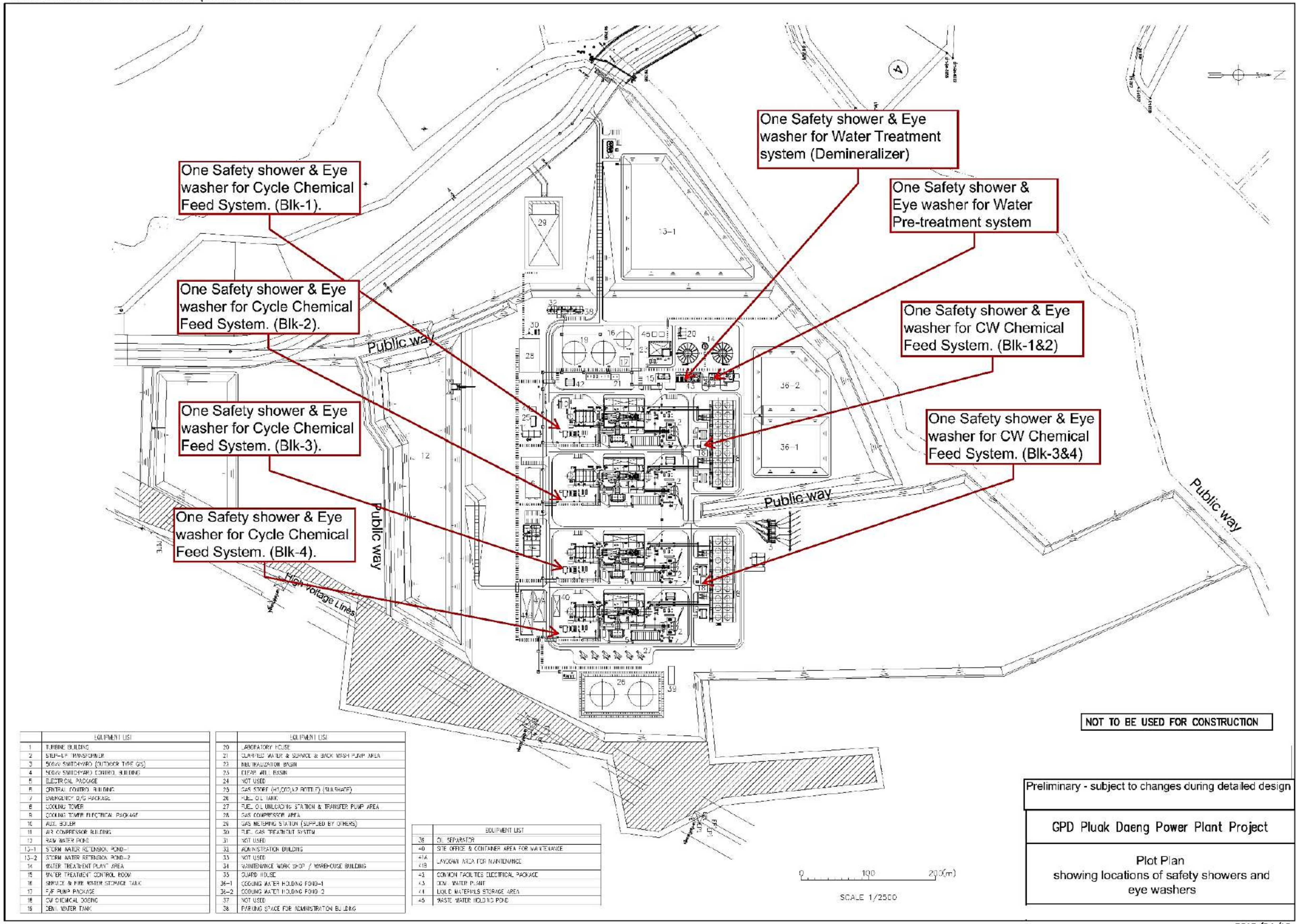


FIGURE 3.14-5 : LOCATIONS OF SAFETY SHOWERS AND EYE WASHERS

Phase 1: Emergency Preparedness Measures:

(1) Preparation, inspection and preventive maintenance of fire prevention and protection equipment to ensure its full working order at all times. The maintenance unit of each work area is responsible for ensuring preparedness of fire alarm, emergency communication and suppression systems. The safety department shall provide consultation on best practices. For fire suppression equipment, responsible persons will be designated to ensure that all equipment is in working order at all times.

(2) Occupational Safety, Health and Environment Unit shall be responsible for emergency responder preparedness, emergency response exercises, and fire suppression training for employees.

(3) Roles, duties and responsibilities of designated emergency responders will be defined and they will strictly perform their duties.

Phase 2: Emergency Response Measures

An emergency can occur due to several causes which are categorized into 2 groups: natural gas emergencies and other emergencies. Therefore, the project has developed a contingency plan to cover both types of emergencies:

Natural Gas Emergency and Fire Prevention and Suppression Plan

(1) Objectives

- To prevent fire caused by natural gas;
- To be effectively prepared for fire suppression.

(2) Background Information

To ensure safety of natural gas related works, we need to understand its hazardous characteristics and general safety practices as follows:

(a) Characteristics of Natural Gas and Causes of Natural Gas Incidents

- Natural gas used for generating electricity is made up mainly of Methane, a dry gas.
- Natural gas has a vapor density of 0.6 by mass compared to air (air is 1.0).
- At normal temperature and atmospheric pressure, methane is present in the form of gas vapor.
- Liquefied methane can expand several times more than other gases.
- The range of methane-to-air mixture ratio that allows it to ignite is called flammable and explosive limit which is at 5.0-14.0% (Low to High Limit).

(b) Natural Gas Hazards

- Leakage into the atmosphere (methane is dangerous when mixed with air at certain ratios).

- Natural gas is colorless and not harmful to human body, but inhaling it can cause unconsciousness due to lack of oxygen.

(c) Danger Area – personnel entering a danger area must strictly abide by the safety rules such as:

- No smoking
- Cigarette lighters, matches or anything that may cause sparks are prohibited.
- Materials that support fire are prohibited.
- Combustible materials such as yellow or white phosphorus and magnesium alloys are prohibited.
- Hot Work such as welding and cutting requires authorization prior to start of work.
- Safety measures must be planned and implemented prior to operation.
- Unauthorized personnel are prohibited from entering danger areas.

(d) Pipeline Monitoring Measures

Safety monitoring and impact mitigation of natural gas pipeline within the project is under the responsibility of the power plant. The safety measures to be implemented at the project gas metering station are as follows:

- Conduct regular inspection of natural gas pipeline for possible leak at welded joints above ground at the gas metering station and gas compressors as per requirement of the project safety procedure.
- Install marker posts indicating locations of underground gas pipeline that may cause danger.

Gas Leakage Procedure

- Approach the fire or leakage from upwind.
- Evacuate everyone from gas leakage and remove any flammable materials out of the way immediately.
- Isolate gas leak area for no less than 200 feet in all directions to prohibit people from entering the area except those authorized to work on the leak incident.
- Gas leak with no fire
    - ➢ Shut the gas valve to block the flow of gas.
    - ➢ Douche the gas leakage with water spray by cutting the gas leak direction or in the manner that changes direction of the gas leak.
    - ➢ If gas leakage cannot be stopped, then control ignition by hosing water at hot metal parts such as hot pipeline or hot metal surface

- Avoid ignition sources.

- Gas leak with fire
  - Shut the gas valve to block the flow of gas.
  - Do not use fire extinguishers until gas flow can be blocked successfully.
  - Douche hot surfaces such as concrete, pipes, metal surfaces, etc. Allow the fire to burn itself out where it leaks.
  - If fire occurs at the block valve, douche the valve with water spray and send in a person wearing firefighting suit to shut the valve.
  - Dry chemical fire extinguishers are effective in suppressing relatively small fire – direct the extinguisher nozzle at the leak. For very low pressure gas leak, CO_2 extinguishers should be used instead.
  - If gas leak cannot be stopped, then control the gas vapor by douching equipment around it.
- Gas leak protective measures
  - When a gas leak is known, shut down all electric equipment that is not explosion proof type in the gas leak area.
  - Shut down the valve to block flow of gas to the leakage.
  - Control fire sources such as flames, hot surfaces, sparks, etc.
  - Check for gas to air mixture ratio in the gas leak area to identify danger area and ventilate accordingly.
  - Personnel not wearing firefighting suits must check possible gas trapped inside their own clothes which can cause danger.

(e) Identifying Gas Leakage Location

- Identify the location of possible gas leakage to be measured.
- Assign the order of valve and flange numbers for gas leak identification test.
- Devise an inspection schedule including inspection duration.
- Conduct daily inspection by the power plant staff, using gas leak detector along the gas pipeline and in machine rooms in the natural gas system.

(f) Repair or Maintenance of Gas Equipment or Pipeline

- Block valve before performing any repair or maintenance.
- Ensure adequate ventilation in the repair or maintenance area.
- Test the gas-air ratio before performing repair or maintenance, and periodically test it during the repair or maintenance.
- Tools or equipment used in repair or maintenance should be non-sparking type.

- Gas facilities must be well maintained to prevent gas leakage with regular inspection such as pipeline thickness test.

Diesel Oil Emergency and Fire Prevention and Suppression Plans

Details of the plan implementation are explained as follows:

(1) Diesel Oil Storage

Diesel will be stored in two tanks with capacity of 14,300 m^3 each and will be filled to no more than 90% capacity, i.e. 13,000 m^3 per tank, in compliance with the Ministerial Regulation on Fuel Storage, B.E. 2556 (2013) of the Ministry of Energy. The storage volume will be sufficient for 3-day reserve of fuel supply. The diesel storage tanks will be surrounded by concrete dike with capacity equal to the 100% storage volume of the largest storage tank so as to contain diesel fuel oil in case of tank failure or leakage according to the Ministerial Regulation on Fuel Storage, B.E. 2556 (2013) of the Ministry of Energy.

(2) Diesel Oil Transfer

Diesel oil loading/unloading area will be paved with concrete and bunded so that stormwater runoff contaminated with fuel oil that may be spilled or leak in the area will be collected to interceptor drains and then flow to an oil separator.

An emergency plan has been prepared for diesel spillage or leakage during transfer operation, with the following details.

Oil Spill Preparedness Plan

(a) Oil Spill Response Training

Safety Officer and the Occupational Safety, Health and Environment Committee will arrange training for every staff to provide basic knowledge about relevant rules, procedures and documents. If there is any change to the procedures/support documents relating to emergency preparedness as well as Emergency Prevention and Suppression Plan, the Safety Officer must inform all personnel of such changes.

(b) Oil Leak Prevention

- Fuel oil-related operation division/section must comply with the fuel oil unloading procedure;
- Personnel with fuel oil-related duties must perform their duties with care to prevent spillage to the environment by complying with the fuel oil unloading procedure and relevant MSDS.

(3) Preparation/Inspection of Emergency Equipment

Emergency equipment must be readily prepared for emergencies at all times.

- Sorbent materials, e.g. sand, sawdust, clothes or other materials with sorbent or oil-spreading prevention properties;

- Appropriate personal protective equipment, e.g. rubber gloves, masks, respirators or other equipment as appropriate;
- Oil contaminated waste containers;
- Inspection of tanks, valves and safety valves must be regularly carried out every month;

(4) Oil Spill Response

- **Small Spills**

The employee who first discovers a minor leak shall immediately take corrective action;

Surround the spill area with sand, sawdust or other materials kept prepared for emergency by the concerned unit to prevent further leak or spill;

Notify promptly the supervisor and person responsible for the area where spill occurs to handle the emergency;

Clean up the spill area using rags or oil absorbent materials;

Collect and dispose of all materials used in the oil spill response operations in the hazardous waste container (according to the hazardous waste management procedure);

Clean up the spill area thoroughly to prevent environmental impacts;

The supervisor and person responsible for the area where spill occurs will hold a meeting to find measures to prevent any recurrence.

- **Large Spills**

The employee who first discovers a large leak shall immediately notify the head of the unit or person responsible for the area where spill occurs as well as concerned persons to respond to the emergency;

Secure the area of large spill to prevent the spreading of oil spill and to facilitate response operations;

Approach the oil release from upwind to avoid diesel vapour and the emergency responders shall wear safety equipment such as gas masks/chemical cartridge respirators for safety;

Oil spill response operations shall follow the Oil Spill Prevention and Response Plan.

(5) Post-Emergency Response

- After the termination of emergency, the Leader of the Emergency Response Team (ERT) shall declare the termination of evacuation plan, return of the evacuated personnel to normal operations. He/she will coordinate with the operation or maintenance unit for recovery and restoration of the oil spill site.

- All managers/section chiefs will survey damages resulting from the emergency incident and jointly work with the Emergency Response Team for recovery and restoration of the oil spill site.
- Recovery and Restoration of Oil Spill Site
  - The Emergency Response Team shall wear appropriate personal protective equipment during on-site operations;
  - The Emergency Response Team shall isolate the spill site and put up hazard warning signs;
  - The Emergency Response Team shall separate and dispose of or treat wastes according to the waste management procedures prior to the cleanup;
  - Wastewater from oil spill response will be collected and the drain outlets will be blocked to prevent the flow of wastewater from oil spill response to the environment. The wastewater will be pumped and collected for further treatment.
- The Safety Officer will prepare and submit a written report of the emergency incident to the power plant manager for information and further submission to the Occupational Safety, Health and Environment Committee's meeting for evaluation and improvement of the emergency response plans and related documents.

In case of an actual emergency situation, the Safety Officer and the Occupational Safety, Health and Environment Committee have the duties to evaluate the effectiveness and efficiency of response operations. They will review the obtained data and information, and then revise and update the emergency response plans and related documents.

Emergency and Fire Prevention and Suppression Plans for Other Causes

(1) Fire within the Power Plant

Fire may spread if there is a strong wind during dry weather and flammable substances are in proximity. Besides, it depends on types of flammable origin. Control of fire incident will be more difficult if fire occurs from flammable and explosive materials such as oil. However, trained employees' skills and quick fire response is crucial to fire control. Other important factors include readiness of fire extinguisher devices, fire hydrant locations, sufficiency of water pressure, readiness of fire pumps, and weekly inspection for ready use. Inspection of all firefighting equipment and review of the emergency plan must be regularly carried out.

(2) Factory Fire in the Vicinity

Communication between the project, Pluak Daeng Industrial Park and nearby factories is necessary in case of factory fires in the vicinity in order to exchange information on risk and emergency probabilities. As a result, the Industrial Park's emergency plan must be prepared in detail including a name list of safety officers and emergency coordinators;

communication, telephone numbers or walkie-talkie frequency of persons involving in emergency coordination. This will contribute to coordinated firefighting activities and evacuation of the project staff, if necessary, including prevention of spread of fire from nearby factories.

(3) Chemical Leakage in the Project Area

Chemicals used in the project may leak during the processes of addition, transportation, truck load/unloading or transfer from tank to chemical pump. In the event of leakage of non-hazardous liquids, the emergency coordinator will assess the situation by investigating chemical contamination in soil or groundwater and providing proper management methods

(4) Leakage Current

There is a very low probability of leakage current because the power plant is designed with better underground connection system than other factory types. However, if leakage current happens, the emergency coordinator must be able to inform everyone of safe rescue procedure for electric shock victims.

(5) Accident

Accidents include falling from height, heavy weight falling during lifting, lost consciousness in confined space or traffic accident. Accidents are sometimes only minor incidents. If such accident renders unrelated employees incapable of working or they become involved in such accident, remedial action and mitigation will be much more complex.

(6) Storm

The emergency coordinator must follow the news and climate forecasts announced by the Meteorological Department. Then he/she will assess the situation and issue orders or take preparedness actions, e.g. securing materials and equipment that may be blown away, removing items stacked on high places to safe places, warning workers or employees to stop working outdoors in exposed areas and to take shelter inside buildings, etc.

Power Plant Emergency Classes

In normal working hours, power plant manager will be responsible for controlling workers safety and responding to emergencies.

For working outside normal hours, shift leaders will be responsible for emergency response until the situation returns to normal or the power plant manager arrives at the emergency area and assumes the responsibility. Emergency incidents are classified into two classes as follows:

(1) Emergency Class 1

Emergency Class 1 is an incident occurring in the power plant area that the emergency coordinator can control the situation and limit the damage with support of employees, workers, fire extinguisher devices available in the power plant until the situation returns to normal.

(2) Emergency Class 2

Emergency Class 2 is an incident that may occur both inside and outside of the power plant. The emergency coordinator assesses and determines that the situation the emergency plan prepared for Class 1 is not applicable, and assistance in terms of manpower and equipment must be requested from Pluak Daeng Industrial Park in order to control the situation and implement the Industrial Park's emergency plan as presented in **Appendix 3AC** (source: Rojana Industrial Park Rayong 2 Co., Ltd., 2016).

Emergency Operating Procedures of the Power Plant

(1) Emergency Operating Procedures during Normal Working Hours

The employee who first discovers an emergency situation will decide whether he can control the situation on his own or not. If not, he will call the central control for help and notify the Emergency Director. The power plant manager is the designated Emergency Director in charge of assessing the situation and determining the emergency class and whether the emergency can be contained using available resources or not. He will be giving orders to control and rectify the situation, ensuring safety of all plant employees and power plant assets. For example, he can call for support from the Industrial Park's firefighting unit, or ambulance from nearby hospitals to take care of any casualties. He is tasked with ordering the deployment of power plant firefighting unit, evacuation of employees to a safe assembly point, closure of relevant roads in the power plant area and entry/exit points on site, etc.

(2) Emergency Operating Procedures outside Normal Working Hours

The employee who first discovers an emergency situation will decide whether he can control the situation on his own or not. If not, he will call the central control for help and notify the Emergency Director. Due to the smaller number of employees working during these hours, the Shift Leader will be designated Emergency Director in emergency situations. If the fire situation is classified as Emergency Class 2, he must call for the Industrial Park's firefighting unit as soon as possible and call upon all on-call employees to report to work. He is also tasked with ordering the firefighting and safety teams to proceed as per training and call for local ambulances for backup medical assistance in case of casualties. He will also order a power shutdown in relevant areas to allow for firefighting and report the situation to the power plant manager.

The emergency situation organization chart is presented in **Figure 3.14-6**, and the emergency operation flowchart is exhibited in **Figure 3.14-7**.

Communication

To establish efficient communications during an emergency, the emergency communications chart to be implemented is depicted in **Figure 3.14-8**.

Emergency telephone numbers for communications with external organizations and communities are presented in **Table 3.14-4**. The readiness of relevant local agencies is detailed herein.

1. **Pluak Daeng Industrial Park**

Firefighting system of Pluak Daeng Industrial Park consists of:

- Fire water pipeline system in combination with water supply pipeline system, not less than 100 mm in diameter;
- 2.5-4–inch two-way fire hydrants installed at intervals not more than 150 meters to allow for use by external fire trucks and emergency cars for firefighting operations;
- Security staff are on 24-hour duty. They will be trained in accordance with the Industrial Park's security measures and jointly trained in firefighting exercises.

2. **Map Yang Phon Sub-district Administrative Organization**

Firefighting system of Map Yang Phon Sub-district Administrative Organization comprise the following.

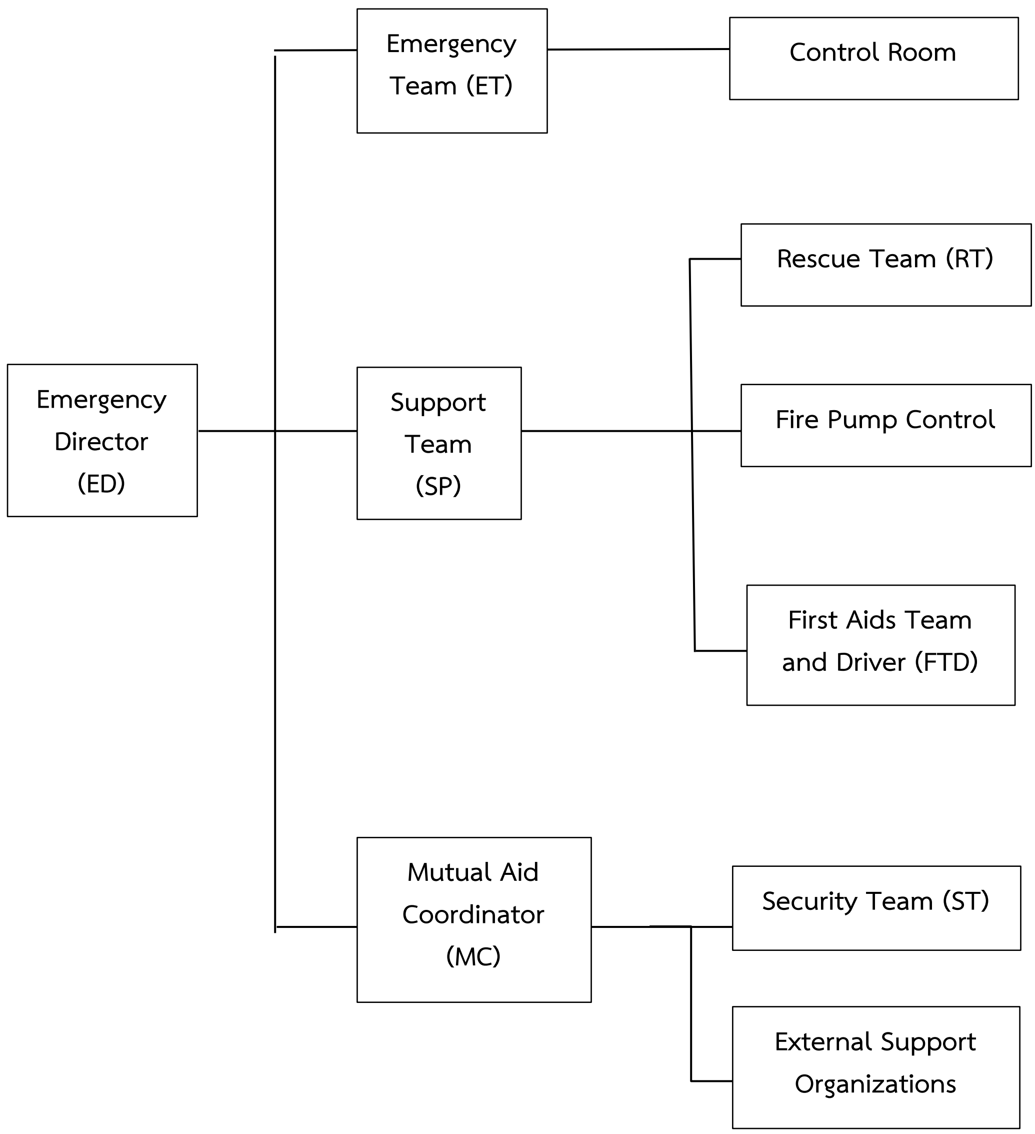
- 1 fire truck, with capacity of 12,000 litres
- 1 platform truck
- 13 disaster mitigation officers
- 190 civil defence volunteers
- 200 dry chemical fire extinguishers, with 10-lb capacity

Map Yang Phon Sub-district Administrative Organization is about 4 km from the project area, with a journey time of 4 minutes.

3. **Pluak Daeng Sub-district Administrative Organization**

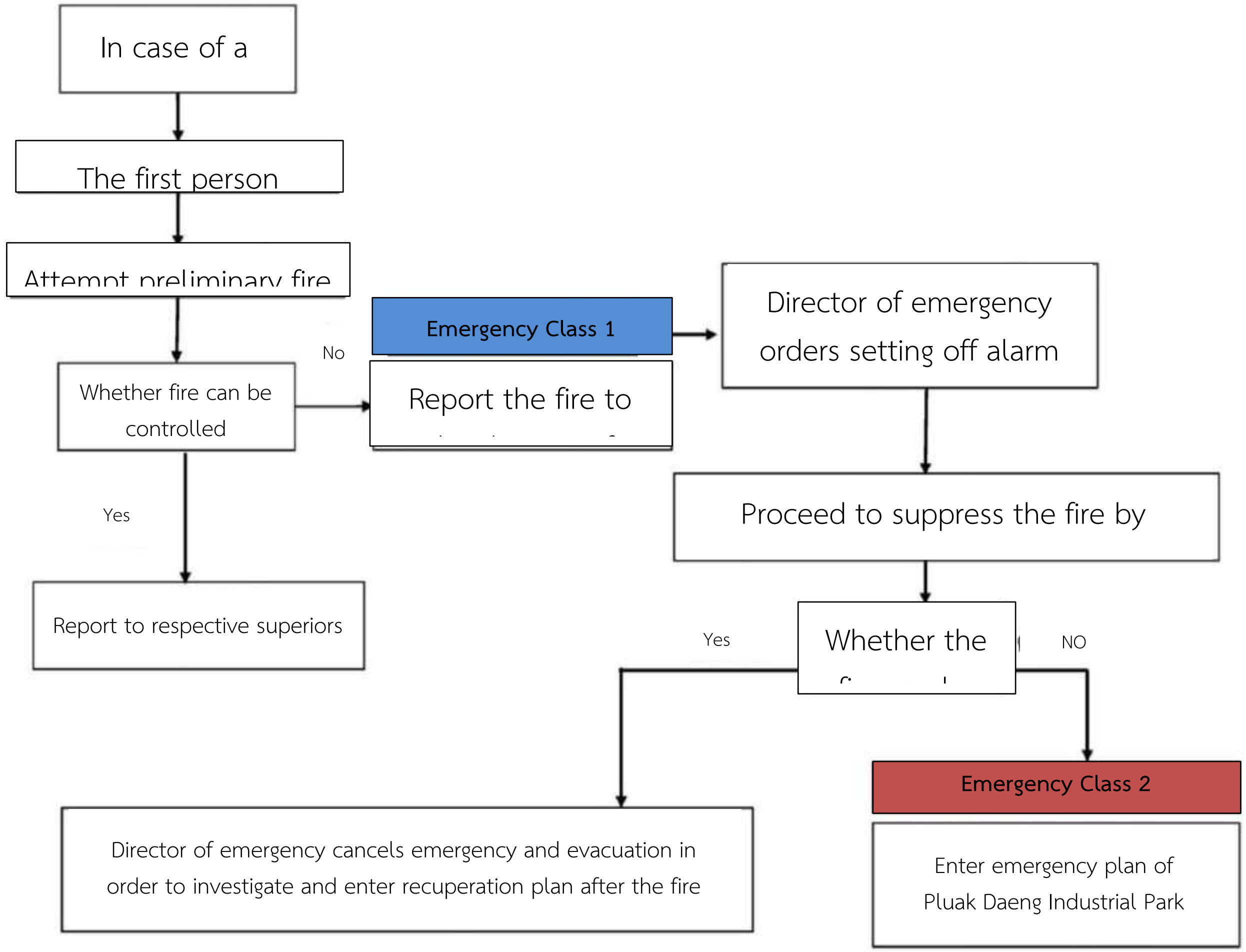
Firefighting system of Pluak Daeng Sub-district Administrative Organization consist of:

- 1 multi-purpose fire truck, with capacity of 12,000 litres
- 1 fire truck with fire nozzles, with capacity of 5,000 litres
- 1 multi-purpose rescue car
- 1 platform truck
- 1 patrol car
- 2 disaster prevention and mitigation officers
- 1 permanent employee



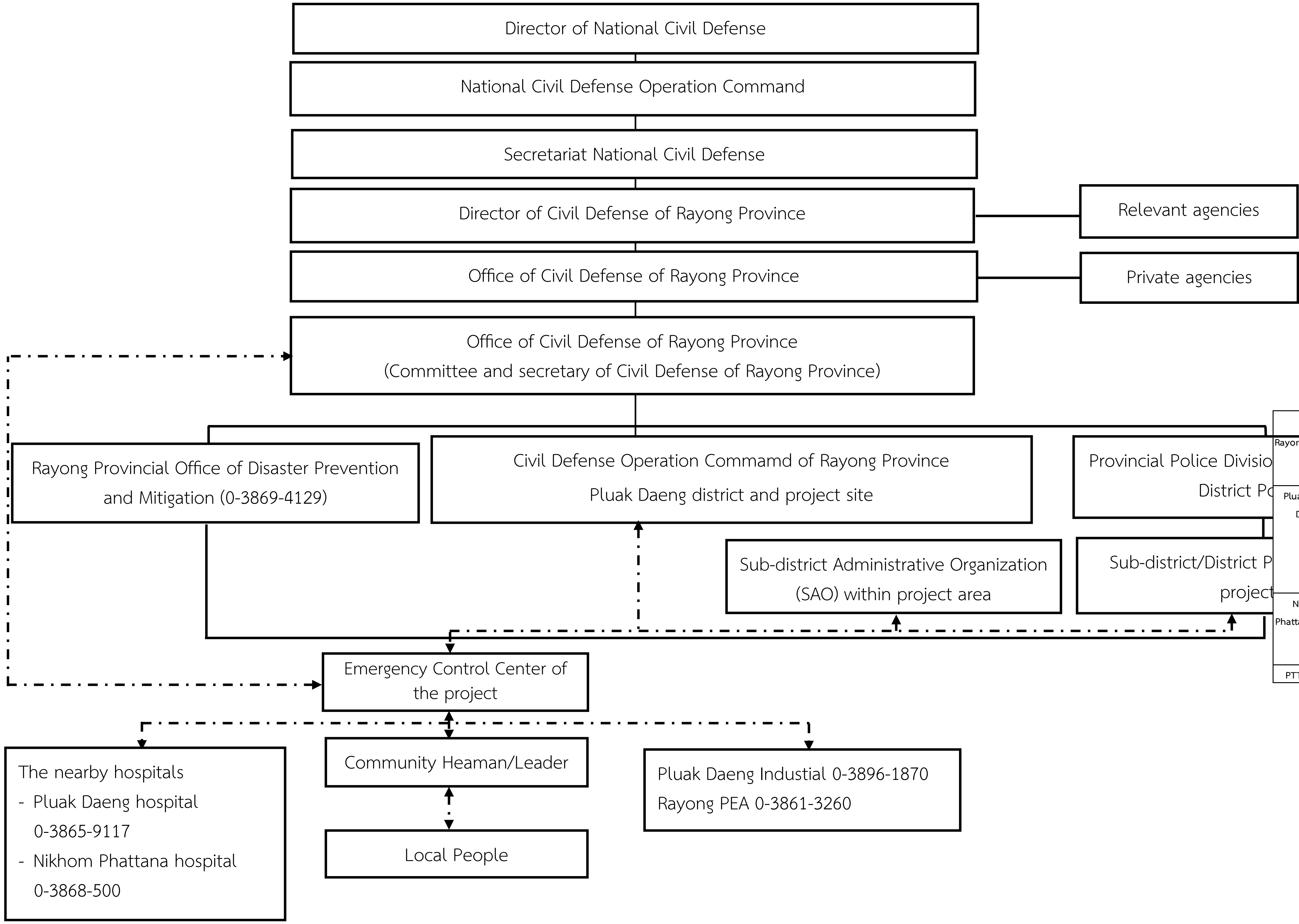
Source: Gulf PD Co., Ltd., 2016

FIGURE 3.14-6: EMERGENCY SITUATION ORGANIZATION CHART



Source: Gulf PD Co., Ltd., 2016

FIGURE 3.14-7: PLUAK DAENG POWER PLANT EMERGENCY OPERATION FLOWCHART



Rayong Province	Rayong Provincial Office of Disaster Prevention and Mitigation	0-3869-4129
	Rayong Provincial Electricity Authority	0-3861-3260
	Rayong Provincial Police Division	0-3861-3340
Pluak Daeng District	Pluak Daeng District Office	0-3865-9002
	Pluak Daeng District Police Station	0-3865-9101
	Map Yang Phon SAO	0-3865-9314
	Pluak Daeng SAO	0-3865-9886
	Mae Nam Khu SAO	0-3801-0800
	Pluak Daeng Hospital	0-3865-9117
Nikhom Phattana District	Nikhom Phattana District Office	0-3863-7373
	Nikhom Phattana District Police Station	0-3863-6111
	Phana Nikhom SAO	0-3887-7200
	Nikhom Phattana Hospital	0-3803-8050
PTT Gas Pipeline Operation Center, Region 3 of PTT Plc.		0-3868-5009

FIGURE 3.14-8 : EXTERNAL PARTIES EMERGENCY COORDINATION CHART

TABLE 3.14-4

EMERGENCY CONTACT PHONE NUMBERS OF EXTERNAL AGENCIES

Area	Agency	Tel.
Rayong Province	Rayong Provincial Office of Disaster Prevention and Mitigation	0-3869-4129
	Rayong Provincial Electricity Authority	0-3861-3260
	Rayong Provincial Police Division	0-3861-3340
Pluak Daeng District	Pluak Daeng District Office	0-3865-9002
	Pluak Daeng Police Station	0-3865-9101
	Map Yang Phon Subdistrict Administrative Organization	0-3865-9314
	Pluak Daeng Subdistrict Administrative Organization	0-3865-9886
	Mae Nam Khu Subdistrict Administrative Organization	0-3801-0800
	Pluak Daeng Hospital	0-3865-9117
Nikhom Phatthana District	Nikhom Phatthana District Office	0-3863-7373
	Nikhom Phatthana Police Station	0-3863-6111
	Phana Nikhom Subdistrict Administrative Organization	0-3887-7200
	Nikhom Phatthana Hospital	0-3803-8050
PTT Gas Pipeline Operation Center, Region 3 of PTT Plc		0-3868-5009

- 2 task-specific workers
- 3 general workers
- 195 civil defence volunteers

Pluak Daeng Sub-district Administrative Organization is about 9 km from the project area, with a journey time of 9 minutes.

4. **Mae Nam Khu Subdistrict Administrative Organization**

Firefighting system of Mae Nam Khu Subdistrict Administrative Organization consist of:

- 2 multi-purpose water trucks
- 4 firefighters
- 103 civil defence volunteers

Mae Nam Khu Subdistrict Administrative Organization is about 14 km from the project area, with a journey time of 14 minutes.

5. **Phana Nikhom Subdistrict Administrative Organization**

Firefighting system of Phana Nikhom Subdistrict Administrative Organization comprise:

- 4 disaster mitigation officers
- 1 water truck, with capacity of 12,000 litres, for immediate fire response

In case of inability to contain the fire, cooperation can be sought from Makham Khu Subdistrict Municipality, Nikhom Phatthana Subdistrict Administrative Organization, Map Kha Subdistrict Municipality, and Map Kha Phatthana Subdistrict Municipality.

Phana Nikhom Subdistrict Administrative Organization is about 12 km from the project area, with a journey time of 12 minutes.

Evacuation Plan

Pluak Daeng Power Plant project has designated assembly points and evacuation routes. The Emergency Director will decide on the most appropriate route, taking consideration of safety and convenience to evacuate personnel from the scene. The fire evacuation plan for Pluak Daeng Power Plant (as shown in **Figure 3.14-9**) takes into account the situation from Emergency Class 1 upwards. The assembly points of Pluak Daeng Power Plant are described in **3.14.2.9 Assembly Points**.

Emergency Relief and Recovery Plan

The emergency relief and recovery plan comprises:

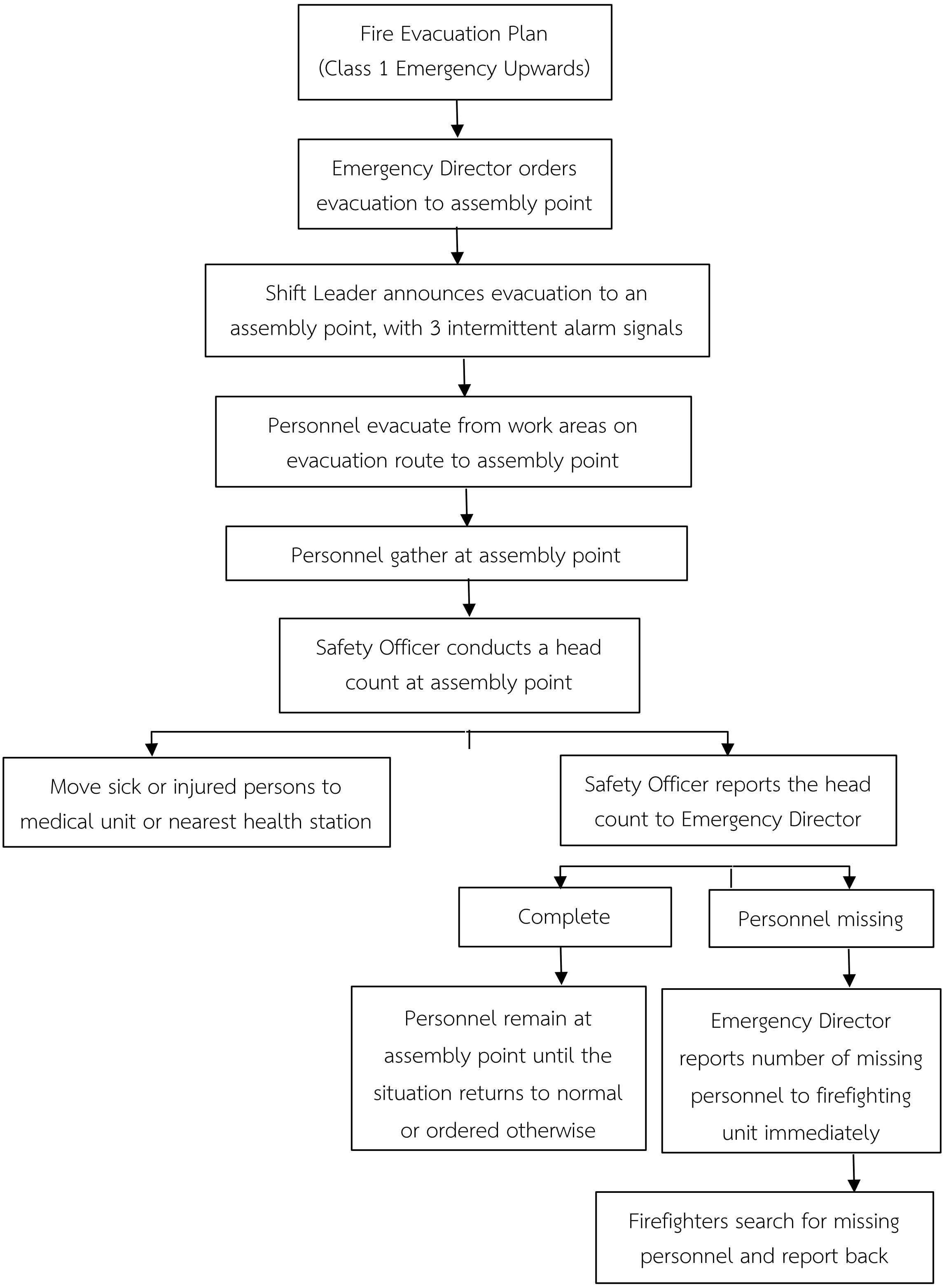
- Coordination with government agencies
- Damage assessment
- Set up a committee comprising one representative from each section and designation of assembly points for awaiting orders
- Survivor rescue and body recovery
- Movement of casualties and properties of the deceased
- Risk and operational assessment, and fire report.

Phase 3: Recovery Measures after Emergency

Recovery plans after fire include revision and update of the evaluation report in all aspects of the actual situation to proceed on remedy, especially on fire protection plan, fire response action plan, impact mitigation plan (to be undertaken immediately after the fire has been extinguished) including provision of assistance to all employees who are injured and disabled in the fire emergency incident.

(1) Improvement of fire protection and suppression plan

- Change of regulations and measures
- Evaluation of fire protection and suppression drill which shows that the existing map or diagram is inefficient
- Addition of equipment to the system to eliminate a probable cause of an abnormal occurrence
- Change of firefighting director
- Change of locations of protection and suppression equipment such as fire hoses, fire extinguishers, etc.



Source: Gulf PD Co., Ltd., 2016

FIGURE 3.14-9: FIRE EVACUATION PLAN, PLUAK DAENG POWER PLANT PROJECT

(2) After the abnormal situation, an observer has to give advice regarding the following issues.
- Have the objective and practice method been achieved as planned?
- Is any adjustment of the plan required?
- Is the implementation of action plan successful?
- Is the communication with other organizations adequately efficient?

(3) Improvement of project recovery
- Give information to the public on the cause of fire and protection guidelines
- Give support to fire victims or those impacted by fire incidents
- Renovation, repair and restoration project

3.14.2.9 Assembly Points

An assembly point is a safe area for personnel not involved in the emergency plan operation to gather for head counting by Shift Leader and Evacuation Leader in preparation for evacuation to outside the power plant site (the project's Emergency Class 1 Plan). Three assembly points are designated for the project, as illustrated in **Figure 3.14-10**, which can sufficiently accommodate all staff.

3.14.2.10 Emergency Drills

An emergency drill is to build preparedness for both personnel and equipment. The drill will be conducted for each emergency class according to the steps specified in the emergency plan. For Emergency Class 1, a drill will be held at least once a year including drill assessment in order to improve the emergency plan for maximum efficiency. An emergency drill assessment requires the following:

(1) Occupational Safety, Health & Environment Officer will follow up and record all emergency drill schedules in the emergency drill schedule form of Pluak Daeng Power Plant once a year. This shall be completed within December every year and submitted to the power plant manager for consideration.

(2) Occupational Safety, Health & Environment Officer gives technical advice or consultation on emergency drill techniques and also attends every meeting of emergency drill planning.

(3) Occupational Safety, Health & Environment Officer is to observe the drill at the following locations:
- Scene of incident
- Traffic management
- Communications management and coordination

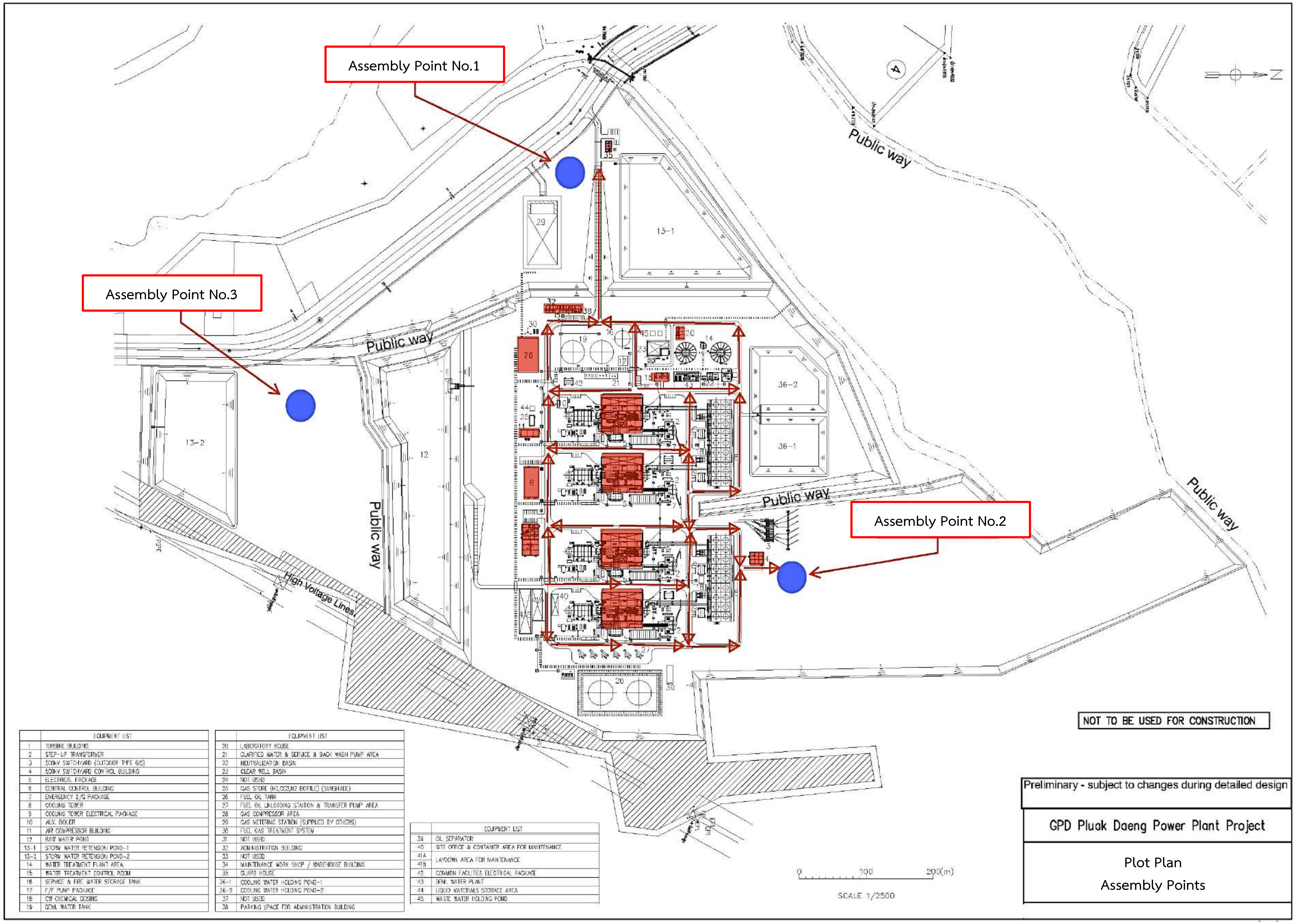


FIGURE 3.14-10 : ASSEMBLY POINTS OF PLUAK DAENG POWER PLANT PROJECT

- Order and suppression

(4) Occupational Safety, Health & Environment Officer will observe the emergency drill, attend drill assessment meetings of all departments and provides his assessment of the drill in an emergency drill assessment form. He then submits the report to the power plant manager for consideration and notification of deficiencies to be rectified (if any).

(5) Occupational Safety, Health & Environment Officer presents the results of improvement and corrective actions to the Occupational Safety, Health & Environment Committee Meeting in the follow-up agenda for emergency plan improvement.

3.14.2.11 Employee Health Check-Up

In accordance with the Ministry of Labour's Ministerial Regulation on Labour Welfare in Workplaces, B.E. 2548 (2005), the project organizes an annual employee health check-up by a medical doctor licensed to practice occupational medicine. A pre-employment health check-up will be provided to new employees and then an annual health check-up once a year, as detailed in **Table 3.14-5.**

Each employee will be issued with a personal health record as part of the company employee health database to monitor health impact especially employees on hazardous work duty. The database is also used for the project occupational health management system. A designated staff will be responsible for safe record keeping of employee health records throughout the duration of his/her employment.

TABLE 3.14-5

EMPLOYEE HEALTH CHECK-UP PLAN OF PLUAK DAENG POWER PLANT PROJECT

Group of Employees	Measured Indices	Implementation and Frequency
New employees	- Physical Examination - Chest X-ray - Blood Test: complete blood count, blood group and hepatitis B	pre-employment
All employees	- Physical Examination - Chest X-ray - Blood Test: complete blood count, blood group and hepatitis B - Vision Test - Audiometric Test	Once per year

Source : Gulf PD Co., Ltd., 2016

3.14.3 Labour Welfare in Workplaces

The project will provide necessary welfare in accordance with the Ministerial Regulation on Labour Welfare in Workplaces, B.E. 2548 (2005) of Labour Protection Act B.E.2541 (1998) such as:

(1) Drinking Water, Wash Rooms, Toilets

The project will provide clean drinking water and adequately maintained wash rooms and toilets for project employees.

(2) First Aid and Health Care

The project will provide healthcare for all employees at designated hospital or clinic as detailed on the employee healthcare card. For first aid and primary treatment for minor injuries or illness during working hours, the project has installed a first aid kit as required by the Ministry of Labour's Ministerial Regulation on Labour Welfare in Workplaces, B.E. 2548 (2005). For injuries requiring treatment, the project is to make an agreement with all employees that they be moved to a 24-hour hospital instead of providing for an in-house medical doctor on the premises.

3.15 COMMUNITY RELATIONS AND COMPLAINT PROCEDURE

3.15.1 Community Relations

The project operations might have direct and indirect impacts on the livelihood and environment of nearby communities. To ensure sustainable development and promote local understanding of the project, a public relations plan will be implemented on a regular basis as per Gulf Group's policy. This is to help boost confidence in the project development and give back to the local communities by sponsoring various community activities. The company has established a public relations plan for each phase of the project as follows:

(1) Public Relations Plan for Pre-construction Period

The objective is to create outreach to the public on the project development. A community relations team will meet up with local government organizations, local leaders and the public to share information pertaining to the project.

(2) Public Relations Plan for Construction Period

The project will continue to conduct outreach and publicize project progress and assimilate the public suggestions and comments on construction activities including social and environmental issues. The feedback will form a basis for improvements and changes to the project and serve as guidelines for improving upon publicity approach.

(3) Public Relations Plan for Operational Period

During the operational period, the project will continue with community relations, support of community activities and participation in community development by providing aid and support, and partaking in community activities as appropriate to build good community relations and give back to the community.

3.15.2 Complaint Procedure

The project is to set up a complaint center and assign a personnel responsible to processing complaints, implement outreach, assimilate suggestions, opinions and requests. The public can use any of the available complaint mechanisms such by words, telephone, fax, note, letter, email or inform another project employee. The complaint procedure is detailed as per **Figure 3.15-1** as follows:

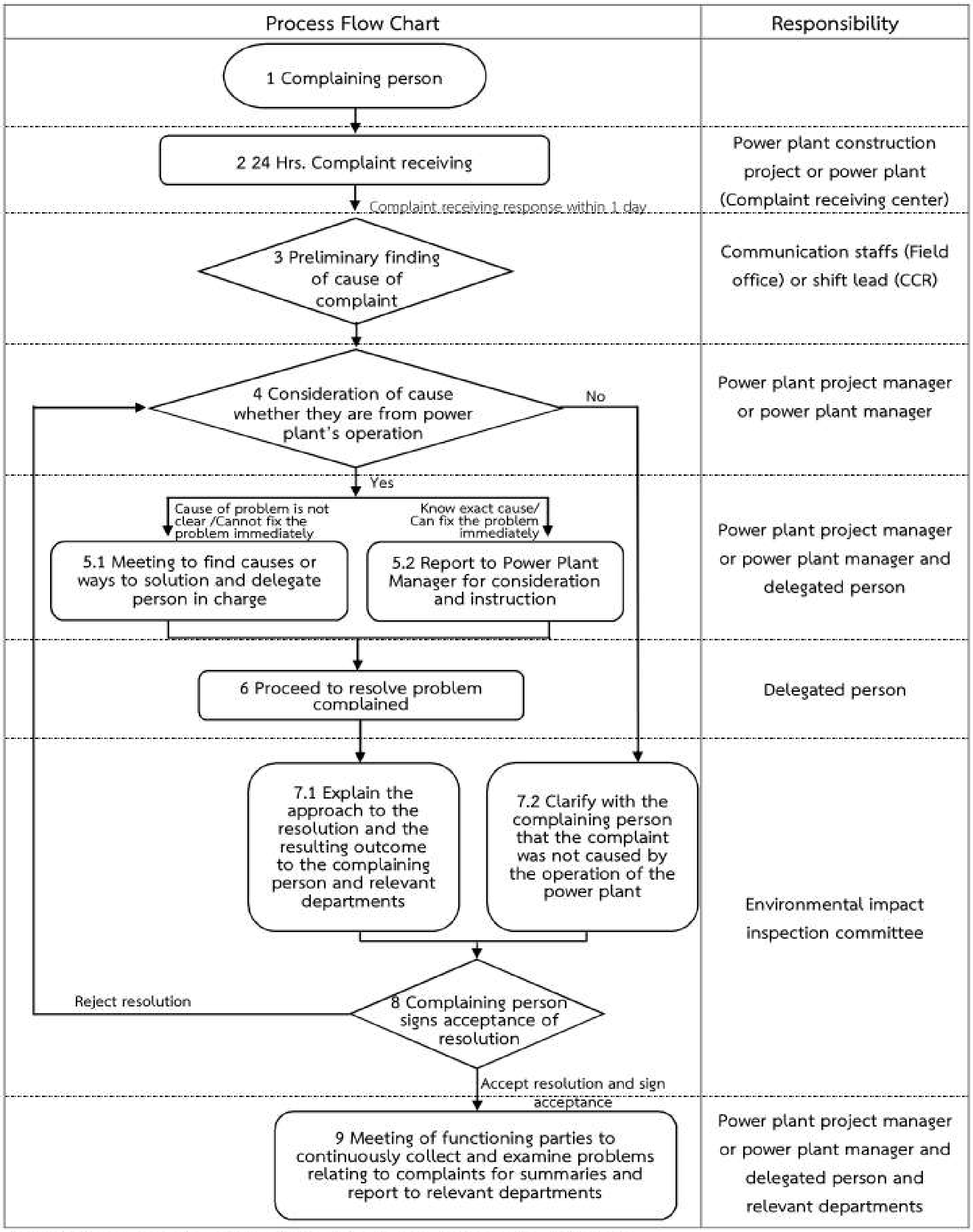
(1) After the complainant has made a complaint via one of the channels to the complaint center or to the power plant, the responsible personnel will preliminarily investigate the cause. If the issue is not caused by the project, then complainant must be informed within 24 hours.

(2) If the issue indeed arises due to the project, the complaint officer will forward the complaint to the site manager if it is during construction phase or to the power plant manager during operational phase. A meeting to rectify the issue and prevent recurrence will be held and personnel assigned to rectify the issue. The complainant must be kept informed of progress every 7 days or as mutually agreed upon.

(3) Site manager or power plant manager is responsible for ordering corrective actions and informing the complainant of the progress every week or as mutually agreed upon. In addition, the Occupational Safety, Health and Environment Committee must be informed. The complaint officer and the complainant shall jointly inspect the problem-solving activities.

3.16 PROJECT IMPLEMENTATION AND MANAGEMENT

The implementation plan of Pluak Daeng Power Plant Project of Gulf PD Co., Ltd., will cover from EIA report preparation to applications for permission as shown in **Figure 3.16-1**. Construction period is expected to be 51th months (power plant construction will begin in the 4th month until the 51th month, totaling 48th months). The construction works will commence in 2020 and be completed in 2023, with the plant operation starting in 2024.



Note: 1. Report causes/resolutions/solving time to complaining party within 5 days.

2. Report progress in resolving problems to the complaining party every 7 days or as agreed.

Source : Gulf PD Co., Ltd., 2018

FIGURE 3.15-1: COMPLAINT PROCEDURE

GPD Project Schedule

Item	Description
1	EIA Study
2	ขออนุญาตประกอบกิจการโรงงาน
3	ขออนุญาตผลิตไฟฟ้า
4	การดำเนินการจัดหาเงินกู้
	Pre Construction Schedule
1	Finding labor camps area
2	Construction of labor camps
3	Construction of Site office
4	Construction of Site laydown area
5	Construction of Temporary Road On Site
6	Construction of Powerplant Equipment laydown area
	Construction Schedule
1	การคัดเลือกและจัดจ้างผู้รับเหมา
2	Engineering/Design
3	Procurement
4	Construction Unit 1 and common facilities
5	Construction Unit 2
6	Construction Unit 3
7	Construction Unit 4
8	Commissioning & Start up Activities Unit 1 and common facilities
9	Commissioning & startup Activities Unit 2
10	Commissioning & Start up Activities Unit 3
11	Commissioning & startup Activities Unit 4
12	Commercial Operation Date
13	งานสนับสนุนการดำเนินโครงการ

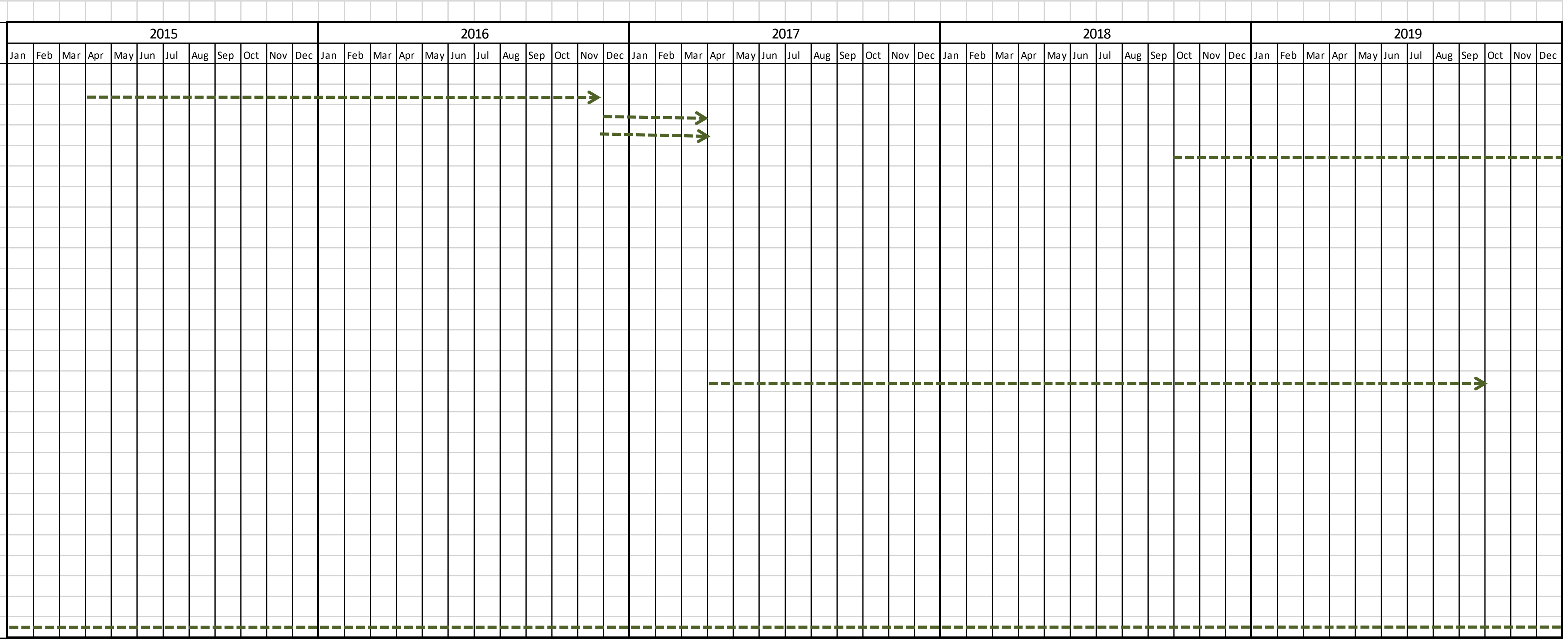


FIGURE 3.16-1 : IMPLEMENTATION PLAN OF PLUAK DAENG POWER PLANT PROJECT

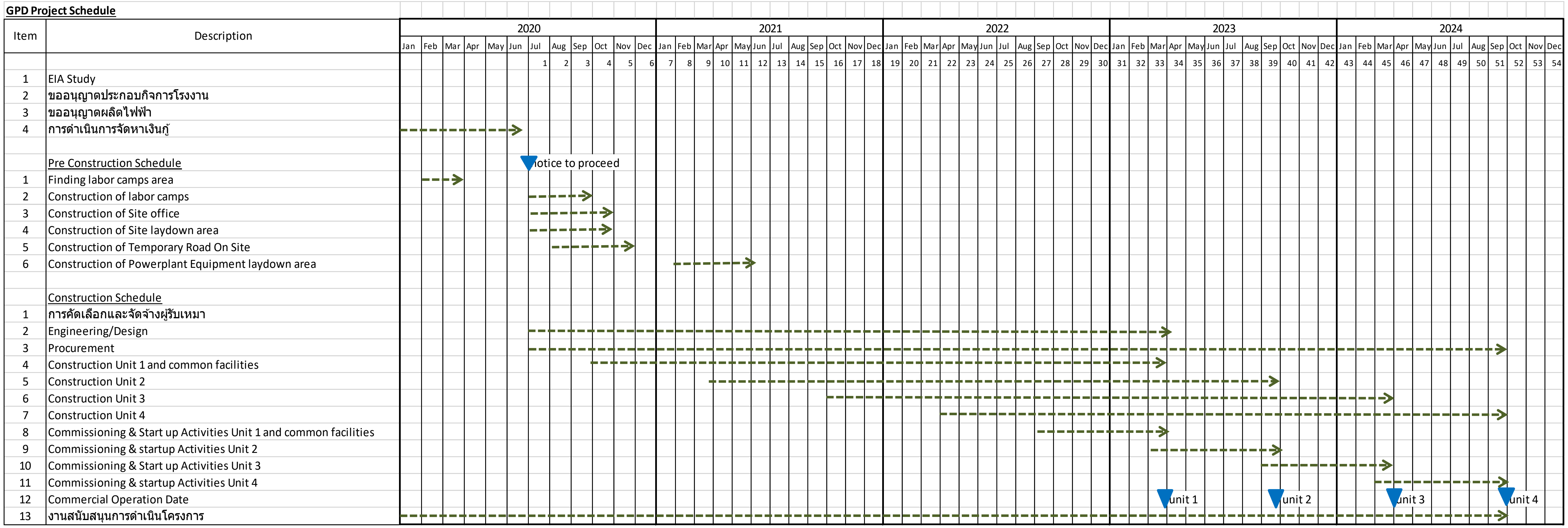
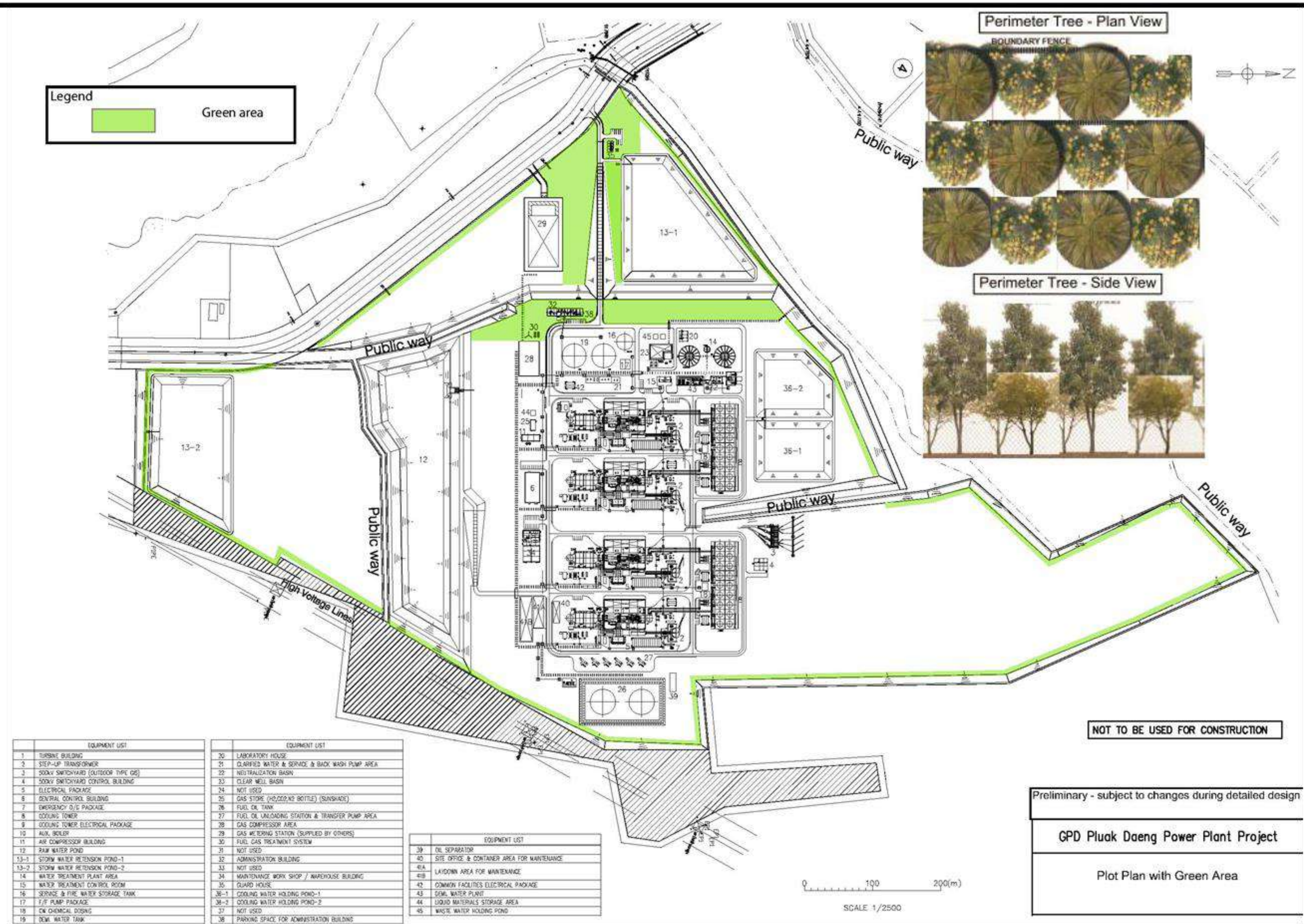


FIGURE 3.16-1 : IMPLEMENTATION PLAN OF PLUAK DAENG POWER PLANT PROJECT (CONT'D)

3.17 GREEN AREA

Pluak Daeng Power Plant Project will set aside 45,000 m^2 of green area or 5.71% of the project total land. Perennials, shrubs and grasses will be planted in three staggered rows, as exhibited in **Figure 3.17-1**. Sample plant species to be planted are Asoke (Mast Tree), Yellow Flame Tree, D.rheedii Seem, Yellow Cotton Tree or other suitable plants with trunk diameter of no less than 5 inches. Adequate spacing between plants should be provided to allow for full plant growth. Soils for the green area will be conditioned to be suitable for plant growth. The green area will be appropriately and orderly maintained. Irrigation water (about 382 m^3/day) will be drawn from the raw water pond and/or cooling water holding pond. Dead or damaged trees will be replaced within 1 month to conserve and maintain the green area according to the specified ratio.

As the project area is situated in Zone A of Pluak Daeng Industrial Park, protection strip has been designated as green area around the project area by growing three staggered rows of trees, about 6 meters wide, as illustrated in **Figure 3.17-1**. As for the buffer zone of Pluak Daeng Industrial Park, the EIA Report for Pluak Daeng Industrial Park Project, Expansion Phase 1 (February 2016) requires that the Industrial Park must establish a 10 m-wide buffer zone at its perimeter fence adjacent to the areas of other persons/public road/public ditches and factory buildings must be 6 meters away from the factory fence, as depicted in **Figure 3.17-2**.



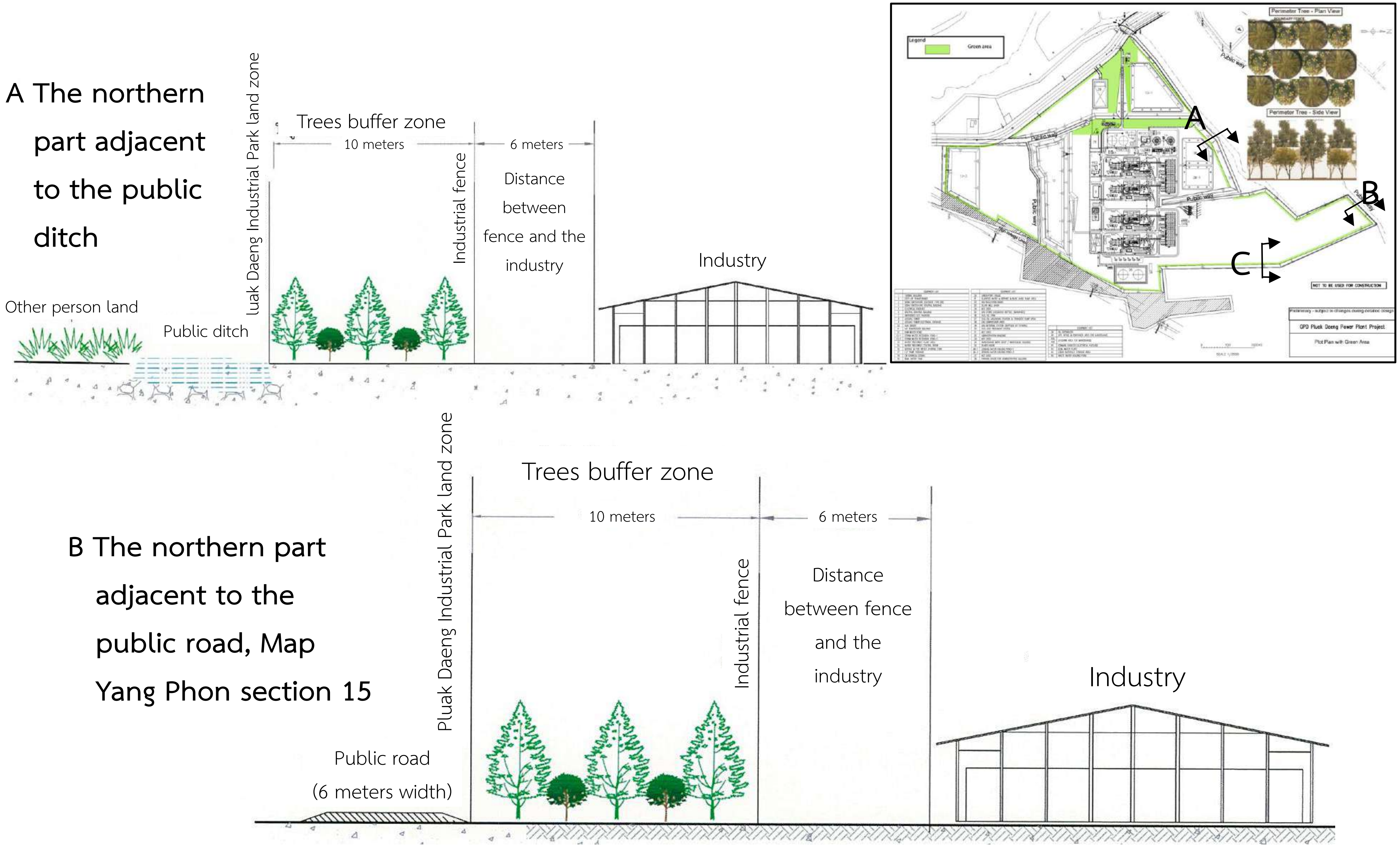
	EQUIPMENT LIST
1	TURBINE BUILDING
2	STEP-UP TRANSFORMER
3	500KV SWITCHYARD (OUTDOOR TYPE GIS)
4	500KV SWITCHYARD CONTROL BUILDING
5	ELECTRICAL PACKAGE
6	CENTRAL CONTROL BUILDING
7	EMERGENCY D/G PACKAGE
8	COOLING TOWER
9	COOLING TOWER ELECTRICAL PACKAGE
10	AUX. BOILER
11	AIR COMPRESSOR BUILDING
12	RAW WATER POND
13-1	STORM WATER RETENSION POND-1
13-2	STORM WATER RETENSION POND-2
14	WATER TREATMENT PLANT AREA
15	WATER TREATMENT CONTROL ROOM
16	SERVICE & FIRE WATER STORAGE TANK
17	F/F PUMP PACKAGE
18	CW CHEMICAL DOSING
19	DEMI. WATER TANK

	EQUIPMENT LIST
20	LABORATORY HOUSE
21	CLARIFIED WATER & SERVICE & BACK WASH PUMP AREA
22	NEUTRALIZATION BASIN
23	CLEAR WELL BASIN
24	NOT USED
25	GAS STORE (H2,CO2,N2 BOTTLE) (SUNSHADE)
26	FUEL OIL TANK
27	FUEL OIL UNLOADING STATION & TRANSFER PUMP AREA
28	GAS COMPRESSOR AREA
29	GAS METERING STATION (SUPPLIED BY OTHERS)
30	FUEL GAS TREATMENT SYSTEM
31	NOT USED
32	ADMINISTRATION BUILDING
33	NOT USED
34	MAINTENANCE WORK SHOP / WAREHOUSE BUILDING
35	GUARD HOUSE
36-1	COOLING WATER HOLDING POND-1
36-2	COOLING WATER HOLDING POND-2
37	NOT USED
38	PARKING SPACE FOR ADMINISTRATION BUILDING

	EQUIPMENT LIST
39	OIL SEPARATOR
40	SITE OFFICE & CONTAINER AREA FOR MAINTENANCE
41A 41B	LAYDOWN AREA FOR MAINTENANCE
42	COMMON FACILITIES ELECTRICAL PACKAGE
43	DEMI. WATER PLANT
44	LIQUID MATERIALS STORAGE AREA
45	WASTE WATER HOLDING POND

FIGURE 3.17-1 : PROTECTION STRIP AND GREEN AREA OF PLUAK DAENG POWER PLANT PROJECT

TEAM



Source : Pluak Daeng Industrial Park project extension part environmental impact assessment report no.1, February 2016

FIGURE 3.17-2 : PROTECTION STRIP OF PLUAK DAENG POWER PLANT PROJECT

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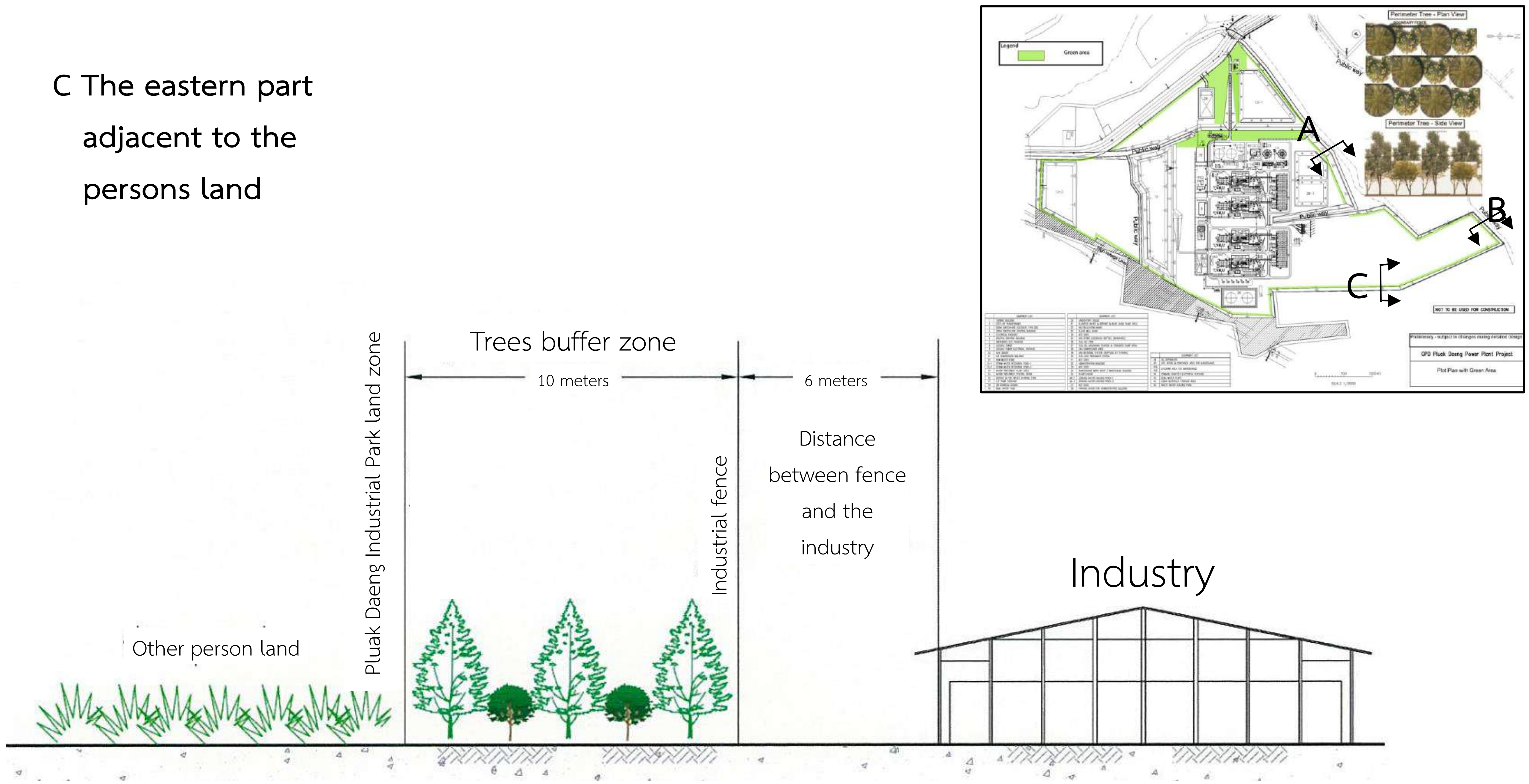

Source : Pluak Daeng Industrial Park project extension part environmental impact assessment report no.1, February 2016

FIGURE 3.17-2 : PROTECTION STRIP OF PLUAK DAENG POWER PLANT PROJECT (CONT'D)

TEAM

CHAPTER 4

DESCRIPTION OF THE ENVIRONMENTAL (BASELINE DATA)

CHAPTER 4
DESCRIPTION OF THE ENVIRONMENTAL (BASELINE DATA)

In conducting the environmental impact assessment for the Pluak Daeng Power Plant Project, collection of secondary data and field survey were necessary to obtain the existing conditions of environmental and natural resources in the project area. The overview of the existing environmental situation and quality in the project's nearby areas was also presented, covering four main environmental components: physical resource, biological resource, human use value, and quality of life value. The project is located in Pluak Daeng Industrial Park, Map Yang Phon sub-district, Rayong province. The EIA report of the Pluak Daeng Industrial Park Expansion Phase 1 was approved by the Office of Natural Resources and Environmental Policy and Planning (ONEP) on 29th December 2015. Therefore, the environmental quality study results of the Pluak Daeng Industrial Park were used as the reference data to clearly indicate the changing trend of the environmental conditions in the study area. The Consultant determined the boundaries of the study area to cover the radius of 5 km from the project site (hereinafter called the "study area"). The study area encompasses parts of Map Yang Phon, Pluak Daeng and Mae Nam Khu sub-districts in Pluak Daeng district; and Phana Nikhom sub-district in Nikhom Phatthana district, Rayong province. The existing environmental conditions of the study area are described below.

4.1 PHYSICAL RESOURCES

4.1.1 Topography

(1) Introduction

The objective of the topographic study was to obtain the existing topographic conditions of the project area and its vicinity to evaluate the suitability of the project location and the impacts of project construction and operation on the topography.

(2) Methodology

- Collection of secondary data from relevant documents
  - Satellite images from Google Earth version 7.1.5.1557
  - Topographic maps at 1:50,000 scale of the Royal Thai Survey Department, Series No. L7018, Sheet Nos. 5234 I, IV and 5235 II, III, year 2005
- Field survey in the study area

(3) Study results

Rayong province is a part of the eastern coast on the Gulf of Thailand and is located about 179 km far from Bangkok. In the south of the province, beaches and beach ridges are found and there above are tidal flats and former tidal flats. The province is mainly formed by undulating and rolling terrains with the slopes of 3-16% above the flat terrains and low lying areas. Besides, hilly terrains and foothill slopes are also discovered in the province. Numerous hills and mountains lie in the north-south direction in the northern, eastern, and central parts of the province. Two major rivers: Rayong river of 50 km in length and Prasae river of 26 km in length, pass through the province.

As for the project's study area, parts of Pluak Daeng and Nikhom Phatthana districts are characterized by undulating and rolling terrains with the slopes in a range of 3-16%; hilly terrains and footing slopes at the elevation of 80 MSL. There are many natural water sources, e.g. Huai Phu Sai, Khlong Lek, Huai Wang Kratha, Huai Chalid, Khlong Hin Loi, and Khlong Chak Oi as illustrated in **Figure 4.1.1-1**.

4.1.2 Geology/Seismology

4.1.2.1 Geology

(1) Introduction

The objective of geological study was to derive the geological structure in the project area and its vicinity to assess the impacts from the project development as well as the impacts that may happen with the project operation.

(2) Methodology

Secondary data were collected from related organizations and previous studies for geological study, including the geological map of Rayong province, prepared by the Geological Survey Bureau, Department of Mineral Resources, 2007, and the geological and mineral resource management zoning report in Rayong province by the Department of Mineral Resources in 2008.

(3) Study Result

75% of land in Rayong province lie on the sedimentary rocks, metamorphic rocks, and sediments. In the project area and the study area, weathering sediments and colluvial deposits **(Figure 4.1.2-1)** are prevalent, especially at foothills or basin edges. Weathering rock layers composed of weathering granite, sand and silt, debris, lateritic soil and terra rossa are commonly found across vast areas, representing more than 40% of land in Rayong province.

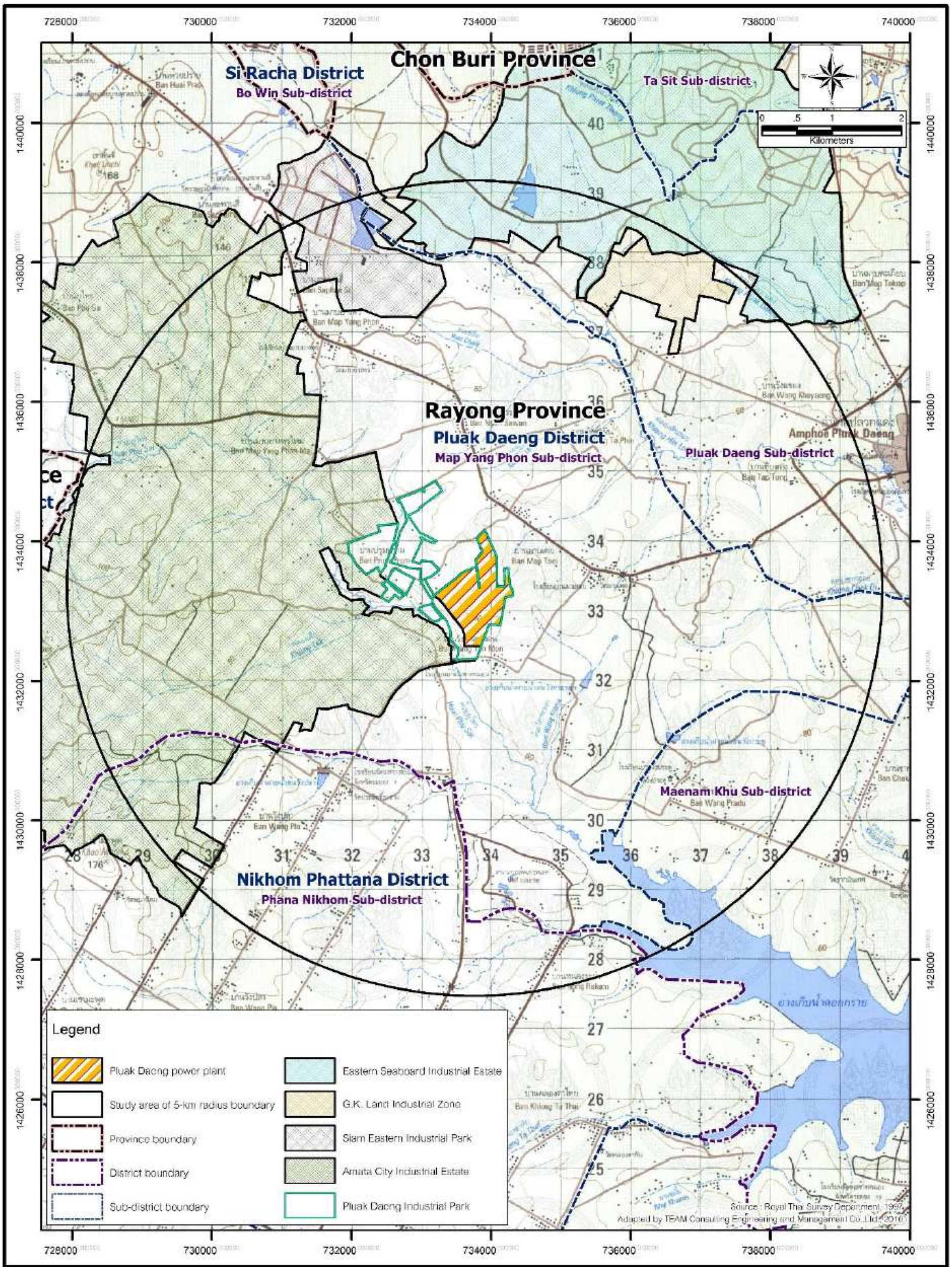

FIGURE 4.1.1-1 : TOPOGRAPHIC CONDITIONS OF THE STUDY AREA

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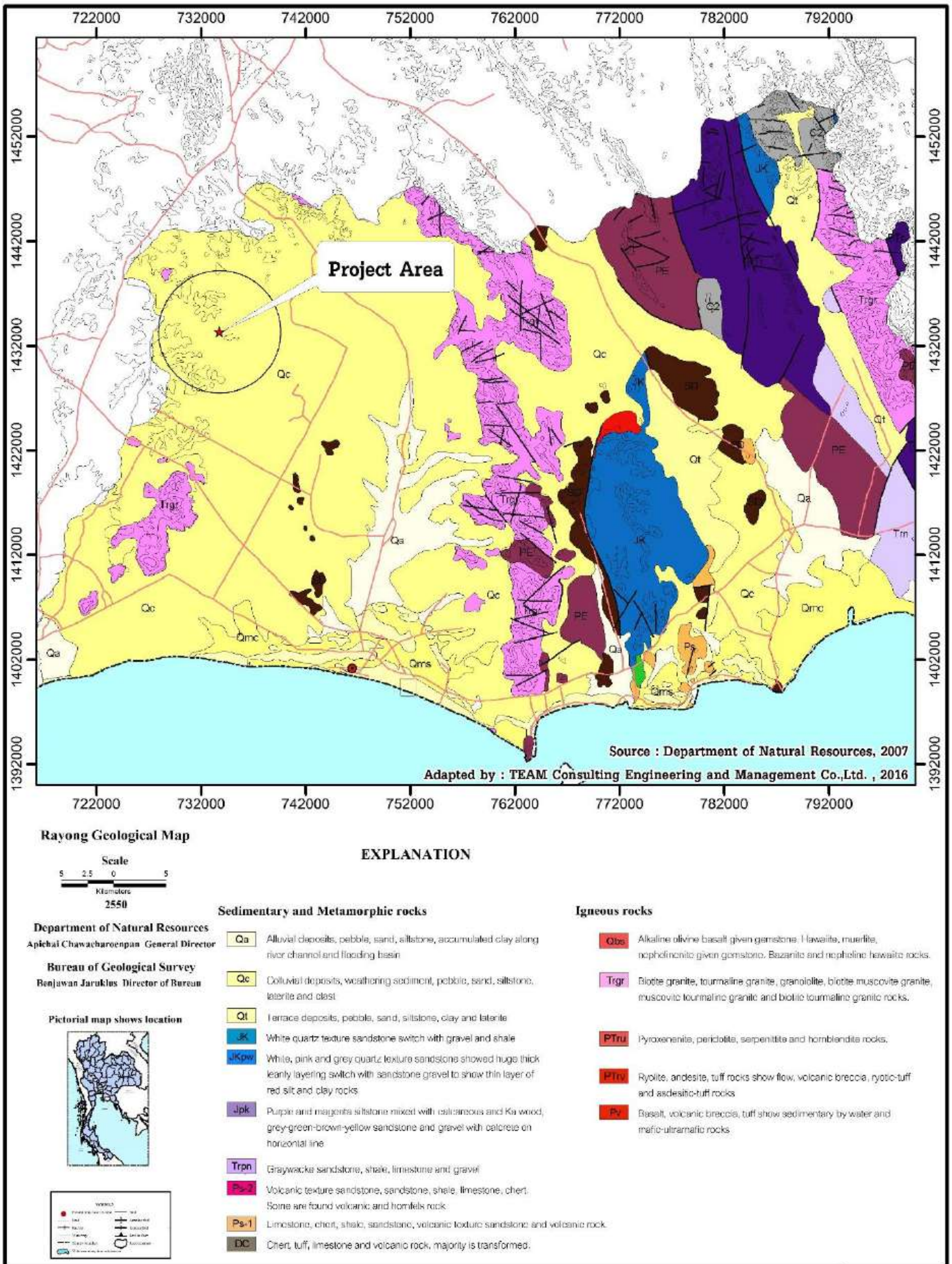

FIGURE 4.1.2-1 : GEOLOGICAL CONDITIONS OF THE STUDY AREA

4.1.2.2 Seismology

(1) Introduction

The objective of seismological study in the study area was to obtain the data on active faults which are likely to become the sources of earthquake and affect the areas near the project site. The study results would be used as the basic data to assess the impacts stemming from the project development as well as the effects on the project operation.

(2) Methodology

Secondary data were collected from previous studies and related organizations, e.g. the Thai Meteorological Department, the Department of Mineral Resources, etc. for seismological study.

(3) Study Result

According to the earthquake data of the Thai Meteorological Department, earthquakes in Thailand originate from two major seismic sources as follows:

(a) Massive earthquakes originate from seismic sources outside Thailand, i.e. the South of the People's Republic of China, the Republic of the Union of Myanmar, Lao PDR, Andaman Sea, and the North Sumatra, shaking the North, the South, the West, the Northeast, and Bangkok of Thailand. According to the historical records, earthquakes mostly generated from the seismic sources outside the country, such as the South of the People's Republic of China, Thailand-Myanmar border, Lao PDR, Andaman Sea and the North Sumatra, which are located along the Alpine-Himalaya orogenic belt. In spite of the far distance from Thailand, the earthquakes originating from these seismic sources are heavy and generate seismic waves which have widespread effects to several countries, including Thailand.

(b) Earthquakes originate from active faults in the country. There are totally 14 major faults in Thailand as illustrated in **Figure 4.1.2-2**.

According to the satellite data, the faults which generated seismic hazards in the past nearly lie in the east-west directions, for example Mae Chan Fault. In the North and the West of Thailand, Mae Hong Son Fault is the north-south strike fault which is parallel with Dan Chedi Sam Ong Fault. Referring to the map showing seismic sources in Thailand and nearby areas during 1900-2014 **(Figure 4.1.2-2)**, the project site is in the East of Thailand where no seismic source is found and located more than 300 km far from seismic sources.

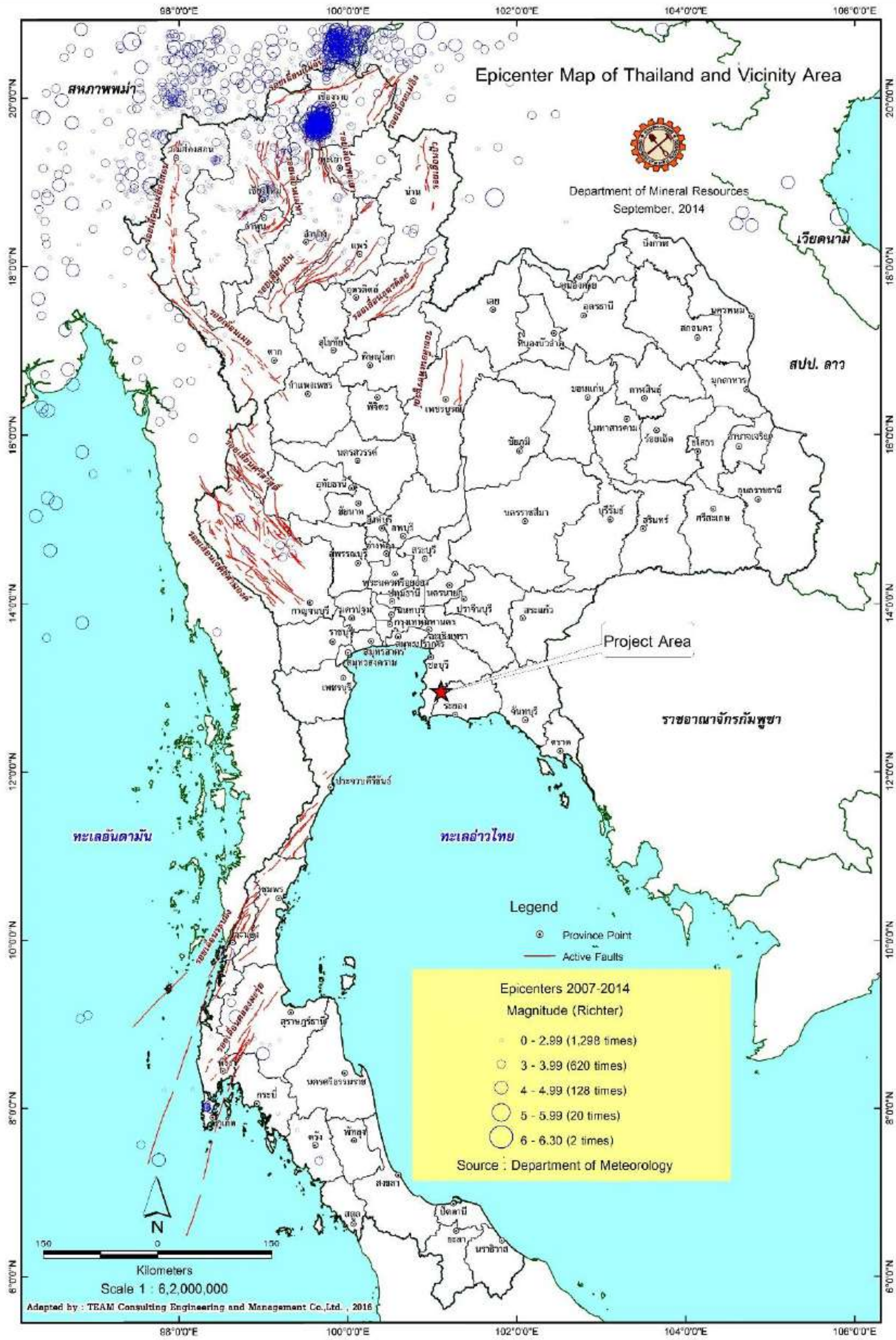

FIGURE 4.1.2-2 : ACTIVE FAULTS AND EPICENTERS IN THAILAND AND NEARBY AREAS

10P2809/Damrongsak.B/24-07-60/P2809-009 (English).mxd

Furthermore, the earthquake statistics of the Thai Meteorological Department during 2005-2016 revealed no earthquake in Rayong province. The statistical data on earthquakes which affected Thailand are presented in **Appendix 4A**. However, according to the seismic hazard map of Thailand revised in October 2013 **(Figure 4.1.2-3)** which shows the earthquake intensity with 10% probability of occurrence in a 50-year period based on the geological conditions, the earthquake intensity in the study area, if occurs, is at IV level which is light. At this intensity level, it is felt by people outdoors and people indoors during the day. At night, it may awaken people.

4.1.3 Soil Resource

(1) Introduction

The objective of soil resources study was to obtain data on physical characteristics and fertility of soil in the project area and the study area for assessing the impacts of the project construction and operation on soil resources.

(2) Methodology

(a) Study and collection of the following data for assessing environmental impacts.

- Soil series map of the Land Development Department, 2002.
- Characteristics and properties of soil series in the eastern coast from the Soil Survey in Rayong Province Report of the Land Development Department (1985), consisting of geomorphological features, parent materials, soil texture, pH, soil drainage, soil slope, and soil organic matter.
- 1:500,000-scale landslide hazard map in Rayong province by the Department of Mineral Resources, 2004.

(b) Collection of Soil Samples from Field Survey: Since the construction activities of the Pluak Daeng Power Plant will cause impact on soil erosion in the project area only, the Consultant gathered 1 soil sample from the project area on 17th March 2016. The Consultant also conducted additional soil sampling by considering the area size and distribution of soil series in the study area **(Figure 4.1.3-1)**. The criteria for determining the number of soil samples within the radius of 5 km from the project site are described below.

- **Number of Soil Series**: In the study area (excluding the industrial estate area), nine soil series were found **(Figure 4.1.3-1)**: Huai Pong (Hp), Khok Kloi (Koi), Map Bon (Mb), Map Bon/Phang-nga Association (Mb/Pga), Phang-nga (Pga), Sattahip (Sh), Sattahip & Thung Wa Complex (Sh&Tg), Thung Wa (Tg), and Thai Mueang (Tim).

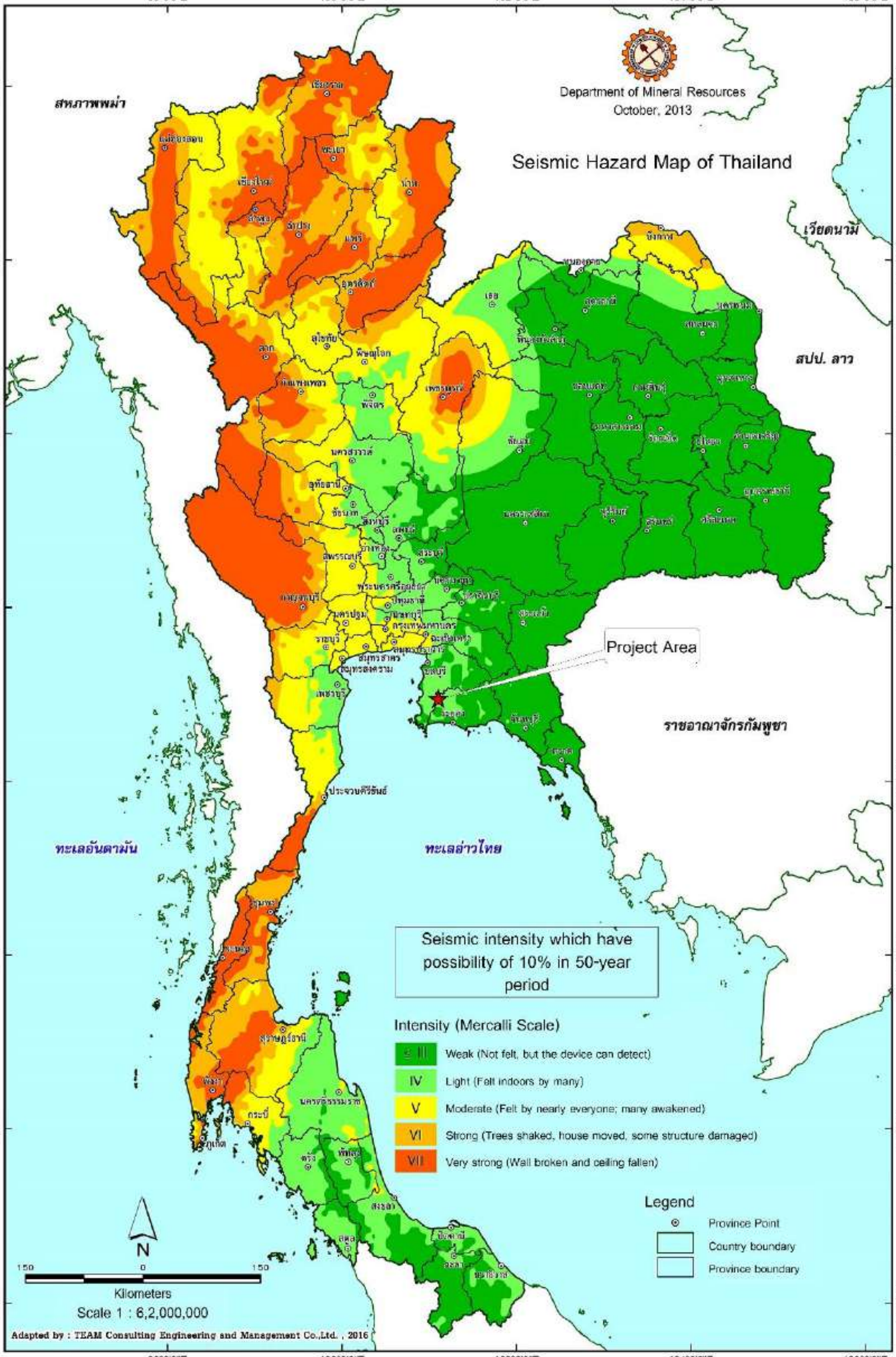

FIGURE 4.1.2-3 : SEISMIC HAZARD MAP OF THAILAND

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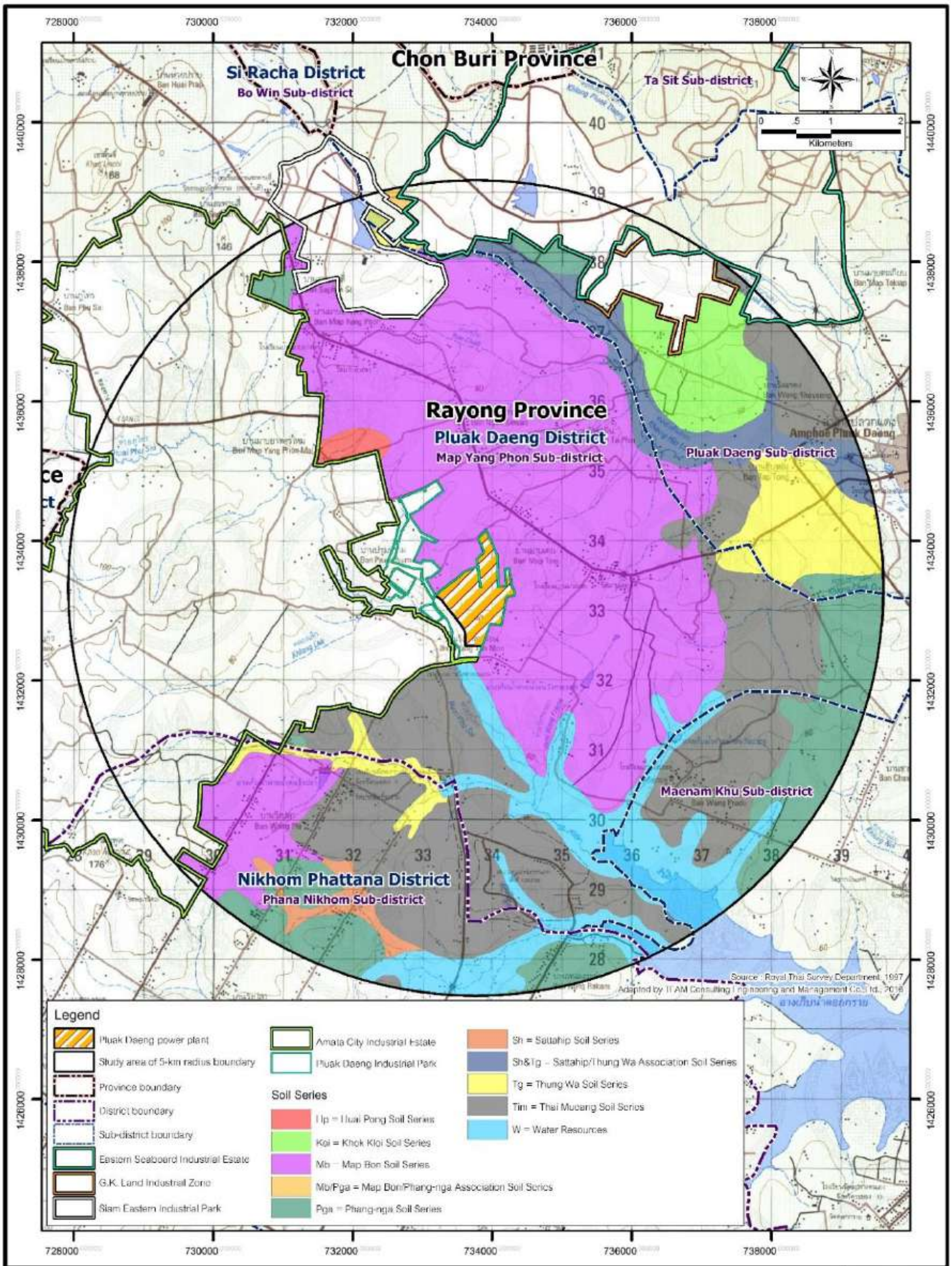


FIGURE 4.1.3-1 : SOIL SERIES MAP IN THE STUDY AREA

10P2809/Damrongsak.B/24-07-60/P2809-005 (ตัดพื้นที่ชุดดิน-English).mxd

- **Proportions of Soil Series in the Study Area**: Samples of the 9 soil series in the study area were collected more than other series. Map Bon series was the most common, followed by Thai Mueang and Phang-nga series **(Table 4.1.3-1)**. These 3 soil series cover about 82% of the study area.
- **Land Uses within the 5-km Radius from the Project Site:** Consideration was made on land uses on agricultural land only because the project's impacts on soil will mostly affect agriculture. According to the land use survey, the land for field crops (cassava/pineapple) and para rubber plantations occupy an area of 65% of the total farmland **(Table 4.1.3-1)**.

Based on the above criteria, sampling locations were identified to collect 3 samples from 3 boreholes for each of Map Bon, Thai Mueang and Phang-nga series. To specify the locations for soil sampling, consideration was given to the mostly found land use type. Land use type found on Map Bon and Thai Mueang soil series are field crops whereas para rubber plantations are found on Phang-nga series. Consequently, totally 4 soil sampling locations were determined, taking into account the proportions of soil series and land uses in the study areas as illustrated in **Figure 4.1.3-2**.

Disturbed samples were collected on 18th March 2016 to study the soil properties at the depth of 0-30 cm which is generally used for cultivation and will be probably affected by the project development **(Photo 4.1.3-1)**. The collected samples were sent to laboratory for analysis of physical and chemical properties and the results are presented in **Appendix 4B**. The soil properties obtained from the analysis were used to assess soil fertility and soil erosion impact from the project activities during the construction and operation periods.

(3) Study Result

(3.1) Secondary Data

(a) Soil Properties

Referring to the Soil Survey in Rayong Province Report of the Land Development Department (1985), most of the study area is covered by sandy loams derived from weathering granite slightly displaced by gravity. The soil properties in the area feature good drainage, medium permeability, and low fertility **(Table 4.1.3-2)**. Undulating terrains with the slopes in a range of 1-6% are common. The surface soil is strongly acidic and slightly alkaline, which is often found in soils derived from granite.

The Map Bon series, generally found in the area of Pluak Daeng Power Plant, is derived from granitic rock. Relief is gently undulating with the slopes in a rage of 3-4%. Map Bon sandy loams have good drainage, fast permeability, and medium fertility. Due to limited fertility and high susceptibility to erosion from water, cover cropping and crop rotation are suggested to prevent erosion and organic matters should be added.

TABLE 4.1.3-1
SOIL SERIES AND LAND USES IN THE STUDY AREA FROM SOIL SAMPLING

Land Uses	Huai Pong Series	Khok Kloi Series	Map Bon Series	Map Bon/ Phang-nga Association	Phang-nga Series	Sattahip Series	Sattahip & Thung Wa Complex	Thung Wa Series	Thai Mueang Series	Total (rai)	Percentage (%)
A2 Field Crops (Cassava, Pineapple)	144.84	1,065.75	8,708.28	19.30	1,491.91	302.61	465.86	962.40	3,722.73	16,883.67	42.74
A3 Para Rubber	14.02	54.47	3,419.99	0.00	2,013.74	123.10	37.74	719.78	3,071.92	9,454.76	23.94
A4 Orchard (Coconut, Cashew Nut)	0.00	7.39	112.11	0.00	53.82	0.00	49.87	7.59	163.17	393.95	1.00
A5 Perennial Crops (Eucalyptus, Other Fast-Growing Plant)	0.00	63.44	35.91	0.00	32.03	0.00	92.93	0.20	16.49	241.01	0.61
A6 Oil Palm	0.00	0.00	212.66	0.00	213.30	0.00	75.32	20.33	34.08	555.69	1.41
A7 Chicken Farm	0.00	0.00	47.50	0.00	0.00	0.00	0.00	7.75	15.80	71.06	0.18
M1 Wasteland	83.79	145.98	2,150.00	0.00	104.34	31.81	856.13	201.30	1,110.33	4,683.68	11.86
M3 Earth Pit, Laterite Pit	0.00	23.95	120.42	0.00	9.77	0.00	23.87	28.63	33.58	230.45	0.58
U1 Commercial Area	0.00	20.15	161.18	0.00	251.65	0.00	54.49	46.43	97.16	389.17	0.99
U2 Community/Residential Area	0.00	176.15	2,094.78	0.00	0.00	8.95	253.67	321.41	756.18	3,862.79	9.78
U3 Government Agency/State Enterprise	0.00	181.46	29.26	0.00	0.00	0.00	32.54	11.26	221.48	476.01	1.21
U4 Educational Institution	0.00	0.00	18.19	0.00	0.00	0.00	0.00	19.87	30.54	68.60	0.17
U5 Religious Place/Archeological Site/ Historical Site	0.00	0.00	36.71	0.00	0.00	0.00	0.00	0.00	59.77	96.48	0.24
U6 Medical Establishment	0.00	0.00	2.42	0.00	0.00	0.00	0.00	0.00	0.00	2.42	0.01
U7 Industrial Factory/Godown	0.00	7.05	188.39	0.00	32.94	17.06	0.00	65.64	250.20	561.26	1.42
U9 Golf Course	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,528.65	1,528.65	3.87
Total Area	**242.65**	**1,745.79**	**17,337.79**	**19.30**	**4,203.49**	**483.54**	**1,942.41**	**2,412.59**	**11,112.08**	**39,499.64**	**100.00**
Proportion of Soil Series in the Study Area (%)	**0.61**	**4.42**	**43.89**	**0.05**	**10.64**	**1.22**	**4.92**	**6.11**	**28.13**	**100.00**	
Soil Samples (Locations)	**0**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**1**	**3**	

Remark: The underlined figures denote the soil series and land use types mostly found in the study areas

Source: Boundaries of soil series and number of soil series from soil map of the Land Development Department, 2002
Land uses obtained from field survey by TEAM Consulting Engineering and Management Ltd. 2015

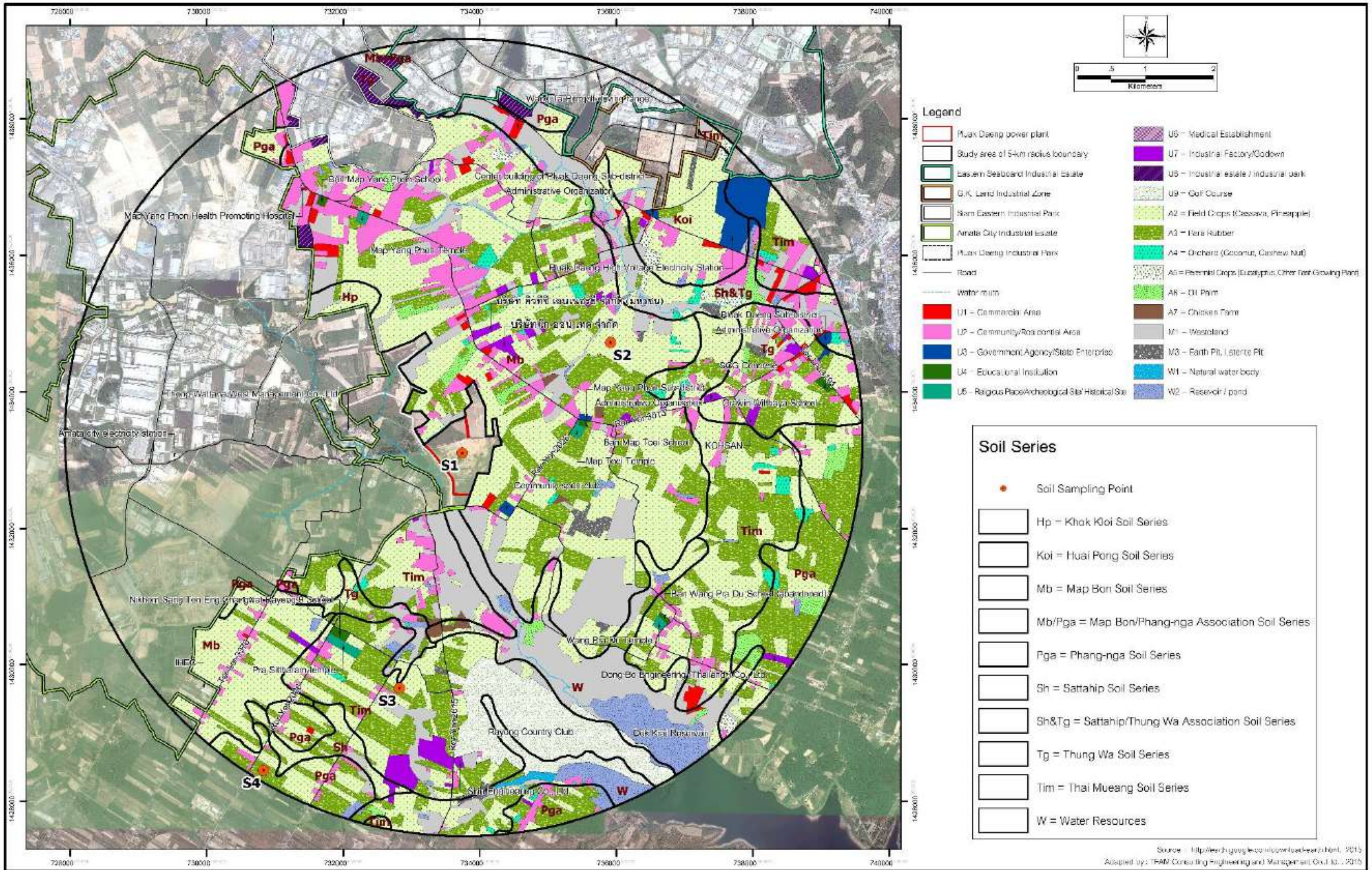


FIGURE 4.1.3-2 : LOCATIONS OF SOIL SAMPLING IN THE PROJECT AREA AND THE STUDY AREA BASED ON PROPORTIONS OF SOIL SERIES AND LAND USES

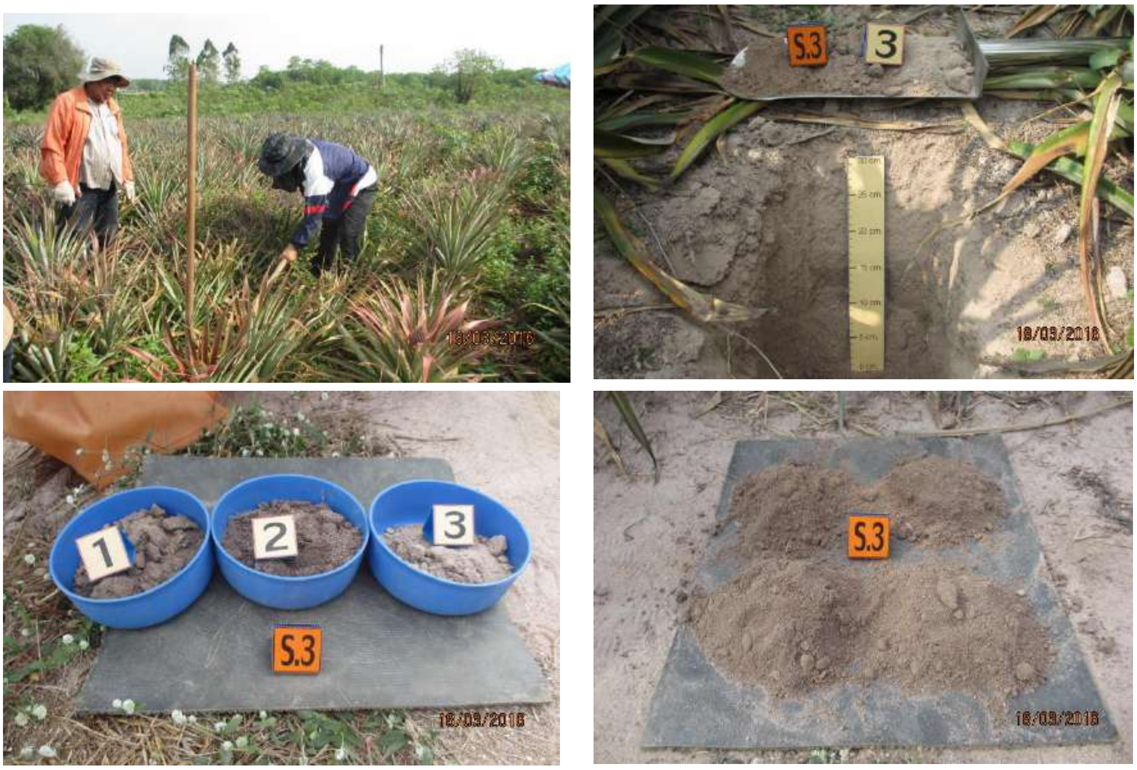


PHOTO 4.1.3-1 : SOIL SAMPLING IN THE STUDY AREA

TABLE 4.1.3-2
PROPERTIES OF SOIL SERIES IN THE STUDY AREA OF PLUAK DAENG POWER PLANT PROJECT

Soil Series	Drainage	Permeability	Slope (%)	Texture		PH		Fertility
				Surface	Substratum	Surface	Substratum	
Map Bon (Mb)	Good	Fast	3-4	Sandy Loam	Sandy Clay Loam	5.2	4.8-5.4	Medium
Thai Mueang (Tim)	Good	Medium	2.5	Sandy Loam	Gravelly Clay	7.5	6.5	Low
Phang-nga (Pga)	Good	Medium	3-5	Sandy Clay Loam	Sandy Clay Loam	6.5	5.0-5.5	Low
Thung Wa (Tg)	Good	Fast	1-4	Sandy Loam	Sandy Loam	5.7-6.0	5.5	Low
Khok Kloi (Koi)	Good	Medium	6	Sandy Loam	Sandy Clay Loam	5.2	4.0-4.8	Low
Sattahip (Sh)	Very Good	Fast	3-5	Loamy Sand	Loamy Sand	6.5	6.5	Low
Huai Pong (Hp)	Good	Medium	2-3	Sandy Loam	Sandy Clay Loam	6.0-6.5	4.5-5.5	Low

Source: Soil Survey in Rayong Province Report of the Land Development Department, 1985

(b) Landslide

Landslide is the disaster caused by movement of masses of earth or rock down a sloped section of land under the influence of gravity. This natural hazard is divided into three major types by mode of movement: landslide, earthflow, and rock fall. There are four main causes of landslide (Department of Mineral Resources, 2008) as follows:

- Geological conditions: weathered rock, bedding fault, fracture, etc.
- Topographic conditions: mountainous terrains with steep slope
- Environmental conditions: changes in land uses without compliance with professional principles, e.g. encroachment upon streams or mountainous areas by constructing houses and plantations thereon; construction of roads on high mountains; or constructions which obstruct natural waterways, e.g. road, bridge, pipeline installation, etc.
- Intense rainfall which leads to slope saturation: 24-hour rainfall of 100 mm, or accumulated rainfall of 300 mm.

According to the study of the Department of Mineral Resources, 74,490 rai of the total 2.2 million rai in Rayong province are prone to landslide, covering 11 villages, 10 sub-districts, 6 districts: Mueang, Klaeng, Ban Khai, Ban Chang, Khao Chamao, and Nikhom Phatthana districts. Pluak Daeng Power Plant is located in Pluak Daeng district which is not in the landslide-vulnerable area.

(3.2) Field Survey

Four disturbed samples (each from 3 boreholes) were collected from the project area during 17th-18th March 2016 as illustrated in **Photo 4.1.3-1** to study the soil properties at the depth of 0-30 cm. The collected samples were sent to laboratory for analysis of physical and chemical properties. The soil properties obtained from the analysis were used to assess soil fertility and soil erosion impact from the project activities during the construction and operation periods as follows:

(a) Assessment of Soil Fertility

Organic matter (OM), cation exchange capacity (CEC), base saturation (BS), available phosphorus (P), and exchange of potassium (K) were taken into account to assess the soil fertility into 3 levels: low, medium, and high as presented in **Table 4.1.3-3**. As for assessment of soil fertility in the study area **(Table 4.1.3-4)**, most soil has low fertility level, except for soil at the project area (S1) which has medium fertility level. According to the soil series map, although soil series at S1 and S2 are the same, the soil fertility at the two areas are different as the ground surface of the project area (S1) was filled with earth from other places.

TABLE 4.1.3-3

SOIL FERTILITY ASSESSMENT METHOD

Fertility Level	Organic Matter (%)	Base Saturation (%)	Cation Exchange Capacity (meq/100 g soil)	Available Phosphorus (mg/kg)	Exchange of Potassium (mg/kg)
Low (Score Level)	<1.5 1	<35 1	<10 1	<10 1	<60 1
Medium (Score Level)	1.5-3.5 2	35-75 2	10-20 2	10-25 2	60-90 2
High (Score Level)	>3.5 3	>75 3	>20 3	>25 3	>90 3

Remark: Based on the total scores, there are 3 soil fertility levels:

5-8 points = Low

9-12 points = Medium

13-15 points = High

Source: Land Development Department, 1991

(b) Assessment of the Existing Soil Loss Conditions

Assessment of the existing soil loss conditions was conducted by taking into account the properties of soil series from the Soil Survey Report of the Land Development Department, soil properties analysis from laboratory, existing land use data, and average annual precipitation in the study area. The universal soil loss equation (USLE) was utilized as follows:

$$A = RK(LS)CP$$

Where A = Average annual soil loss (tons/hectare/year)

R = Rainfall Erosivity Index : R-factor

K = Soil Erodibility Index : K-factor

L = Slope Length Index : L-factor

S = Slope Steepness Index : S-factor

C = Crop Management Index : C-factor

P = Soil Conservation Measures Index : P-factor

TABLE 4.1.3-4

ASSESSMENT OF SOIL FERTILITY IN THE STUDY AREA

Soil Sample	Soil Series	OM		BS		CEC		Avail. P		Exch. K		Total Score	Soil Fertility Level[2/]
		Measurement Result (%)	Score [1/]	Measuremen t Result (%)	Score [1/]	Measurement Result (meq/100g)	Score [1/]	Measurement Result (mg/kg)	Score [1/]	Measurement Result (mg/kg)	Score [1/]		
S1	Map Bon (Mb)	2.0	2	49.42	2	2	1	33	3	29	1	9	Medium
S2	Map Bon (Mb)	1.5	2	18.61	1	1	1	14	2	17	1	7	Low
S3	Thai Mueang (Tim)	2.5	2	35.54	2	1	1	21	2	25	1	8	Low
S4	Phang-nga (Pga)	1.9	2	20.81	1	1	1	20	2	29	1	7	Low
Overview of Soil Series in the Study Area[3/]		**1.98**	**2**	**31.10**	**1**	**1.25**	**1**	**22**	**2**	**25**	**1**	**7**	**Low**

Remark: OM = Organic Matter, BS = Base Saturation, CEC = Cation Exchange Capacity, Avail P = Available Phosphorous, and Exch. K = Exchange of Potassium

[1/] Fertility Level (Low = 1, Medium = 2, High = 3)

[2/] Soil Fertility Level (Low = Total Scores: 5-8, Medium = Total Scores: 9-12, High = Total Scores: 13-15)

[3/] Overview of Soil Series in the Study Area obtained from the average scores of soil components in each soil series in the study area

Each index of the construction area must be determined as presented below and applied to the above equation.

1. Rainfall Erosivity Index : R-factor

According to the review by Manu Srikajorn et al (1982), R-factor in Thailand covers two major zones: R-factor in tropical rainforest climate zone found in the South from Chumphon province southwards and in the lower East encompassing Chanthaburi and Trat provinces; and R-factor in savanna climate zone in the remaining areas of Thailand. The project area which is located at the joint between Chon Buri and Rayong provinces is in savanna climate zone. As for the suitable equation to calculate the R-factor for Thailand, KE>1 is more suitable than EI_{30}. The results are Y = 0.163X-0.0375, r = 0.727, n = 22. The average rainfall at Huai Pong station is 1,459.9 mm/year, and therefore R = 237.93 m-tons/ha-year.

2. Soil Erodibility Index : K-factor

K-factor was calculated from soil properties in the project area by using the equation of USDA (1990) as follows:

$$K = K1*K2*K3*K4$$

Where $K1 = 0.2+0.3\exp[-0.0256\ Sand\ (1-Silt/100)]$

$K2 = [Silt/(Silt + Clay)]^{0.3}$

$K3 = 1-[0.25C/\{C + \exp(3.72-2.95C)\}]$

$K4 = 1-[0.7SN1/\{SN1+\exp(-5.51+22.9SN1)\}]$

Sand, Silt, Clay = % of Sand, Silt and Clay

C = % of Organic Carbon

SN1 = 1-Sand / 100

As for the analysis result of soil properties in the project area which is prone to erosion, the project area (S1) has the proportion of sand, silt, and clay of 81.7%, 3.4%, and 14.9%, respectively. The soil texture is sandy loam with medium organic matter **(Table 4.1.3-5)**. When using the above equation to obtain K-factor, the K-factor in the project area is 0.09.

TABLE 4.1.3-5

SOIL PROPERTIES AND K-FACTOR OF THE SOIL SERIES IN THE PROJECT AREA

Soil Sample	Soil Series	Soil Texture 1/	Proportion (%) 1/			Organic Matter	Organic Carbon 1/	K
			Sand	Silt	Clay	(OM, %)	(OC, %)	factor 2/
S1	Map Bon (Mb)	Sandy Loam	81.7	3.4	14.9	2.0	1.16	0.09

Reamrk: 1/ Organic Carbon (OC) = Organic Matter (OM)/1.724

2/ K-factor derived from the K-factor equation of USDA (1990)

Source: Field survey conducted by TEAM Consulting Engineering and Management Ltd., March 2016

3. **LS Factors**

They represent two factors which have effects on soil erosion, i.e. slope length (L) and slope gradient (S). Wischmeier & Smith (USDA, 1978) continually studied the relationship between the two factors and soil loss in the demonstration plots under different conditions for a long period before creating the LS-factor equation for use with the universal soil loss equation. The Land Development Department studied and compared S and L from equations used in various countries and applied to the cases in Thailand. The LS factors were computed for different slopes based on the soil series map as presented in **Table 4.1.3-6**.

The study result revealed that Map Bon soil series in the project area has the slope gradient in a range of 3-4% **(Table 4.1.3-2)** and categorized as the C type of slope as shown in **Table 4.1.3-6**. The slope length is 100 m and thus LS-factors = 0.567.

TABLE 4.1.3-6
LS-FACTORS OF SLOPES IN SOIL SERIES MAP

Slopes in Soil Series Map	Slope Gradient (S, %)	Slope Length (λ, m)	LS Factors
A	1.2	160	0.226
B	2.0	150	0.323
C	**5.0**	**100**	**0.567**
D	12.0	50	1.927
E	20.0	50	2.753
F (62 Soil Series Groups)	35.0	50	4.571

Source: Land Development Department, 2000

4. **Crop Management Index (C-Factor)**

The project area is mainly composed of abandoned land in Pluak Daeng Industrial Park. According to the C-factor and P-factor criteria in Thailand (Land Development Department, 2002) as presented in **Table 4.1.3-7**, the C factor in the project area is 0.25.

5. **Soil Conservation Measures Index (P-Factor)**

P-factor in the project area is 1 because it covers the abandoned land in Pluak Daeng Industrial Park as presented in **Table 4.1.3-7** and no soil conservation measure has been issued.

The existing soil loss conditions were compared with the soil loss severity in Thailand of the Land Development Department (2002) to estimate the severity of soil loss due to the project development as shown in **Table 4.1.3-8**.

TABLE 4.1.3-7
C-FACTOR AND P-FACTOR FOR LAND USE MAP AT 1:50,000 SCALE

Crops	C-Factor	P-Factor
Abandoned Paddy Field	0.100	0.100
Paddy Field, Transplanted Paddy Field, Paddy-Sown Field, Rain-Fed Paddy Field	0.280	0.100
Mixed Agriculture/Paddy Field	0.225	1.000
Wheat, Barley, Rye	0.280	1.000
Field Crops, Mixed Field Crops, Other Field Crops	0.340	1.000
Pineapple, Aloe Vera, Caribbean Agave	0.380	1.000
Black Bean, Red Bean, Sesame, Opium	0.389	1.000
Mungbean	0.390	1.000
Peanut	0.400	1.000
Soybean	0.406	1.000
Cotton, Abandoned Field	0.421	1.000
Corn	0.500	1.000
Cassava, Kenaf, Jute, Hemp, Fiber Plant	0.502	1.000
Potato, Jam Bean, Sweet Potato, Water Melon, Ginger, Cabbage, Tomato, Chilli	0.600	1.000
Marijuana, Roselle	0.600	1.000
Millet, Job's Tears	0.650	1.000
Upland Rice, Tobacco, Sunflower	0.700	1.000
Castor	0.790	1.000
Teak, Neem Tree, Lead Tree, Burma Padauk, Beechwood	0.088	1.000
Perennial Crops, Mixed Perennial Crops, Para Rubber, Eucalyptus, Son Pradi Phat (Casuarina junghuhniana Miq.)	0.150	1.000
Oil Palm	0.300	1.000
Mangrove	0.000	0.000
Wintergreen, Zalacca	0.020	1.000
Mimosa, Rain Tree	0.088	1.000
Tea, Bamboo, Fruit Tree, Mixed Orchards, Orchards, Durian, Rambutan, Lychee, Mango	0.150	1.000
Banana, Tamarind, Longan, Jack Fruit, Santol, Rose Apple, Mangosteen, Langsat, Long Kong	0.150	1.000
Sapodilla	0.150	1.000
Strawberry, Raspberry	0.270	1.000
Coffee, Kapok, Cerbera odollam, Orange, Monkey Apple, Custard Apple, Guava, Lime	0.300	1.000
Temperate Fruit	0.300	1.000
Flowering Plant	0.356	1.000

TABLE 4.1.3-7

C-FACTOR AND P-FACTOR FOR LAND USE MAP AT 1:50,000 SCALE (Cont'd)

Crops	C-Factor	P-Factor
Betel Palm, Coconut, Cashew Nut, Toddy Palm	0.400	1.000
Mulberry, Croton, Papaya, Horticultural Crops, Mixed Horticultural Crops, Vegetables, Grape, Pepper	0.000	1.000
Passion Fruit, Olive	0.600	1.000
Abandoned Field	**0.250**	**1.000**
Crop Rotation, Upland Rice (Rotation), Corn (Rotation)	0.250	1.000
Beans and Peas (Rotation), Sesame (Rotation), Potatoes (Rotation)	0.250	1.000
Vegetables (Rotation), Opium (Rotation)	0.250	1.000
Preparation Area for Swidden Cultivation, Abandoned Swidden Cultivation	0.250	1.000
Abandoned Land from Swidden Cultivation, Shifting Cultivation (in Use)	0.250	1.000
Pasture and Animal Farm Houses	0.100	1.000
Mixed Animal Farm Houses: Livestock, Poultry, and Pork	0.000	0.000
Stable	0.000	0.000
Aquatic Plant, Mixed Aquatic Plants, Reed, Lotus, Water Chestnut, Truffle, Water Morning Glory, Water Mimosa	0.000	0.000
Abandoned Fishery, Mixed Fishery	0.000	0.000
Aquatic Animal Farm (Fish, Prawn, Crab, Shell, Others), and Crocodile Farm	0.000	0.000
Fresh Water Swamp Forest, Mangrove Forest	0.000	0.000
Tropical Rain Forest, Tropical Evergreen Forest, Other Deciduous Forests	0.001	1.000
Hill Evergreen Forest	0.003	1.000
Dry Evergreen Forest, Coniferous Forest	0.019	1.000
Forest Area, Mixed Deciduous Forest, Dry Dipterocarp Forest, Deciduous Dipterocarp Forest, Deciduous Forest	0.020	1.000
Deteriorated Evergreen Forest, Destroyed Tropical Rain Forest	0.040	1.000
Scrub Forest	0.048	1.000
Bamboo Forest	0.150	1.000
Deteriorated Deciduous Forest, Deteriorated Forest	0.250	1.000
Beach Forest	0.450	1.000
Mangrove Plantation	0.000	0.000
Pine Plantation, Rubber Plantation, Eucalyptus Plantation, Teak Plantation, Neem Plantation	0.088	1.000
Son Pradi Phat Plantation, Lead Tree Plantation, Burma Padauk Plantation, Beechwood Plantation	0.088	1.000

TABLE 4.1.3-7

C-FACTOR AND P-FACTOR FOR LAND USE MAP AT 1:50,000 SCALE (Cont'd)

Crops	C-Factor	P-Factor
Bead Tree Plantation, Wild Himalayan Cherry Plantation, Tree of Heaven Plantation, Milk Fruit Plantation	0.088	1.000
Nitta Tree Plantation, Catechu Tree Plantation, Other Plantations	0.088	1.000
Forest Plantation, Mixed Forest Plantation, Other Kinds of Forest Plantations, Agro-forestry	0.088	1.000
Abandoned Paddy Field (Irrigation Zone)	0.100	0.100
Transplanted Paddy Field (Irrigation Zone), Paddy-Sown Field (Irrigation Zone)	0.280	1.000
Mixed Orchards (Irrigation Zone)	0.100	1.000
Banana (Irrigation Zone)	0.150	1.000
Sugarcane (Irrigation Zone)	0.400	1.000
Cassava (Irrigation Zone)	0.600	1.000
Wetland, Swamp, Marsh	0.000	0.000
Grassland, Range Land, Improved Grassland, Golf Course	0.015	1.000
Bamboo	0.020	1.000
Grassland and Grove Wood	0.032	1.000
Grassland and Bush, Grassland and Shrub, Bush and Grove Wood	0.048	1.000
Old Pit, Laterite Pit, Sand Pit, Earth Pit, Miscellaneous Land	0.000	0.000
Beach, Outcrop Area, Sand Bar	0.800	1.000
Mine	0.800	1.000
Wasteland, Other Wasteland	0.800	1.000
Unused Land, Land Allocation, Road, Miscellaneous Areas	0.800	1.000
Garbage Dump Site	0.000	0.000
Salt Pan	0.000	0.100
Land Allocation Project	0.000	0.000
Town and Commercial Area, Village, Government Office, and other Institution	0.000	0.000
Village on Plain Area, Highland Village, Other Residential Areas	0.000	0.000
Transport Station, Airport, Train Station, Bus Terminal, Seaport	0.000	0.000
Industrial Zone, Industrial Estate, Industrial Factory, Immigration Center	0.000	0.000
Cemetery, Recreational Area	0.000	0.000
Water Bodies, River, Canal, Natural Water Resources, Built-up Water Resources	0.000	0.000
Lake, Marsh, Reservoir, Pond in Field	0.000	0.000

Source: Land Development Department, 2000

TABLE 4.1.3-8
SOIL LOSS SEVERITY RATES IN THAILAND

Soil Loss Severity	Soil Loss Severity Rate (Tons/Rai/Year)
Slight	0.00 - 2.00
Moderate	2.01 - 5.00
Severe	5.01-15.00
Very Severe	15.01-20.00
Extremely Severe	> 20.00

Source: Revision from the Land Development Department, 2002

Upon obtaining the factors which have effects on soil erosion, the average annual soil loss was computed by using the USLE to find the soil loss severity rate in the study area as follows:

$$A = 237.93 \times 0.09 \times 0.567 \times 0.250 \times 1.00$$
$$= 3.04 \text{ tons/ha/year}$$
$$= 0.49 \text{ tons/rai/year}$$

The soil loss severity rate in the study area is 0.49 tons/rai/year which is slight when compared to the soil loss severity rates in Thailand prepared by the Land Development Department (2002) as shown in **Table 4.1.3-8**. The soil loss rate in the study area is even lower than the soil tolerance goal of 2 tons/rai/year set by the Land Development Department (2002).

4.1.4 Meteorology

(1) Introduction

The microscale meteorological condition is the factor which affects the dispersion of air pollutants from the sources to the receptors in the study area. The severity in each area is different depending on the coordinates of the sources and the receptors, including changes in meteorological conditions and weather conditions in each study period. The microscale meteorological condition is therefore fundamental for assessment of air quality impact during the construction and operation periods of the project.

(2) Methodology

Secondary data were collected from Huai Pong agrometeorological station in Mueang district, Rayong province which is closest to the project area. It is located at Latitude: 12° 44' 0.0" N and Longitude: 101° 8' 0.0" E. The 10-year statistical data during 2006-2015 from this station were used to estimate the impacts from the project development. Since the Huai Pong agrometeorological station has only 10 years of statistical data, consideration was also made on the 23-year meteorological data during

1993-2015 at Laem Chabang station in Si Racha district, Chon Buri province which is the second closest station to the project area. It is located at Latitude: 13° 4' 37.0" N and Longitude: 100° 52' 33.0" E.

(3) Study Result

The project site is under the tropical savanna climate (AW), according to the Köppen climate classification categories. The average annual temperature is quite stable. Influenced by southwest monsoon and northeast monsoon, there are three distinct seasons as follows:

- **Summer** starts from the middle of February to the end of April. During this season, it is influenced by the southern winds which bring humid air to the coastal areas and therefore the weather is not too hot.
- **Rainy Season** begins from May to October. Influenced by the southwest monsoon, it rains frequently and sometimes there are depressions from the South China Sea.
- **Winter** commences from November to February. During this season, the northeast monsoon brings chill air from China. However, since the province is close to sea and influenced by local wind, the weather in general is not cold.

The 10-year data (2006-2015) collected from Huai Pong agrometeorological station in Rayong province, and the 23-year data (1993-2015) from Laem Chabang station in Chon Buri province as presented in **Tables 4.1.4-1** and **4.1.4-2** can be summarized below.

(a) Huai Pong Agrometeorological Station, Mueang District, Rayong Province

- **Pressure**

The annual mean pressure is 1,009.35 hPa. The maximum mean pressure is 1,012.20 hPa in January whereas the minimum mean pressure is 1,007.00 hPa in June.

- **Temperature**

The annual mean temperature is 28 °C. The maximum mean temperature is 29.4 °C in April whereas the minimum mean temperature is 26.2 °C in January.

- **Wind Speed and Direction**

The mean speed is in a range of 0.7-1.8 knots (0.3-0.9 m/s). The minimum mean speed is found during April-May whereas the maximum mean speed in December. The wind directions are as follows: NNE during November-January; S during February-April; SW during May-August; W in September; and NE in October **(Figure 3.4-1)**.

TABLE 4.1.4-1
10-YEAR STATISTICAL DATA OF HUAI PONG AGROMETEOROLOGICAL STATION DURING 2006-2015

Station	HUAI PONG AGROMET.		Elevation of station above MSL	43	Meters
Index Station	48479		Height of barometer above MSL	45.1	Meters
Latitude	12° 44' 0.0" N		Height of Thermometer above ground	1.2	Meters
Longitude	101° 8' 0.0" E		Height of wind vane above ground	10	Meters
			Height of rainguage	0.8	Meters

Elements		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
Pressure(hPa)	Mean	1012.2	1011.1	1010.4	1009.1	1007.7	1007	1007.3	1007.6	1008.2	1009.8	1010.4	1011.4	1009.35
	Mean Daily Range	4.2	4.2	4.4	4.2	3.8	3.4	3.3	3.5	4	4.2	4.1	4.1	3.95
	Ext.Max.	1020.65	1019.21	1022.28	1015.34	1013.69	1013.82	1013.12	1012.94	1014.61	1016.16	1017.43	1018.2	1022.28
	Ext.Min.	1005.03	1004.34	1003.29	1002.2	1002.02	999.57	1000.88	1000.82	1001.05	1002.23	1004.02	1003.55	999.57
Temperature(Celsius)	Mean Max.	32.1	32.3	33.1	34.2	33.8	33.2	32.7	32.8	32.2	31.9	32.4	32.1	32.7
	Ext.Max.	36	35.9	36.8	39	38.2	40.2	36	36.6	36.3	34.5	36.2	35.5	40.2
	Mean Min.	21.8	23.9	25.3	26.1	26.1	25.8	25.4	25.3	24.8	24.2	23.5	22.2	24.5
	Ext.Min.	15.1	18.5	18.4	22.6	23	22	22	22.6	21.2	21.3	18	17.4	15.1
	Mean	26.2	27.4	28.5	29.4	29.3	29	28.5	28.4	27.9	27.2	27.2	26.5	28
Dew Point Temp.(Celsius)	Mean	19.5	22.5	23.7	24.6	25.1	25	24.5	24.4	24.4	24	21.9	19.8	23.3
Relative Humidity(%)	Mean	69	76	76	76	79	80	80	80	82	83	74	69	77
	Mean Max.	84	89	88	89	91	91	91	91	93	94	88	83	89.3
	Mean Min.	50	59	60	60	65	66	66	65	67	68	57	50	61
	Ext.Min.	26	26	27	35	41	49	35	43	45	48	29	29	26
Visibility(Km.)	Mean	6.3	6.4	7.2	8.7	9.8	10	9.9	9.7	9.5	7.5	7.5	7.5	8.3
	07.00LST	5.7	5.7	6.6	8.5	9.7	9.9	9.9	9.4	9.1	7.5	7.9	7.2	8.1
Cloud Amount(1-10)	Mean	4.2	5.4	5.7	5.9	6.6	7.3	7.7	7.6	7.8	7	5.1	4.2	6.2
Wind (Knots)	Prev.Wind	NE	S	S	S,SW	SW	SW	SW	SW	W	NE	NE	NE	-
	Mean	1.3	0.8	0.8	0.7	0.7	0.8	1.1	0.9	0.9	0.9	1.5	1.8	1
	Max.	19	20	26	22	39	35	40	40	26	23	21	24	40
Pan Evaporation(mm.)	Total	123.8	108.8	127.5	135.7	127.4	119.3	122.9	120.5	102.1	98.2	119	126.7	1431.9
Rainfall(mm)	Total	34.6	45.9	66.5	98.7	175	160.5	159.8	135.5	239.5	268.3	65.2	10.4	1459.9
	Num. of Days	3.3	4.2	5.5	7.8	15	15.5	15.5	16	19	19.3	6.7	1.9	129.7
	Daily Max.	111.3	73.3	123	112.3	116.5	88.4	111.8	108	142.1	183.9	79.9	26.7	183.9
Sunshine Duration(hr.)	Mean	234	200.3	198.8	202.6	167.1	139.8	119	129	117.3	147.6	208.4	247.4	2111.3
Phenomena(Days)	Fog	1.1	1	0.5	0.3	0	0	0	0	0.1	0.1	0.1	0.3	3.5
	Haze	22.2	13.8	13.9	9.7	2.4	2.1	1.9	1.8	0.9	5.6	14	19.7	108
	Hail	0.2	0	0.2	0	0.1	0	0.1	0	0.2	0	0.1	0	0.9
	ThunderStorm	0.4	0.7	2.1	5.9	9.4	6.4	4	5.8	5.8	11.2	3.3	0.3	55.3
	Squall	0	0	0.1	0	0	0.2	0	0	0	0	0	0.1	0.4

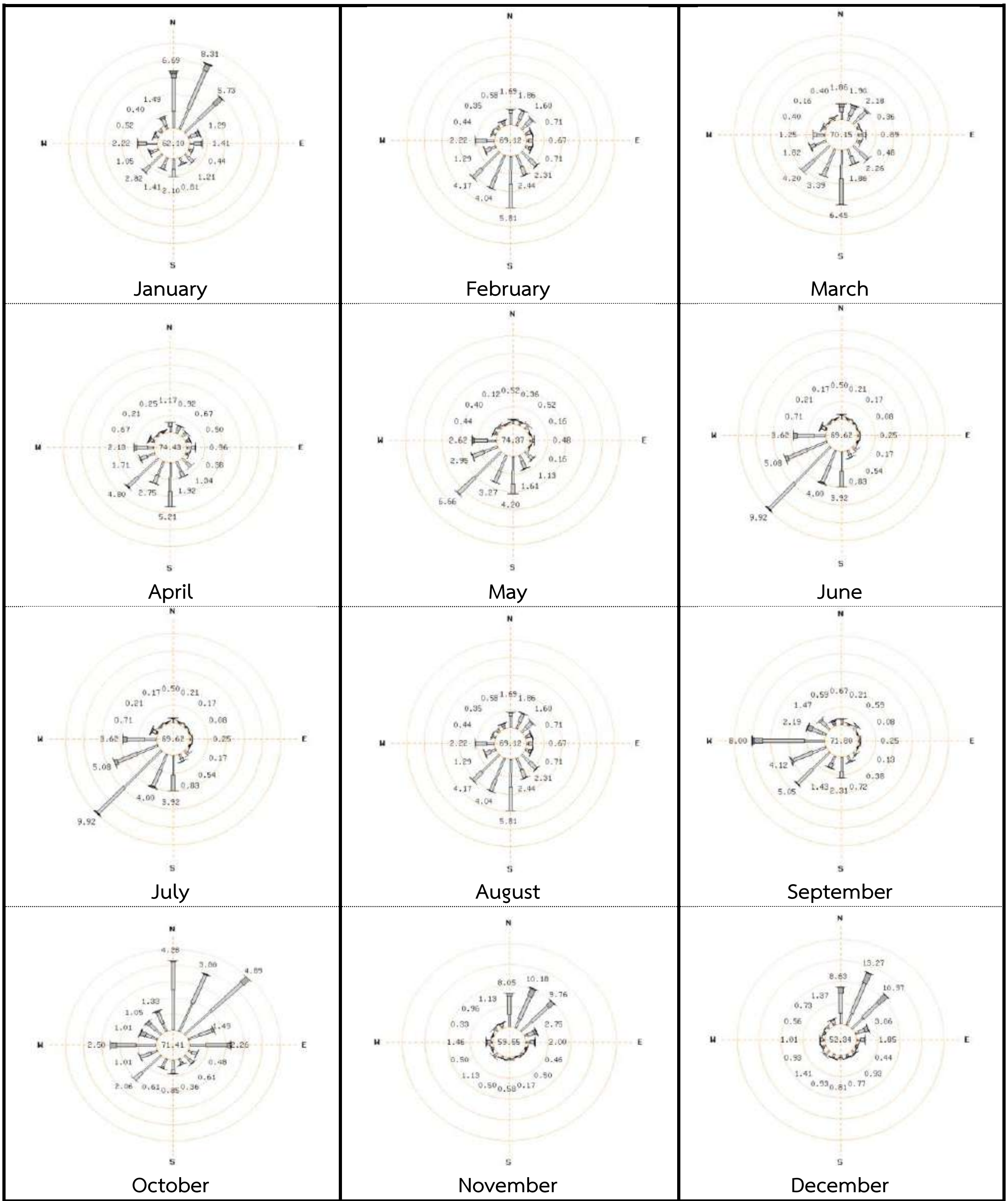
Source: Thai Meteorological Department, 2016

TABLE 4.1.4-2
23-YEAR STATISTICAL DATA OF LAEM CHABANG METEOROLOGICAL STATION DURING 1993-2015

Station	LAEM CHABANG.	Elevation of station above MSL	81	Meters
Index Station	48463	Height of barometer above MSL	81.7	Meters
Latitude	13° 4' 37.0" N	Height of Thermometer above ground	1.2	Meters
Longitude	100° 52' 33.0" E	Height of wind vane above ground	97	Meters
		Height of rainguage	0.8	Meters

Elements		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
Pressure(hPa)	Mean	1012.6	1011.4	1010.7	1009.4	1007.7	1007	1007.4	1007.7	1008.3	1010	1010.8	1011.9	1009.57
	Mean Daily Range	4.4	4.3	4.5	4.3	3.8	3.2	3	3.3	3.9	4.3	4.2	4.2	3.95
	Ext.Max.	1021.66	1019.27	1022.01	1015.91	1013.88	1014.97	1013.97	1014.51	1018.34	1016.45	1017.48	1019.36	1022.01
	Ext.Min.	1005.9	1004.96	1003.6	1003.4	1002.05	999.95	1000.41	1000.71	1001.44	1002.61	1003.76	1005.13	999.95
Temperature(Celsius)	Mean Max.	32	32.1	32.6	33.4	32.9	31.9	31.4	31.6	31.3	31.5	32	31.8	32
	Ext.Max.	39	38	37.5	38.5	38.7	37.5	36.3	37.5	37.2	37.7	38	37.2	39
	Mean Min.	22.2	23.4	24.5	25.6	25.8	25.7	25.6	25.2	24.5	23.9	23.6	22.3	24.4
	Ext.Min.	14.9	16.5	18.5	19.2	19.2	20	20.1	21	19.6	20	17	14	14
	Mean	28	28.4	28.9	29.9	29.9	29.2	28.8	28.9	28.5	28.4	28.8	28.3	28.8
Dew Point Temp.(Celsius)	Mean	19.8	22.6	23.6	24.5	24.6	24.4	24	24	24.2	24.1	22.2	20	23.2
Relative Humidity(%)	Mean	63	72	74	74	74	76	76	75	78	78	69	62	72.6
	Mean Max.	77	87	87	86	84	84	84	84	88	89	80	75	83.7
	Mean Min.	52	62	65	65	66	69	70	68	70	70	61	52	64.2
	Ext.Min.	23	23	25	31	43	51	50	48	49	45	25	27	23
Visibility(Km.)	Mean	5.1	5.3	6.6	7.7	10.2	10.6	10.2	10.5	9.8	7	6.3	5.8	7.9
	07.00LST	4.8	4.8	6	7.4	9.2	9.9	9.8	9.4	8.6	6.4	6.2	5.7	7.4
Cloud Amount(1-10)	Mean	5.5	6.2	6.5	6.7	7.3	7.6	8	7.9	7.8	7.5	6.5	5.7	6.9
Wind (Knots)	Prev.Wind	N,E	SW	SW	SW	SW	SW	SW	SW	SW	E	N	N	-
	Mean	5.9	7	8.3	7	7.8	9.5	9.6	8.5	6.7	4.7	5.3	5.8	7.2
	Max.	30	35	36	50	50	52	48	52	60	45	30	37	60
Pan Evaporation(mm.)	Total	-	-	-	-	-	-	-	-	-	-	-	4.3	4.3
Rainfall(mm)	Total	18.4	16.7	49.5	62.1	122	155.7	100.8	110.3	235	205.9	38.3	9	1123.7
	Num. of Days	1.7	2.4	4.7	6	11.4	13	12	12.9	17.1	16.4	4.7	1.4	103.7
	Daily Max.	176.5	35.7	63.8	78.4	87.2	97.9	80.6	126	116.2	116.2	36.8	37.2	176.5
Sunshine Duration(hr.)	Mean	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenomena(Days)	Fog	0.3	0.2	0	0	0	0	0	0	0	0	0	0	0.5
	Haze	21.3	13.4	10.4	8	1.9	0.3	0.5	0.5	0.7	6.8	17.8	24.2	105.8
	Hail	0	0	0	0	0	0	0	0	0	0	0	0	0
	ThunderStorm	0.6	1	3.1	5.6	7.6	6.1	4	3.8	7.4	9.1	2.5	0.6	51.4
	Squall	0	0	0.3	0	0.1	0	0.2	0.3	0.3	0	0	0	1.2

Source: Thai Meteorological Department, 2016



Source: Meteorological Development Bureau, Thai Meteorological Department, 2015

FIGURE 4.1.4-1: WIND ROSES AT HUAI PONG AGROMETEOROLOGICAL STATION FOR 10 YEARS (2006-2015)

- **Rainfall**

The total annual rainfall is 1,459.9 mm. The minimum mean rainfall is 10.4 mm in December whereas the maximum mean rainfall is 268.3 mm in October. The total number of rain days is 130 days per year.

(b) Laem Chabang Meteorological Station in Si Racha District, Chon Buri Province

- **Pressure**

The annual mean pressure is 1,009.57 hPa. The maximum mean pressure is 1,012.6 hPa in January whereas the minimum mean pressure is 1,007.00 hPa in June.

- **Temperature**

The annual mean temperature is 28.8 °C. The maximum mean temperature is 29.9 °C in April and May whereas the minimum mean temperature is 28 °C in January.

- **Wind Speed and Direction**

The mean speed is in a range of 4.7-9.6 knots (2.5-5.2 m/s). The minimum mean speed is found in October whereas the maximum mean speed in July. The wind directions are as follows: N during November-January; S and SSW during February-August; W in September; and E in October **(Figure 4.1.4-2)**.

- **Rainfall**

The total annual rainfall is 1,123.7 mm. The minimum mean rainfall is 9.0 mm in December whereas the maximum mean rainfall is 235 mm in September. The total number of rain days is 104 days per year.

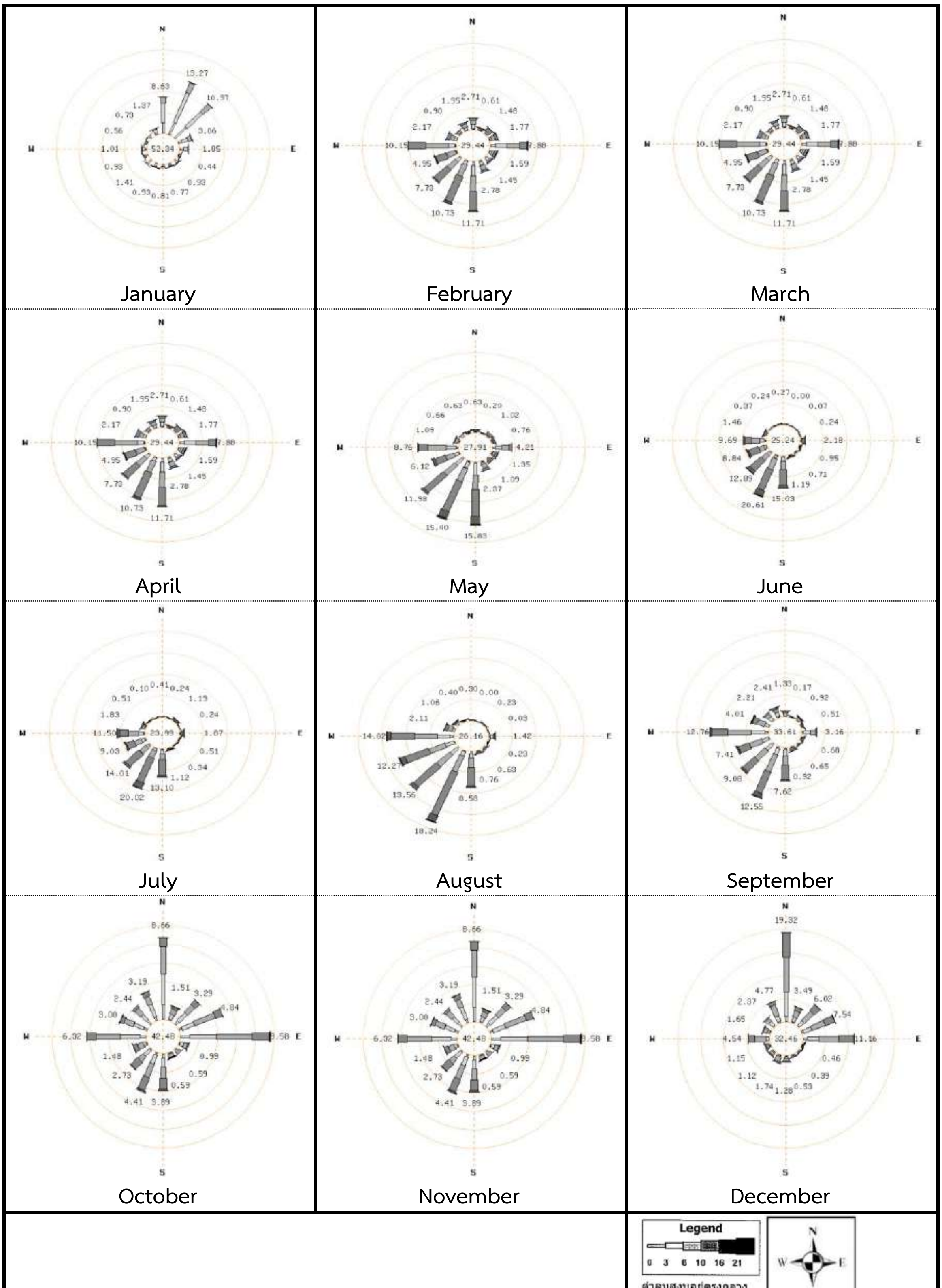
4.1.5 Air Quality

(1) Introduction

The air quality study was conducted to obtain the existing air quality and air pollution carrying capacity in the project area and its vicinity. It was necessary to conduct detailed study of air quality in the past until the present time around the project area to evaluate the probable project impacts.

(2) Methodology

- Project gathers the secondary data from 1 permanent air quality monitoring stations which are:
  - The Pollution Control Department Air Quality Monitoring System (AQMS) at Pluak Daeng Public Health Office. This station is located approximately 6.6 kilometers East-Southeast (WSE) of the project. The consultant collected that measurement data during 2015 with 4 parameters (SO_2, NO_2, and PM-10) from this station.



Source: Meteorological Development Bureau, Thai Meteorological Department, 2015

FIGURE 4.1.4-2 : WIND ROSES AT LAEM CHABANG METEOROLOGICAL STATION FOR 23 YEARS (1993-2015)

This AQMS data was collected from Pollution Control Department. Additional, Pluak Daeng Public Health Office's AQMS data has online hourly in Pollution Control Department website as shown in the link (http://air4thai.pcd.go.th/webV2/) and the example of AQMS air quality data is shown in the **Photo 4.1.5-1**.

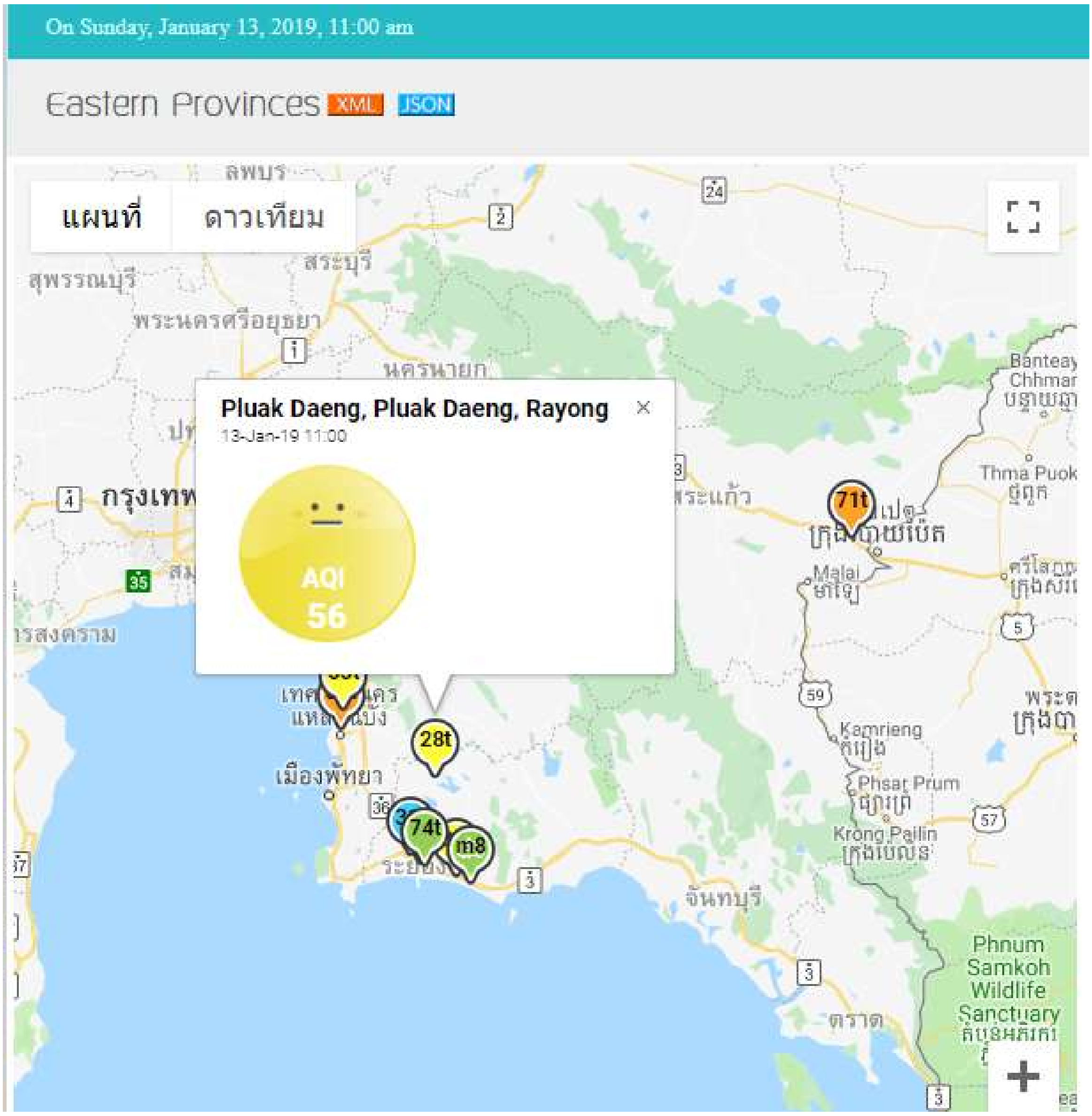


PHOTO 4.1.5-1 : EXAMPLE OF AQMS AIR QUALITY DATA

- Secondary data on air quality in the nearby area of the project site were collected from the environmental impact prevention and mitigation measure and environmental impact monitoring measure reports of the Eastern Seaboard Industrial Estate (Rayong), Siam Eastern Industrial Park, GK. Land Industrial Park (Siam Green City), and Amata City Industrial Estate (Expansion) Phase 5, (No. 1).

- Ambient air quality study was conducted in local communities around the project area for 7 consecutive days during weekday and weekend at 5 stations. Monitoring of air quality was conducted twice at each station. The criteria for selection of monitoring stations covered sensitive receptors (e.g. temples and schools), and density of communities under prevailing wind directions (during March-September and November-February). Measurement parameters comprised Total Suspended Particulates (TSP), PM-10, Nitrogen Dioxide (NO_2), SO_2 (Sulfur Dioxide), and Carbon Monoxide (CO), including wind speed and direction. The selected sampling method and the parameter analysis method are accepted by the Office of Natural Resources and Environmental Policy and Planning (ONEP) as presented in **Table 4.1.5-1**. According to the regulation of Department of Industrial Work of private laboratory registration in 2007, such laboratory must has certified document of calibration equipment. Calibration certificates of Air quality sampling and noise sampling used for this project are as shown in **Appendix 4C.**

Baseline monitoring stations were determined by considered the wind direction of the project study area. According to meteorology data of Huai Pong Agrometeorological Station during 2006-2015, the project's wind direction is from NNE during November-January; S during February-April; SW during May-August; W in September; and NE in October. The wind directions of Laem Chabang Meteorological Station during 1993-2015 are as follows: N during November-January; S and SSW during February-August; W in September; and E in October. Therefore, the baseline monitoring station should be located in the downwind direction of project site (**Table 4.1.5-2**).

TABLE 4.1.5-1

PARAMETERS USED IN SAMPLING METHOD AND ANALYSIS METHOD

Parameter	Sampling Method and Analysis Method
1. Total Suspended Particulates (TSP)	- Sampling by High Volume Sampler and analyze by Gravimetric Method
2. PM-10	- Sampling by PM-10 Sampler and analyze by Gravimetric Method
3. Nitrogen Dioxide (NO_2)	- Sampling by Chemiluminescence Analyzer and analyze by Chemiluminescence Method
4. Sulfur Dioxide (SO_2)	- Sampling by UV-Fluorescence Analyzer and analyze by UV-Fluorescence Method
5. Carbon Monoxide (CO)	- Sampling by CO NDIR Analyzer and analyze by CO NDIR Method
6. Wind Speed and Wind Direction	- Using equipment to measure wind speed and wind direction

TABLE 4.1.5-2
DOWNWIND DIRECTION OF AIR QUALITY MONITORING STATION

Location	Downwind of wind from	
	Huai Pong Agrometeorological Station	Laem Chabang Meteorological Station
A1 Pluak Daeng Power Plant	-	-
A2: Ban Noen Sawan Community, Village no. 2	- South (S) during February to April - Southwest (SW) during May to August	- South (S) and South-Southwest (SSW) during Februar to -August
A3: Prasittharam Temple	- North-Northeast (NNE) during November to January - Northeast (NE) in October	- North (N) during November to January
A4: Ban Map Toei School	- West (W) in September	- West (W) in September
A5: Western Community of the Project Site at Village no. 5	-	- East (E) in October

(3) Study Result

(a) Collection of Secondary Data

According to data on air quality collected from the environmental impact prevention and mitigation measure and environmental impact monitoring measure reports of Amata City Industrial Estate (Expansion) Phase 5, (No. 1) (2015), GK. Land Industrial Park (Siam Green City) (2015), and Eastern Seaboard Industrial Estate (2014), air quality monitoring was conducted at 5 stations within the study area **(Figure 4.1.5-1)**, i.e. Map Yang Phon Sub-district Health Promoting Hospital (A1); communities in GK. Land Industrial Park (A2); Village no.4, Ban Wang Ta Phin, Pluak Daeng Sub-district (A3); Ban Wang Ta Phin (A4); and Ban Wang Tan Mon School (A5) during 2013-2015. Except for the PM-10 measured at Map Yang Phon Sub-district Health Promoting Hospital in October 2013 which was greater than the established standard, all monitoring results were lower than the national ambient air quality standards, indicating the good air quality **(Table 4.1.5-3)**.

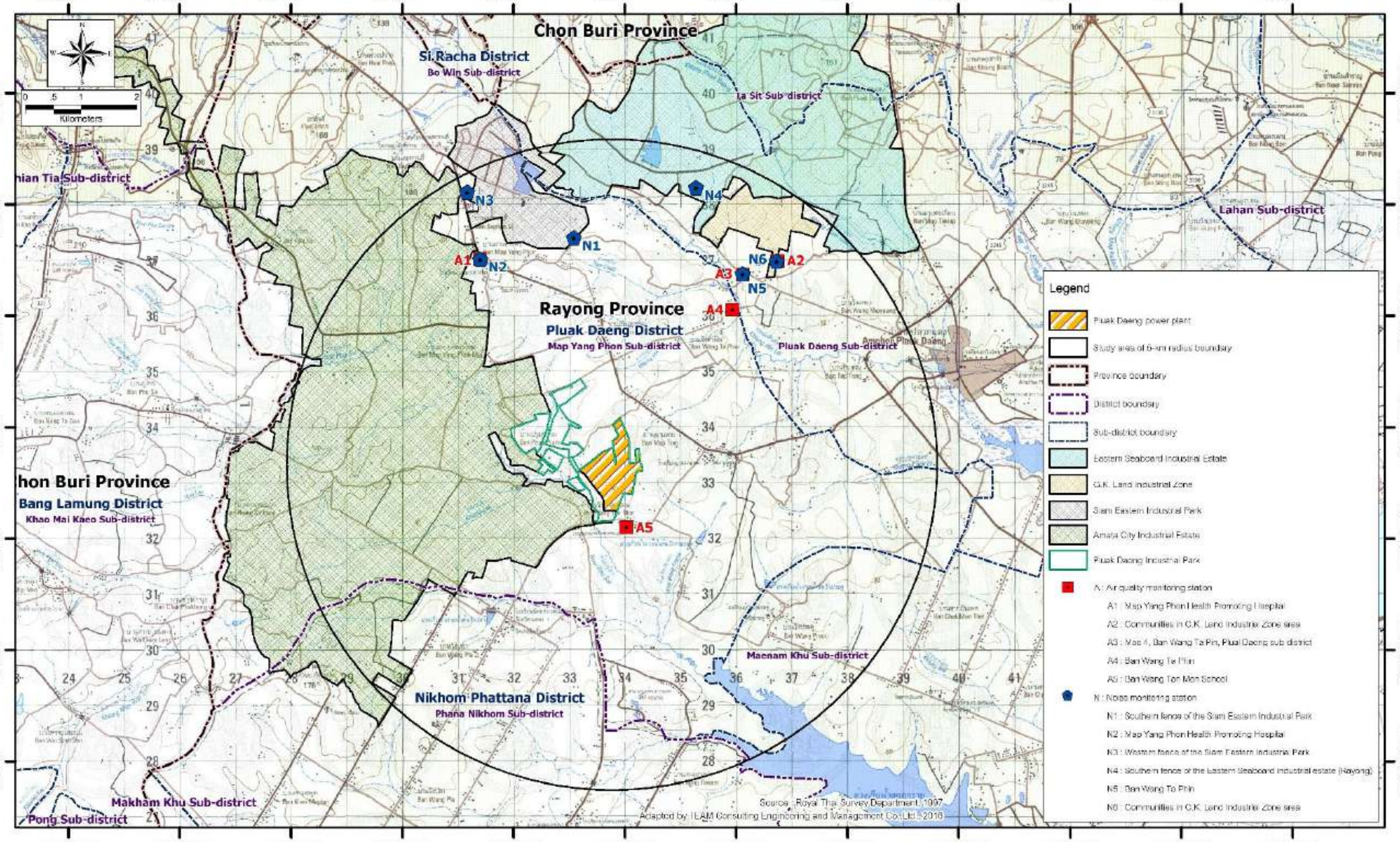


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FIGURE 4.1.5-1 : AIR QUALITY AND NOISE MONITORING STATIONS FOR SECONDARY DATA COLLECTION

TEAM

TABLE 4.1.5-3
AMBIENT AIR QUALITY MONITORING RESULTS DURING 2013-2015

Monitoring Station	Monitoring Period	Monitoring Concentration Results ($\mu g/m^3$)			
		TSP (24-hour Avg.)	PM-10 (24-hour Avg.)	NO_2 (1-hour Avg.)	SO_2 (1-hour Avg.)
Map Yang Phon Sub-district Health Promoting Hospital (A1)[5/]	Jun 2013	40-130	30-70	15.1-16.9	<2.6-5.2
	Oct 2013	60-300	50-170	20.7-88.4	2.6-13.1
	Jun 2014	50-120	20-70	<1.9-15.1	<2.6-5.2
	Dec 2014**	56-152	36-91	7.5-75.3	2.6-141.5
	Jun 2015**	16-46	11-30	3.8-45.2	0.0-13.1
Communities in GK. Land Industrial Park (A2)[6/]	May 2013	21.69	11-23	0.2-41.8	<1
	Dec 2013	18-29	4-9	0.2-77.7	<1
	Jun 2014	26-33	10-27	1.9-128.0	<1
	Nov 2014	17-27	11-13	0.2-5.6	<1
	May 2015	16-25	10-15	4.9-34.8	<1
	Sep 2015	14-30	6-18	0.6-9.0	<1
Village no. 4, Ban Wang Ta Phin, Pluak Daeng Sub-district (A3)[6/]	May 2013	27-47	21-34	0.2-29.2	<1-1
	Dec 2013	57-96	24-35	5.5-47.0	<1
	Jun 2014	34-49	18-34	0.9-77.0	<1
	Nov 2014	31-54	12-30	9.8-42.9	<1
	May 2015	30-41	9-10	5.3-30.9	<1
	Sep 2015	16-43	5-14	16.0-57.0	<1
Ban Wang Ta Phin (A4)[7/]	Mar 2013	16-60	-	7.7-33.5	<1-1
	Nov 2013	47-71	-	6.0-45.5	<1
	Mar 2014	28-77	-	1.9-79.0	<1-1
	Nov 2014	23-44	-	3.8-13.2	0.6-2.6
Ban Wang Tan Mon School (A5)[5/]	Jun 2013	20-50	10-40	<1.9-161.8	2.6-18.3
	Oct 2013	50-150	40-80	<1.9-24.5	<2.6-15.7
	Jun 2014	30-70	20-60	1.9-33.9	<2.6-18.3
	Dec 2014	160-220	80-110	5.6-65.9	68.1-76.0
	Jun 2015	30-40	30-40	<1.9-1.9	23.6-49.8
National Standard Values		**330[1/]**	**120[1/]**	**320[2/]**	**780[3/]**
WHO Standard[4/]		**-**	**50**	**200**	**-**

Remarks:
** Continuous ambient air quality monitoring station (permanent station)
- No monitoring
1/ Ambient air quality standards according to the Notification of the National Environmental Board No. 24, B.E. 2547 (2004)
2/ Ambient nitrogen dioxide standards according to the Notification of the National Environmental Board No. 33, B.E. 2552 (2009)
3/ 1-hr sulfur dioxide standards according to the Notification of the National Environmental Board No. 21, B.E. 2544 (2001)
4/ WHO Ambient Air Quality Guidelines in Environmental, Health, and Safety (EHS) Guidelines for International Finance Corporation (2007)

Sources:
5/ The environmental impact prevention and mitigation measure and environmental impact monitoring measure report of Amata City Industrial Estate (Expansion) Phase 5, (No. 1), 2015
6/ The environmental impact prevention and mitigation measure and environmental impact monitoring measure report of GK. Land Industrial Park (Siam Green City), 2015
7/ The environmental impact prevention and mitigation measure and environmental impact monitoring measure report of Siam Eastern Industrial Park (Expansion), 2014

- **Map Yang Phon Sub-district Health Promoting Hospital (A1)**

The 24-hour average TSP concentration at Map Yang Phon Sub-district Health Promoting Hospital was in a range of 40-300 μg/m^3 or 12.1-90.9% of the national standard value which was set at 330 μg/m^3. The 24-hour average PM-10 concentration ranged between 20 and 170 μg/m^3 or 16.7-141.7% of the national standard value which was set at 120 μg/m^3. The measurement concentration results in October 2013 revealed that TSP was high and PM-10 exceeded the established standards. Perhaps, this was due to vehicles running all days on the main roads near the monitoring station. Road repair and construction were undertaken near the station. The weather was dry and it was always windy, leading to dust dispersion. The 1-hour average NO_2 concentration was in a range of 1.9-88.4 μg/m^3 or 0.6-27.6% of the national standard value which was set at 320 μg/m^3 whereas the 1-hour average SO_2 concentration in a range of 2.6-141.5 μg/m^3 or 0.3-18.1% of the national standard value which was set at 780 μg/m^3 as presented in **Table 4.1.5-3** and **Figure 4.1.5-1**.

- **Communities in GK. Land Industrial Park (A2)**

The 24-hour average TSP concentration at communities in GK. Land Industrial Park was in a range of 16-69 μg/m^3 or 4.8-20.9% of the national standard value which was set at 330 μg/m^3. The 24-hour average PM-10 concentration ranged between 4 and 27 μg/m^3 or 3.3-22.5% of the national standard value which was set at 120 μg/m^3. The 1-hour average NO_2 concentration was in a range of 1.9-128 μg/m^3 or 0.6-40% of the national standard value which was set at 320 μg/m^3 whereas the 1-hour average SO_2 concentration was less than 1.0 μg/m^3 or 0.1% of the national standard value which was set at 780 μg/m^3 as presented in **Table 4.1.5-3** and **Figure 4.1.5-1**.

- **Village no. 4, Ban Wang Ta Phin, Pluak Daeng Sub-district**

The 24-hour average TSP concentration at Village no. 4, Ban Wang Ta Phin, Pluak Daeng sub-district was in a range of 16-96 μg/m^3 or 4.8-29.1% of the national standard value which was set at 330 μg/m^3. The 24-hour average PM-10 concentration ranged between 5 and 35 μg/m^3 or 4.2-29.2% of the national standard value which was set at 120 μg/m^3. The 1-hour average NO_2 concentration was in a range of 0.2-77 μg/m^3 or 0.1-24.1% of the national standard value which was set at 320 μg/m^3 whereas the 1-hour average SO_2 concentration was less than 1.0 μg/m^3 or 0.1% of the national standard value which was set at 780 μg/m^3 as presented in **Table 4.1.5-3** and **Figure 4.1.5-1**.

- **Ban Wang Ta Phin**

The 24-hour average TSP concentration at Ban Wang Ta Phin was in a range of 16-77 µg/m^3 or 4.8-23.3% of the national standard value which was set at 330 µg/m^3. The 1-hour average NO_2 concentration was in a range of 1.9-79 µg/m^3 or 0.6-24.7% of the national standard value which was set at 320 µg/m^3 whereas the 1-hour average SO_2 concentration was 1.0-2.6 µg/m^3 or 0.1-0.3% of the national standard value which was set at 780 µg/m^3 as presented in **Table 4.1.5-3** and **Figure 4.1.5-1**.

- **Ban Wang Tan Mon School**

The 24-hour average TSP concentration at Ban Wang Tan Mon School was in a range of 20-220 µg/m^3 or 6.1-66.7% of the standard value which was set at 330 µg/m^3. The 24-hour average PM-10 concentration ranged between 10 and 110 µg/m^3 or 8.3-91.7% of the standard value which was set at 120 µg/m^3. The 1-hour average NO_2 concentration was in a range of 1.9-161.8 µg/m^3 or 0.6-50.6% of the standard value which was set at 320 µg/m^3 whereas the 1-hour average SO_2 concentration was 2.6-76 µg/m^3 or 0.3-9.7% of the standard value which was set at 780 µg/m^3 as presented in **Table 4.1.5-3** and **Figure 4.1.5-1**.

(b) Field Survey

The Consultant conducted air quality monitoring during two prevailing winds: March-September and November-February at 5 stations (Pluak Daeng Power Plant (A1); Ban Noen Sawan community, Village no. 2, Map Yang Phon sub-district (A2); Prasittharam Temple (A3); Ban Map Toei School (A4); and the western community of the project site at Village no. 5, Map Yang Phon sub-district (A5) as illustrated in **Figure 4.1.5-2** and **Photo 4.1.5-1**. Monitoring of air quality was conducted twice at each station for 7 consecutive days during weekday and weekend.

The Consultant carried out two air quality monitoring activities during the southwest monsoon and the northeast monsoon as follows:

- **The 1st monitoring** was conducted during 9th -16th September 2015, representing the monitoring results during the southwest monsoon.
- **The 2nd monitoring** was carried out during 13th -20th February 2016, representing the monitoring results during the northeast monsoon.

The air quality parameters comprise TSP, PM-10, NO_2, SO_2, CO, wind direction and wind speed. The measurement results were compared to the ambient air quality standards for Thailand.

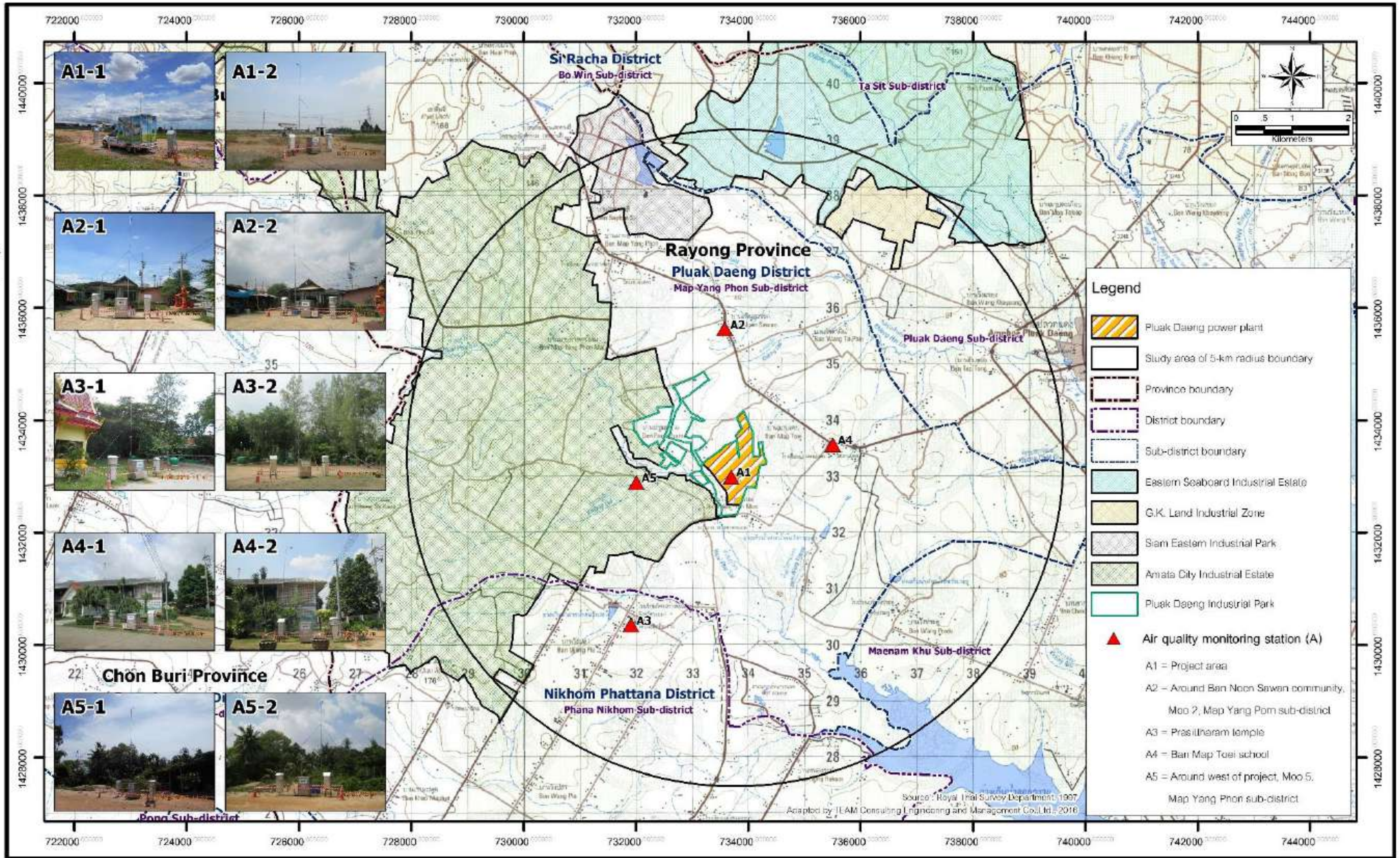


FIGURE 4.1.5-2 : AIR QUALITY MONITORING STATION MAP

Station 1 : Pluak Daeng Power Plant (A1) Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province

Station 2 : Ban Noen Sawan Community, Village no. 2 (A2) Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province

Station 3 : Prasittharam Temple (A3) Phana Nikhom Sub-district, Nikhom Phatthana District, Rayong Province

Station 4 : Ban Map Toei School (A4) Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province

Station 5 :Western Community of the Project Site at Village no. 5 (A5) Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province

PHOTO 4.1.5-1 : AIR QUALITY MONITORING STATIONS OF THE PROJECT

1) The 1st Air Quality Monitoring Results during 9th-16th September 2015

All air quality monitoring results do not exceed the established standards **(Appendix 4D-1)** as presented in **Tables 4.1.5-4** and **4.1.5-5**, and **Figure 4.1.5-3** as follows:

- **Pluak Daeng Power Plant (A1)**

All air quality monitoring results do not exceed the established standards. The 24-hour average TSP concentration is in a range of 26-41 µg/m^3 or 7.88-12.42% of the standard value at 330 µg/m^3. The 24-hour average PM-10 concentration ranges between 15 and 27 µg/m^3 or 12.5-22.5% of the national standard value at 120 µg/m^3. The 1-hour average NO_2 concentration is in a range of 12.04-27.47 µg/m^3 or 4.69-8.44% of the national standard value at 320 µg/m^3. The 24-hour and 1-hour average SO_2 concentrations are 4.19-4.98 µg/m^3 and 4.45-5.24 µg/m^3 or 1.40-1.66% and 0.57-0.67% of the national standard values at 300 µg/m^3 and 780 µg/m^3, respectively. The 8-hour and 1-hour average CO concentrations are 458.24-801.92 µg/m^3 and 458.24-801.92 µg/m^3 representing 4.47-7.82% and 1.34-2.34% of the national standard values at 10,260 and 34,200 µg/m^3, respectively as presented in **Table 4.1.5-4** and **Figure 4.1.5-4.**

As for wind directions and wind speed in the project area, NNW winds are the most common (24.4%), followed by N winds (15.5%), and calm winds (11.3%). The wind speed ranges between 0.4 and 4.1 m/s as presented in **Figure 4.1.5-3**.

- **Ban Noen Sawan Community, Village no. 2, Map Yang Phon Sub-district (A2)**

All air quality monitoring results do not exceed the established standards. The 24-hour average TSP concentration is in a range of 33-63 µg/m^3 or 10.00-19.09% of the standard value at 330 µg/m^3. The 24-hour average PM-10 concentration ranges between 18 and 38 µg/m^3 or 15.00-31.67% of the national standard value at 120 µg/m^3. The 1-hour average NO_2 concentration is in a range of 21.26-57.96 µg/m^3 or 5.63-11.88% of the national standard value at 320 µg/m^3. The 24-hour and 1-hour average SO_2 concentrations are 5.24-47.17 µg/m^3 and 6.29-11.79 µg/m^3 or 1.75-15.72% and 0.81-1.51% of the national standard values at 300 µg/m^3 and 780 µg/m^3, respectively. The 8-hour and 1-hour average CO concentrations are 687.36-1,031.04 µg/m^3 and 1,145.60-2,062.09 µg/m^3 representing 6.70-10.05% and 3.35-6.03% of the national standard values at 10,260 and 34,200 µg/m^3, respectively as presented in **Table 4.1.5-4** and **Figure 4.1.5-5.**

As for wind directions and wind speed in Ban Noen Sawan Community, Village no. 2, Map Yang Phon sub-district, NW winds are the most common (18.5%), followed by NNW winds (14.9%), and calm winds (11.3%). The wind speed ranges between 0.4 and 4.1 m/s as presented in **Figure 4.1.5-3**.

TABLE 4.1.5-4
AMBIENT AIR QUALITY MONITORING RESULTS DURING 9th-16th SEPTEMBER 2015

Monitoring Station	Date/Month/Year	Ambient Air Quality Monitoring Concentration Results (µg/m^3)						
		TSP (24-Hour Avg.)	PM-10 (24-Hour Avg.)	NO_2 (1-Hour Avg.)	SO_2 (24-Hour Avg.)	SO_2 (Max. 1-Hour Avg.)	CO (Max. 8-Hour Avg.)	CO (Max. 1-Hour Avg.)
Station 1: Pluak Daeng Power Plant (A1) Coordinate: 47P 0733541E 1432617N	9th-10th/09/2015	39	24	27.47	4.19	4.45	572.80	687.36
	10th-11th/09/2015	26	15	13.74	4.45	4.45	458.24	572.80
	11th-12th/09/2015	31	17	14.30	4.45	4.45	458.24	458.24
	12th-13th/09/2015	36	21	25.78	4.45	4.72	458.24	572.80
	13th-14th/09/2015	31	19	12.04	4.72	4.98	572.80	687.36
	14th-15th/09/2015	37	23	14.11	4.72	4.98	458.24	572.80
	15th-16th/09/2015	41	27	18.44	4.98	5.24	801.92	801.92
	Min-Max	**26-41**	**15-27**	**12.04-27.47**	**4.19-4.98**	**4.45-5.24**	**458.24-801.92**	**458.24-801.92**
Station 2: Ban Noen Sawan Community, Village no. 2, Map Yang Phon Sub-district (A2) Coordinate: 47P 0733578E 1435618N	9th-10th/09/2015	58	32	52.50	5.24	7.60	916.48	1,145.60
	10th-11th/09/2015	50	28	31.61	4.71	6.29	916.48	2,062.09
	11th-12th/09/2015	33	20	38.95	4.71	6.81	801.92	1,489.28
	12th-13th/09/2015	63	38	29.92	5.76	7.86	1,031.04	1,718.40
	13th-14th/09/2015	52	30	57.96	6.03	8.65	801.92	1,260.16
	14th-15th/09/2015	48	28	21.26	6.55	10.22	687.36	1,260.16
	15th-16th/09/2015	36	18	29.54	6.03	11.79	916.48	1,260.16
	Min-Max	**33-63**	**18-38**	**21.26-57.96**	**5.24-4.71**	**6.29-11.79**	**687.36-1,031.04**	**1,145.60-2,062.09**
Station 3: Prasittharam Temple (A3) Coordinate: 47P 0731906E 1460358N	9th-10th/09/2015	42	28	12.80	4.98	5.50	572.80	572.80
	10th-11th/09/2015	35	22	10.35	4.72	4.98	458.24	458.24
	11th-12th/09/2015	30	17	10.54	4.72	5.24	343.68	458.24
	12th-13th/09/2015	41	27	13.93	4.72	5.24	458.24	458.24
	13th-14th/09/2015	38	24	14.87	4.72	5.50	572.80	572.80
	14th-15th/09/2015	38	26	16.75	4.72	5.50	572.80	572.80
	15th-16th/09/2015	37	23	24.84	4.98	5.50	687.36	687.36
	Min-Max	**30-42**	**17-28**	**10.35-24.84**	**4.72-4.98**	**4.98-5.50**	**343.68-687.36**	**458.24-687.36**

TABLE 4.1.5-4
AMBIENT AIR QUALITY MONITORING RESULTS DURING 9th-16th SEPTEMBER 2015 (CONT'D)

Monitoring Station	Date/Month/Year	Ambient Air Quality Monitoring Concentration Results ($\mu g/m^3$)						
		TSP (24-Hour Avg.)	PM-10 (24-Hour Avg.)	NO_2 (1-Hour Avg.)	SO_2 (24-Hour Avg.)	SO_2 (Max. 1-Hour Avg.)	CO (Max. 8-Hour Avg.)	CO (Max. 1-Hour Avg.)
Station 4: Ban Map Toei School (A4) Coordinate 47P 0735509E 1433548N	9th-10th/09/2015	45	27	41.40	4.98	7.08	458.24	572.80
	10th-11th/09/2015	33	20	25.40	4.45	4.98	458.24	572.80
	11th-12th/09/2015	46	26	33.31	4.72	5.24	572.80	801.92
	12th-13th/09/2015	39	24	26.72	4.98	5.24	572.80	687.36
	13th-14th/09/2015	57	29	40.46	4.72	5.50	572.80	801.92
	14th-15th/09/2015	50	27	41.21	4.98	6.03	572.80	687.36
	15th-16th/09/2015	43	27	40.46	4.98	6.81	687.36	687.36
	Min-Max	**33-57**	**20-29**	**25.40-41.40**	**4.45-4.98**	**4.98-7.08**	**458.24-687.36**	**572.80-801.92**
Station 5: Western Community of the Project Site at Village no. 5, Map Yang Phon sub-district (A5) Coordinate: 47P 0732005E 1432902N	9th-10th/09/2015	38	22	21.83	4.98	7.08	572.80	801.92
	10th-11th/09/2015	29	15	21.08	5.50	10.74	458.24	458.24
	11th-12th/09/2015	30	17	19.76	5.50	7.34	458.24	458.24
	12th-13th/09/2015	40	24	21.83	5.50	7.34	458.24	572.80
	13th-14th/09/2015	50	28	38.58	5.50	6.81	458.24	572.80
	14th-15th/09/2015	45	29	23.71	5.50	7.08	572.80	916.48
	15th-16th/09/2015	46	23	34.06	5.50	7.34	572.80	687.36
	Min-Max	**29-50**	**15-29**	**19.76-38.58**	**4.98-5.50**	**6.81-10.74**	**458.24-572.80**	**458.24-916.48**
National Standard Values		**330[1/]**	**120[1/]**	**320[2/]**	**300[1/]**	**780[3/]**	**10,260[4/]**	**34,200[4/]**
WHO[5/]		**-**	**50**	**200**	**20**	**-**	**-**	**-**

Remarks:
[1/] Notification of the National Environmental Board No. 24, B.E. 2547 (2004) Regarding Ambient Air Quality Standards
[2/] Notification of the National Environmental Board No. 33, B.E. 2552 (2009) Regarding Ambient Nitrogen Dioxide Standards
[3/] Notification of the National Environmental Board No. 12, B.E. 2538 (1995) Regarding 1-hr Sulfur Dioxide Standards
[4/] Notification of the National Environmental Board No. 10, B.E. 2538 (1995) Regarding Ambient Air Quality Standards
[5/] WHO Ambient Air Quality Guidelines in Environmental, Health, and Safety (EHS) Guidelines for International Finance Corporation (2007)

Source: Field survey by TEAM Consulting Engineering and Management Ltd., September 2015

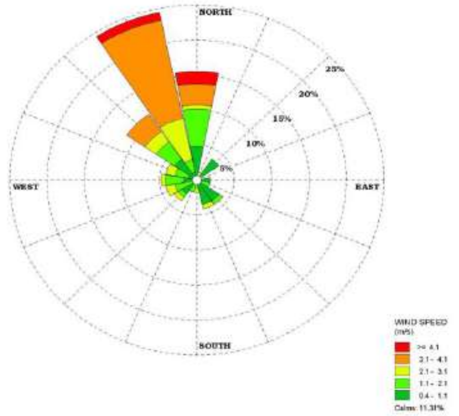
TABLE 4.1.5-5

WIND SPEED AND WIND DIRECTION MEASUREMENT RESULTS

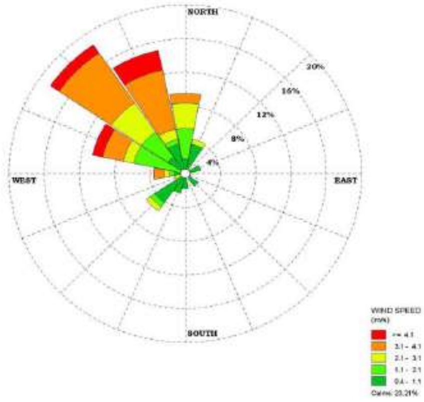
DURING 9th-16th SEPTEMBER 2015

Wind Direction	Percentage of Wind Direction				
	Pluak Daeng Power Plant	Ban Noen Sawan Community, Village no.2, Map Yang Phon Sub-district	Prasittharam Temple	Ban Map Toei School	Western Community of the Project Site at Village no.5, Map Yang Phon Sub-district
N	15.5	9.5	2.4	4.2	2.4
NNE	1.2	4.2	1.2	1.2	1.8
NE	3.6	0.6	1.2	0.0	0.0
ENE	0.6	1.8	0.0	0.6	3.6
E	1.8	0.0	0.6	0.0	1.8
ESE	1.8	0.6	0.0	0.0	4.2
SE	4.2	1.8	0.6	0.6	0.6
SSE	4.2	0.0	0.6	0.0	2.4
S	1.8	1.8	0.0	1.8	0.6
SSW	1.8	2.4	3.0	3.0	2.4
SW	3.6	5.4	14.9	6.0	1.8
WSW	4.2	1.2	13.1	0.6	10.7
W	4.8	3.6	3.6	1.8	23.8
WNW	4.2	10.7	6.0	24.4	10.7
NW	11.3	18.5	3.0	14.9	4.2
NNW	24.4	14.9	7.1	8.3	0.6
Total	**88.7**	**76.8**	**57.1**	**67.3**	**71.4**
Calm Wind (<1 km/hr)	**11.3**	**23.2**	**42.9**	**32.7**	**28.6**

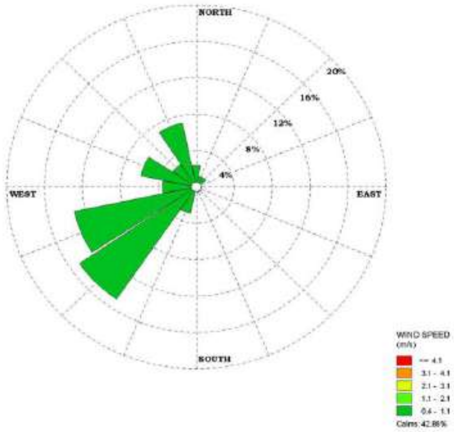
Source: Field Survey by TEAM Consulting Engineering and Management Ltd., September 2015



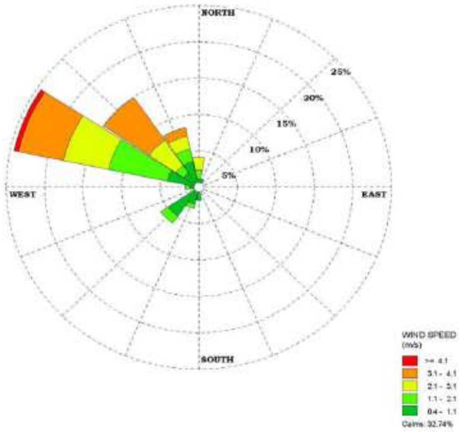
Station 1 : Pluak Daeng Power Plant (A1)
Map Yang Phon Sub-district, Pluak Daeng District,
Rayong Province



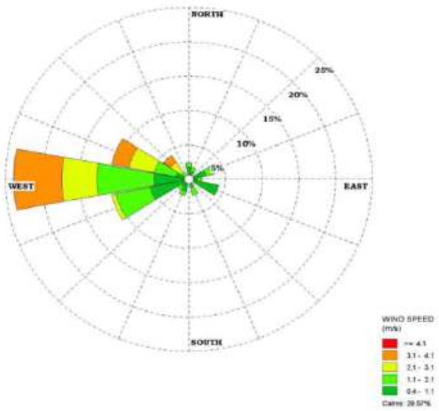
Station 2 : Ban Noen Sawan Community, Village no. 2 (A2)
Map Yang Phon Sub-district, Pluak Daeng District,
Rayong Province



Station 3 : Prasittharam Temple (A3)
Phana Nikhom Sub-district, Nikhom Phatthana District,
Rayong Province



Station 4 : Ban Map Toei School (A4)
Map Yang Phon Sub-district, Pluak Daeng District,
Rayong Province



Station 5 : Western Community of the Project Site at Village no. 5 (A5)
Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province

FIGURE 4.1.5-3 : WIND DIRECTION AND WIND SPEED (DURING 9th-16th SEPTEMBER 2015)

FIGURE 4.1.5-4 AIR QUALITY MONITORING RESULTS
(DURING 9th-16th SEPTEMBER 2015)
IN THE PROJECT AREA (A1)

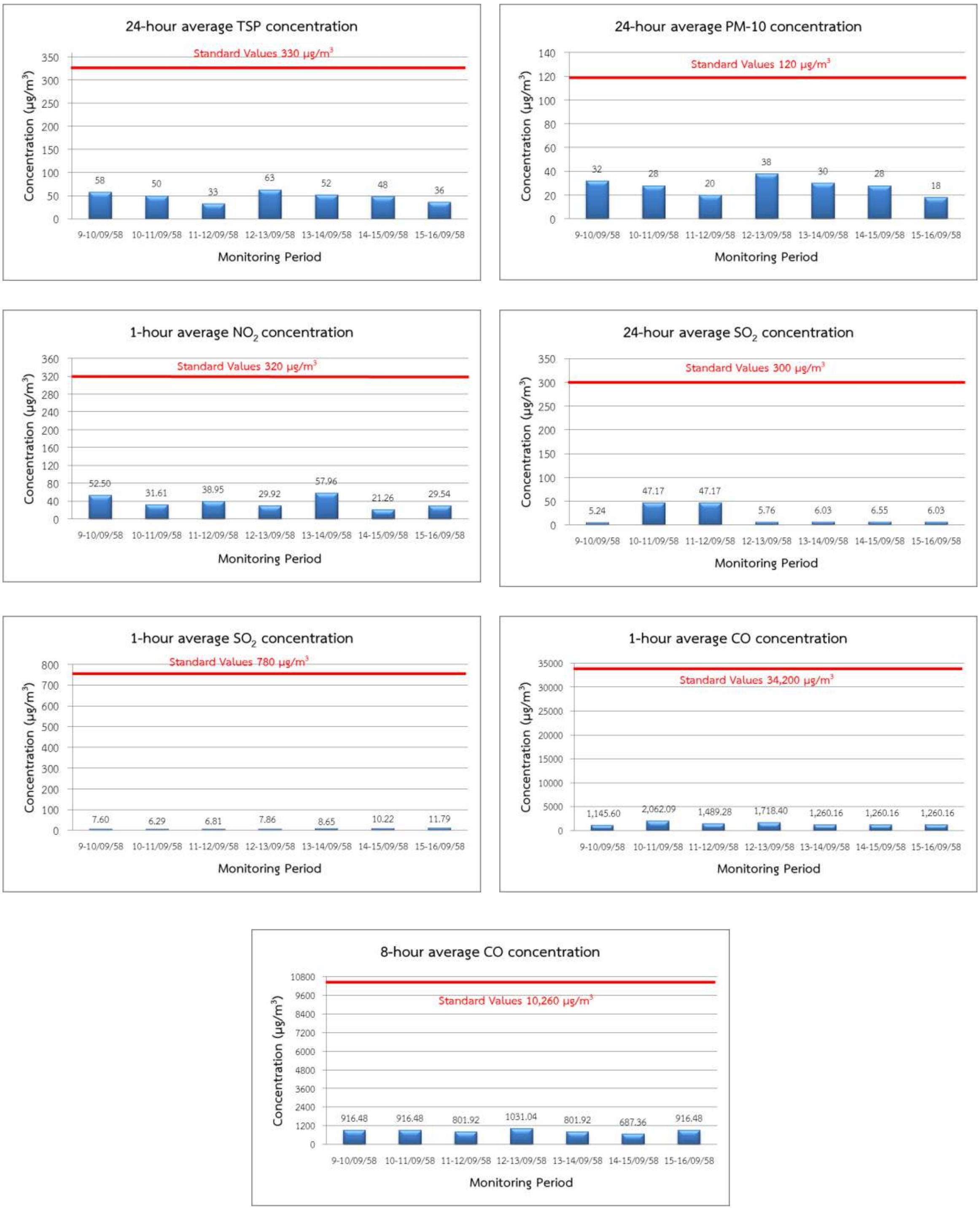


FIGURE 4.1.5-5 : AIR QUALITY MONITORING RESULTS (DURING 9th-16th SEPTEMBER 2015) IN BAN NOEN SAWAN COMMUNITY, VILLAGE NO. 2, MAP YANG PHON SUB-DISTRICT (A2)

- **Prasittharam Temple (A3)**

All air quality monitoring results do not exceed the established standards. The 24-hour average TSP concentration is in a range of 30-42 µg/m^3 or 9.09-12.73% of the national standard value at 330 µg/m^3. The 24-hour average PM-10 concentration ranges between 17 and 28 µg/m^3 or 14.17-23.33% of the national standard value at 120 µg/m^3. The 1-hour average NO_2 concentration is in a range of 10.35-24.84 µg/m^3 or 5.31-8.75% of the national standard value at 320 µg/m^3. The 24-hour and 1-hour average SO_2 concentrations are 4.72-4.98 µg/m^3 and 4.98-5.50 µg/m^3 or 1.57-1.66% and 0.64-0.71% of the national standard values at 300 µg/m^3 and 780 µg/m^3, respectively. The 8-hour and 1-hour average CO concentrations are 343.68-687.36 µg/m^3 and 458.24-687.36 µg/m^3 representing 3.35-6.7% and 1.34-2.01% of the national standard values at 10,260 and 34,200 µg/m^3, respectively as presented in **Table 4.1.5-4** and **Figure 4.1.5-6.**

As for wind directions and wind speed around Prasittharam Temple, SW winds are the most common (14.9%), followed by WSW winds (13.1%). Calm winds occupy 42.9%. The wind speed ranges between 0.4 and 1.1 m/s as presented in **Figure 4.1.5-3**.

- **Ban Map Toei School (A4)**

All air quality monitoring results do not exceed the established standards. The 24-hour average TSP concentration is in a range of 33-57 µg/m^3 or 10.00-17.27% of the national standard value at 330 µg/m^3. The 24-hour average PM-10 concentration ranges between 20 and 29 µg/m^3 or 16.67-24.17% of the national standard value at 120 µg/m^3. The 1-hour average NO_2 concentration is in a range of 25.40-41.40 µg/m^3 or 6.25-9.06% of the national standard value at 320 µg/m^3. The 24-hour and 1-hour average SO_2 concentrations are 4.45-4.98 µg/m^3 and 4.98-7.08 µg/m^3 or 1.48-1.66% and 0.64-0.91% of the national standard values at 300 µg/m^3 and 780 µg/m^3, respectively. The 8-hour and 1-hour average CO concentrations are 458.24-687.36 µg/m^3 and 572.80-801.92 µg/m^3 representing 4.47-6.70% and 1.67-2.34% of the national standard values at 10,260 and 34,200 µg/m^3, respectively as presented in **Table 4.1.5-4** and **Figure 4.1.5-7.**

As for wind directions and wind speed around Ban Map Toei school, WNW winds are the most common (24.4%), followed by NW winds (14.9%). Calm winds occupy 32.7%. The wind speed ranges between 0.4 and 4.1 m/s as presented in **Figure 4.1.5-3**.

FIGURE 3.5-6 : AIR QUALITY MONITORING RESULTS (DURING 9th-16th SEPTEMBER 2015) AROUND PRASITTHARAM TEMPLE (A3)

FIGURE 4.1.5-7 : AIR QUALITY MONITORING RESULTS
(DURING 9th-16th SEPTEMBER 2015)
AROUND BAN MAP TOEI SCHOOL (A4)

- **Western Community of the Project Site at Village no. 5, Map Yang Phon Sub-district (A5)**

All air quality monitoring results do not exceed the established standards. The 24-hour average TSP concentration is in a range of 29-50 µg/m^3 or 8.79-15.15% of the national standard value at 330 µg/m^3. The 24-hour average PM-10 concentration ranges between 15 and 29 µg/m^3 or 12.50-24.17% of the national standard value at 120 µg/m^3. The 1-hour average NO_2 concentration is in a range of 19.76-38.58 µg/m^3 or 4.69-9.06% of the standard value at 320 µg/m^3. The 24-hour and 1-hour average SO_2 concentrations are 4.98-5.50 µg/m^3 and 6.81-10.74 µg/m^3 or 1.66-1.83% and 0.87-1.38% of the national standard values at 300 µg/m^3 and 780 µg/m^3, respectively. The 8-hour and 1-hour average CO concentrations are 458.24-572.80 µg/m^3 and 458.24-916.48 µg/m^3 representing 4.47-5.58% and 1.34-2.68% of the national standard values at 10,260 and 34,200 µg/m^3, respectively as presented in **Table 4.1.5-4** and **Figure 4.1.5-8.**

As for wind directions and wind speed around the western community of the project site at Village no. 5, Map Yang Phon sub-district, W winds are the most common (23.8%), followed by WNW winds (10.7%). Calm winds occupy 28.6%. The wind speed ranges between 0.4 and 4.1 m/s as presented in **Figure 4.1.5-3**.

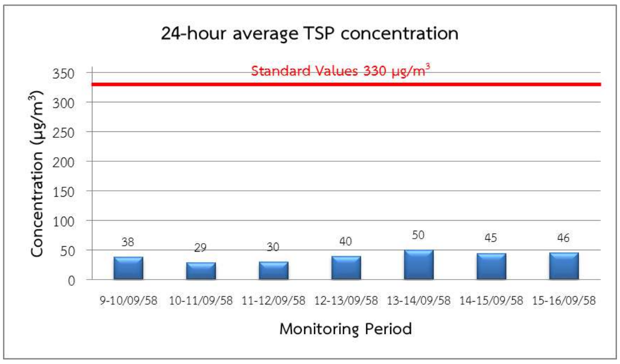
2) The 2nd Air Quality Monitoring Results during 13th-20th February 2016

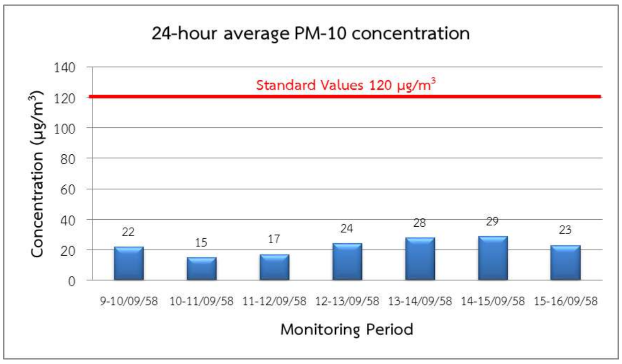
All air quality monitoring results do not exceed the established standards **(Appendix 4D-2)** as presented in **Tables 4.1.5-6** and **Table 4.1.5-7**, and **Figure 4.1.5-9** as follows:

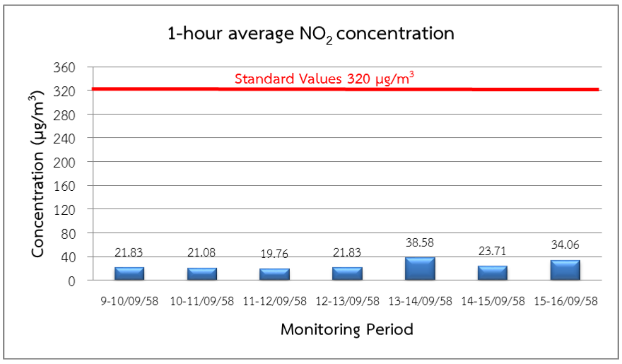
- **Pluak Daeng Power Plant (A1)**

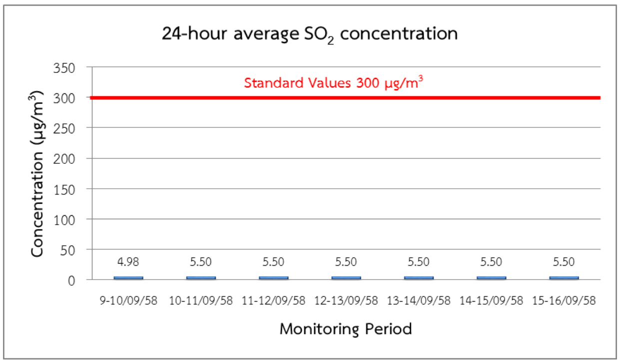
All air quality monitoring results do not exceed the established standards. The 24-hour average TSP concentration is in a range of 71-106 µg/m^3 or 21.52-32.12% of the national standard value at 330 µg/m^3. The 24-hour average PM-10 concentration ranges between 36 and 63 µg/m^3 or 30.0-52.5% of the national standard value at 120 µg/m^3. The 1-hour average NO_2 concentration is in a range of 16.37-40.65 µg/m^3 or 11.25-19.69% of the national standard value at 320 µg/m^3. The 24-hour and 1-hour average SO_2 concentrations are 4.19-6.03 µg/m^3 and 6.03-11.01 µg/m^3 or 1.40-2.01% and 0.77-1.41% of the national standard values at 300 µg/m^3 and 780 µg/m^3, respectively. The 8-hour and 1-hour average CO concentrations are 458.24-1,031.04 µg/m^3 and 572.80-1,145.60 µg/m^3 representing 4.47-10.05% and 1.67-3.35% of the national standard values at 10,260 and 34,200 µg/m^3, respectively as presented in **Table 4.1.5-6** and **Figure 4.1.5-10.**

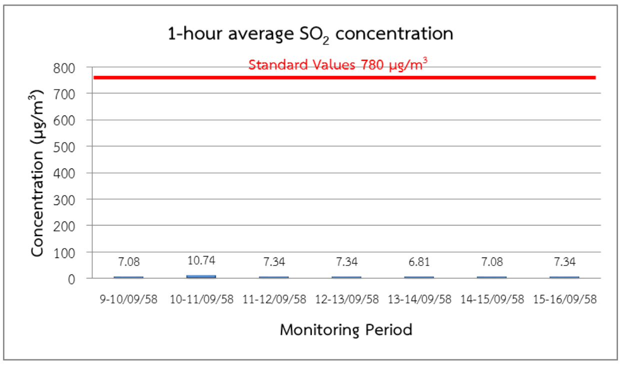
As for wind directions and wind speed in the project area, S winds are the most common (11.3%), followed by SSW winds (10.1%). Calm winds occupy 48.8%. The wind speed ranges between 0.4 and 4.1 m/s as presented in **Figure 4.1.5-9**.

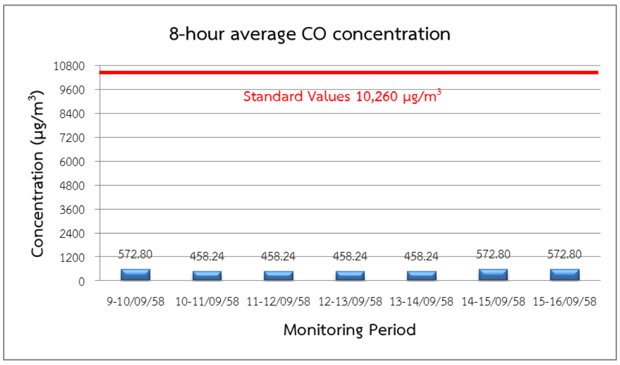












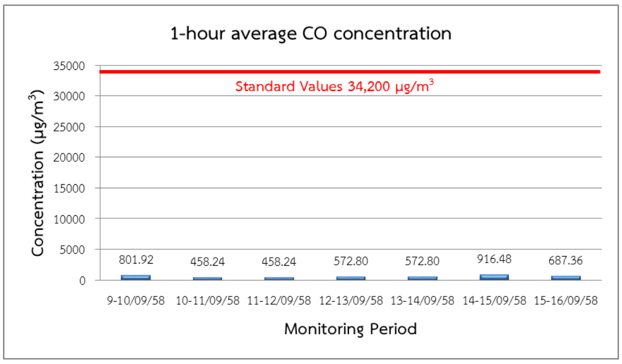


FIGURE 4.1.5-8 : AIR QUALITY MONITORING RESULTS (DURING 9th-16th SEPTEMBER 2015)IN THE WESTERN COMMUNITY OF THE PROJECT SITE AT VILLAGE NO. 5, MAP YANG PHON SUB-DISTRICT (A5)

TABLE 4.1.5-6

AMBIENT AIR QUALITY MONITORING RESULTS DURING 13th-20th FEBRUARY 2016

Monitoring Station	Date/Month/Year	Ambient Air Quality Monitoring Concentration Results (µg/m^3)						
		TSP (24-Hour Avg.)	PM-10 (24-Hour Avg.)	NO_2 (1-Hour Avg.)	SO_2 (24-Hour Avg.)	SO_2 (Max. 1-Hour Avg.)	CO (Max. 8-Hour Avg.)	CO (Max. 1-Hour Avg.)
Station 1: Pluak Daeng Power Plant (A1) Coordinate: 47P 0733541E 1432617N	13th-14th/02/2016	80	45	29.92	4.72	6.03	687.36	687.36
	14th-15th/02/2016	82	43	21.45	4.98	6.03	458.24	572.80
	15th-16th/02/2016	71	36	22.39	4.98	8.12	687.36	916.48
	16th-17th/02/2016	73	38	40.65	6.03	9.43	916.48	1,031.04
	17th-18th/02/2016	95	60	34.06	5.24	6.81	1,031.04	1,145.60
	18th-19th/02/2016	106	63	29.73	4.72	7.08	1,031.04	1,031.04
	19th-20th/02/2016	101	58	16.37	4.19	11.01	916.48	916.48
	Min-Max	**71-106**	**36-63**	**16.37-40.65**	**4.19-6.03**	**6.03-11.01**	**458.24-1,031.04**	**572.80-1,145.60**
Station 2: Ban Noen Sawan Community, Village no. 2, Map Yang Phon Sub-district (A2) Coordinate: 47P 0733578E 1435618N	13th-14th/02/2016	144	78	35.00	4.72	6.29	916.48	1,145.60
	14th-15th/02/2016	105	60	44.98	6.03	6.81	687.36	1,145.60
	15th-16th/02/2016	113	59	40.84	6.55	7.60	572.80	1,374.72
	16th-17th/02/2016	90	58	36.51	5.24	6.29	801.92	1,718.40
	17th-18th/02/2016	117	68	36.88	5.24	6.29	1,031.04	1,947.53
	18th-19th/02/2016	128	76	37.82	5.50	8.12	1,031.04	1,947.53
	19th-20th/02/2016	133	76	25.40	5.50	7.08	916.48	1,374.72
	Min-Max	**90-144**	**58-78**	**25.40-44.98**	**4.72-6.55**	**6.29-8.12**	**572.80-1,031.04**	**1,145.60-1,947.53**
Station 3: Prasittharam Temple (A3) Coordinate: 47P 0731906E 1460358N	13th-14th/02/2016	92	55	23.90	4.98	10.74	458.24	572.80
	14th-15th/02/2016	126	83	26.35	4.45	7.60	572.80	1,374.72
	15th-16th/02/2016	73	39	25.40	4.98	7.34	458.24	458.24
	16th-17th/02/2016	83	43	33.87	4.72	8.12	572.80	687.36
	17th-18th/02/2016	96	62	21.83	5.24	9.17	572.80	687.36
	18th-19th/02/2016	128	80	22.58	4.72	9.96	687.36	1,031.04
	19th-20th/02/2016	100	61	19.57	4.98	9.70	687.36	687.36
	Min-Max	**73-128**	**42-88**	**24.28-34.44**	**3.93-5.24**	**4.98-6.55**	**458.24-801.92**	**687.36-1,145.60**

TABLE 4.1.5-6

AMBIENT AIR QUALITY MONITORING RESULTS DURING 13th-20th FEBRUARY 2016 (CONT'D)

Monitoring Station	Date/Month/Year	Ambient Air Quality Monitoring Concentration Results (µg/m^3)						
		TSP (24-Hour Avg.)	PM-10 (24-Hour Avg.)	NO_2 (1-Hour Avg.)	SO_2 (24-Hour Avg.)	SO_2 (Max. 1-Hour Avg.)	CO (Max. 8-Hour Avg.)	CO (Max. 1-Hour Avg.)
Station 4: Ban Map Toei School (A4) Coordinate 47P 0735509E 1433548N	13th-14th/02/2016	103	54	31.99	3.93	4.98	458.24	687.36
	14th-15th/02/2016	98	62	32.56	4.19	4.98	687.36	916.48
	15th-16th/02/2016	138	88	34.44	4.45	4.98	801.92	1,031.04
	16th-17th/02/2016	126	65	32.74	4.98	6.03	801.92	1,145.60
	17th-18th/02/2016	111	61	24.28	4.98	5.76	572.80	687.36
	18th-19th/02/2016	103	57	27.29	4.98	6.03	572.80	687.36
	19th-20th/02/2016	71	42	28.60	5.24	6.55	458.24	687.36
	Min-Max	**71-138**	**42-88**	**24.28-34.44**	**3.93-5.24**	**4.98-6.55**	**458.24-801.92**	**687.36-1,145.60**
Station 5: Western Community of the Project Site at Village no. 5, Map Yang Phon sub-district (A5) Coordinate: 47P 0732005E 1432902N	13th-14th/02/2016	62	37	24.65	5.24	7.86	458.24	687.36
	14th-15th/02/2016	91	49	26.91	4.72	5.24	458.24	687.36
	15th-16th/02/2016	110	65	35.75	4.98	5.50	458.24	458.24
	16th-17th/02/2016	82	41	48.36	5.50	6.55	687.36	916.48
	17th-18th/02/2016	93	60	41.40	5.24	6.03	687.36	916.48
	18th-19th/02/2016	95	58	36.88	5.24	6.29	687.36	801.92
	19th-20th/02/2016	94	57	19.38	4.98	5.50	572.80	687.36
	Min-Max	**62-110**	**37-65**	**19.38-48.36**	**4.72-5.50**	**5.24-7.86**	**458.24-687.36**	**458.24-916.48**
National Standard Values		330 1/	120 1/	320 2/	300 1/	780 3/	10,260 4/	34,200 4/
WHO 5/		-	50	200	-	-	-	-

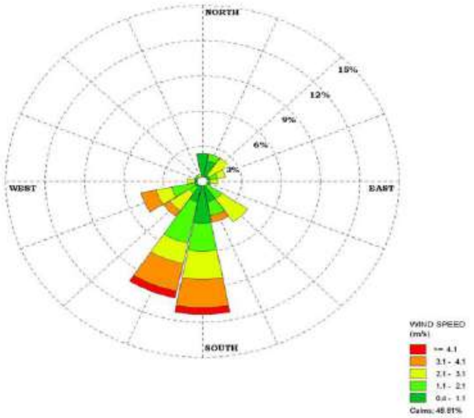
Remarks:
1/ Notification of the National Environmental Board No. 24, B.E. 2547 (2004) Regarding Ambient Air Quality Standards
2/ Notification of the National Environmental Board No. 33, B.E. 2552 (2009) Regarding Ambient Nitrogen Dioxide Standards
3/ Notification of the National Environmental Board No. 12, B.E. 2538 (1995) Regarding 1-hr Sulfur Dioxide Standards
4/ Notification of the National Environmental Board No. 10, B.E. 2538 (1995) Regarding Ambient Air Quality Standards
5/ WHO Ambient Air Quality Guidelines in Environmental, Health, and Safety (EHS) Guidelines for International Finance Corporation (2007)

Source: Field survey by TEAM Consulting Engineering and Management Ltd., February 2016

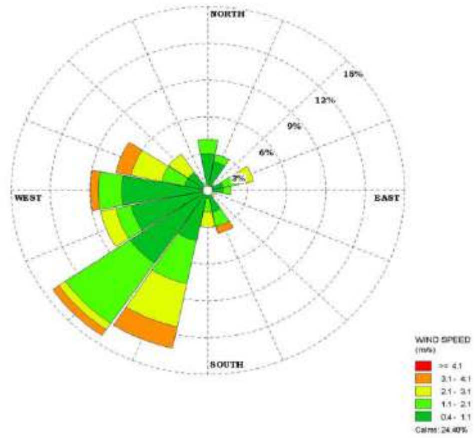
TABLE 4.1.5-7
WIND SPEED AND WIND DIRECTION MEASUREMENT RESULTS
DURING 13th-20th FEBRUARY 2016

Wind Direction	Percentage of Wind Direction				
	Pluak Daeng Power Plant	Ban Noen Sawan Community, Village no. 2, Map Yang Phon Sub-district	Prasittharam Temple	Ban Map Toei School	Western Community of the Project Site
N	2.4	4.2	0.0	0.6	1.8
NNE	2.4	3.0	0.0	0.6	1.2
NE	2.4	0.6	1.8	0.0	0.6
ENE	1.8	3.6	6.0	1.2	7.1
E	1.2	1.8	3.0	3.0	3.6
ESE	0.6	0.0	1.2	0.6	3.6
SE	4.2	0.6	0.6	9.5	2.4
SSE	3.6	3.6	0.6	2.4	11.3
S	11.3	3.0	0.0	4.2	0.0
SSW	10.1	13.1	1.2	5.4	1.8
SW	3.6	14.3	4.2	1.2	1.8
WSW	4.8	8.3	11.9	0.0	0.0
W	1.2	8.9	10.7	0.0	1.2
WNW	0.6	7.1	4.2	1.2	0.0
NW	0.6	3.6	0.6	0.0	0.6
NNW	0.6	0.0	0.0	0.0	0.0
Total	**51.2**	**75.6**	**45.8**	**29.8**	**36.9**
Calm Wind (<1 km/hr)	**48.8**	**24.4**	**54.2**	**70.2**	**63.1**

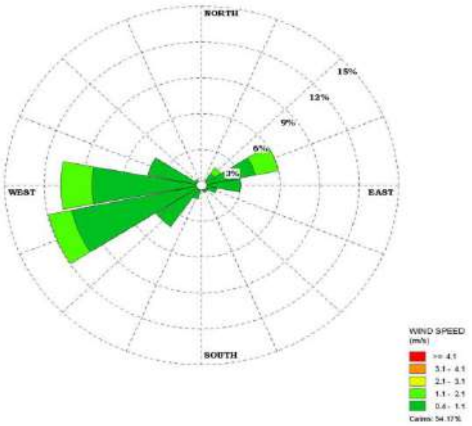
Source: Field Survey by TEAM Consulting Engineering and Management Ltd., February 2016



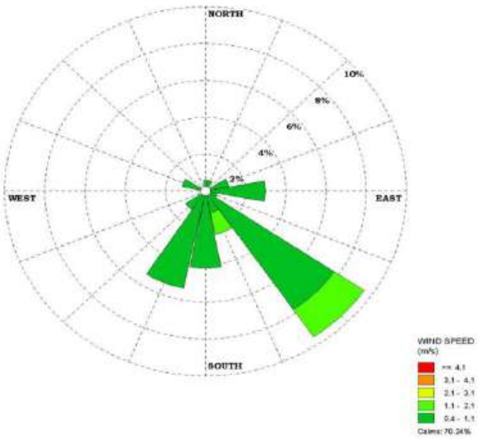
Station 1 : Pluak Daeng Power Plant (A1)
Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province



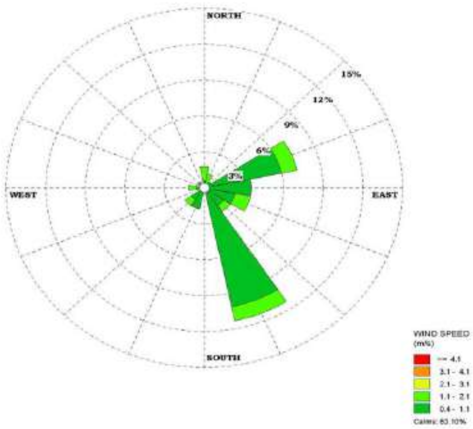
Station 2 : Ban Noen Sawan Community, Village no. 2 (A2)
Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province



Station 3 : Prasittharam Temple (A3)
Phana Nikhom Sub-district, Nikhom Phatthana District, Rayong Province



Station 4 : Ban Map Toei School (A4)
Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province



Station 5 : Western Community of the Project Site at Village no. 5 (A5)
Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province

FIGURE 4.1.5-9 : WIND DIRECTIONS AND WIND SPEED (DURING 13th-20th FEBRUARY 2016)

FIGURE 4.1.5-10 : AIR QUALITY MONITORING RESULTS (DURING 13th-20th FEBRUARY 2016) IN THE PROJECT AREA (A1)

- **Ban Noen Sawan Community, Village no. 2, Map Yang Phon Sub-district (A2)**

All air quality monitoring results do not exceed the established standards. The 24-hour average TSP concentration is in a range of 90-144 µg/m^3 or 27.27-43.64% of the national standard value at 330 µg/m^3. The 24-hour average PM-10 concentration ranges between 58 and 78 µg/m^3 or 48.33-65% of the national standard value at 120 µg/m^3. The 1-hour average NO_2 concentration is in a range of 25.40-44.98 µg/m^3 or 18.13-24.38% of the national standard value at 320 µg/m^3. The 24-hour and 1-hour average SO_2 concentrations are 4.72-6.55 µg/m^3 and 6.29-8.12 µg/m^3 or 1.57-2.18% and 0.81-1.04% of the national standard values at 300 µg/m^3 and 780 µg/m^3, respectively. The 8-hour and 1-hour average CO concentrations are 572.80-1,031.04 µg/m^3 and 1,145.60-1,947.53 µg/m^3 representing 5.58-10.05% and 3.35-5.69% of the national standard values at 10,260 and 34,200 µg/m^3, respectively as presented in **Table 4.1.5-6** and **Figure 4.1.5-11.**

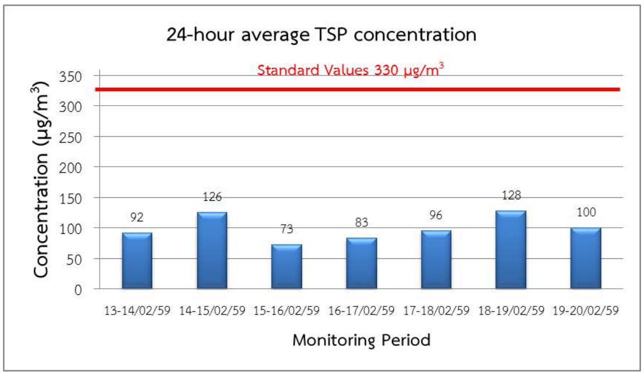
As for wind directions and wind speed in Ban Noen Sawan Community, Village no. 2, Map Yang Phon sub-district, SW winds are the most common (14.3%), followed by SSW winds (13.1%), and calm winds (24.4%). The wind speed ranges between 0.4 and 4.1 m/s as presented in **Figure 4.1.5-9**.

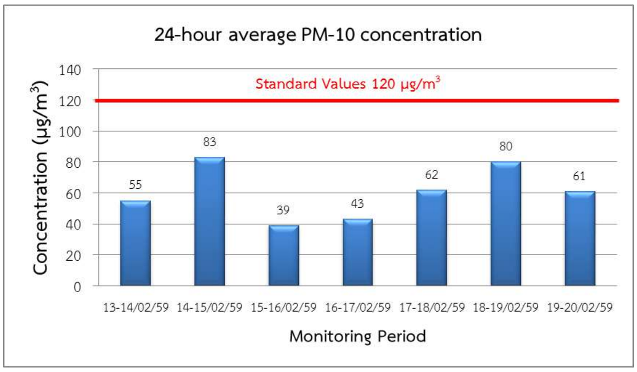
- **Prasittharam Temple (A3)**

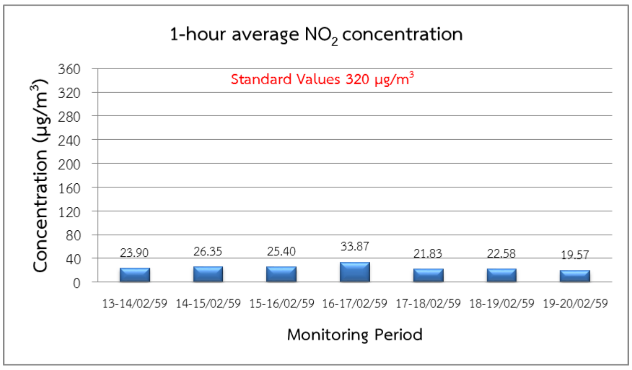
All air quality monitoring results do not exceed the established standards. The 24-hour average TSP concentration is in a range of 73-128 µg/m^3 or 22.12-38.79% of the national standard value at 330 µg/m^3. The 24-hour average PM-10 concentration ranges between 42 and 88 µg/m^3 or 32.50-69.17% of the national standard value at 120 µg/m^3. The 1-hour average NO_2 concentration is in a range of 24.28-34.44 µg/m^3 or 12.19-25.94% of the national standard value at 320 µg/m^3. The 24-hour and 1-hour average SO_2 concentrations are 3.93-5.24 µg/m^3 and 4.98-6.55 µg/m^3 or 1.48-1.75% and 0.94-1.38% of the national standard values at 300 µg/m^3 and 780 µg/m^3, respectively. The 8-hour and 1-hour average CO concentrations are 458.24-801.92 µg/m^3 and 687.36-1,145.60 µg/m^3 representing 4.47-6.70% and 1.34-4.02% of the national standard values at 10,260 and 34,200 µg/m^3, respectively as presented in **Table 4.1.5-6** and **Figure 4.1.5-12.**

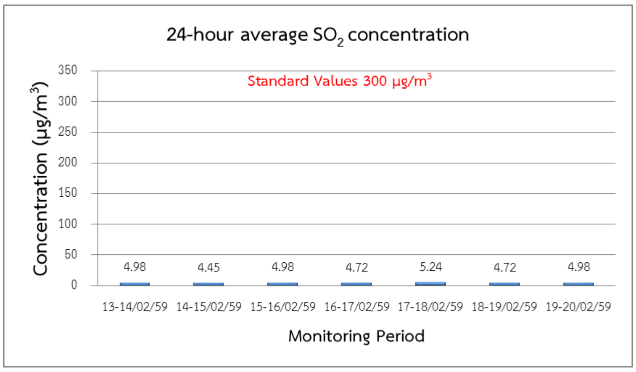
As for wind directions and wind speed around Prasittharam Temple, WSW winds are the most common (11.9%), followed by W winds (10.7%). Calm winds occupy 54.2%. The wind speed ranges between 0.4 and 2.1 m/s as presented in **Figure 4.1.5-9**.

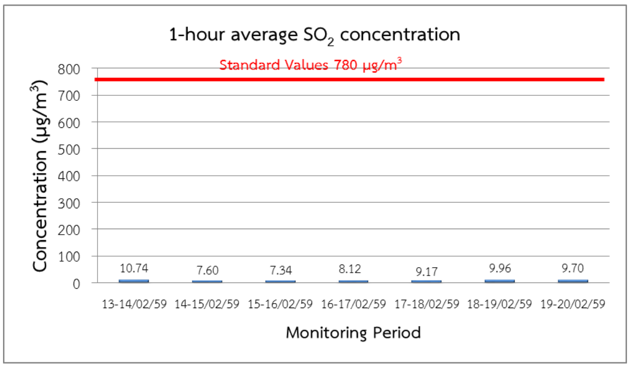
FIGURE 4.1.5-11 AIR QUALITY MONITORING RESULTS (DURING 13th-20th FEBRUARY 2016) AROUND BAN NOEN SAWAN COMMUNITY, VILLAGE NO. 2, MAP YANG PHON SUB-DISTRICT (A2)

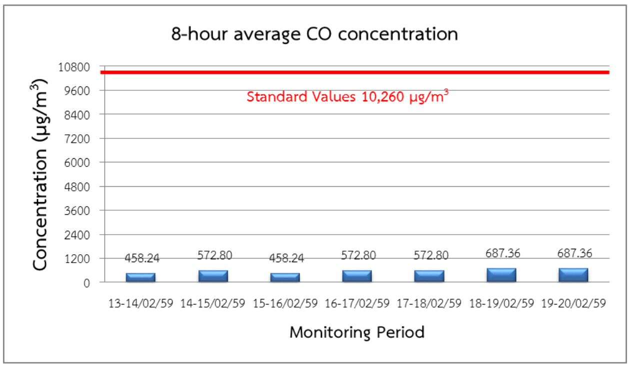












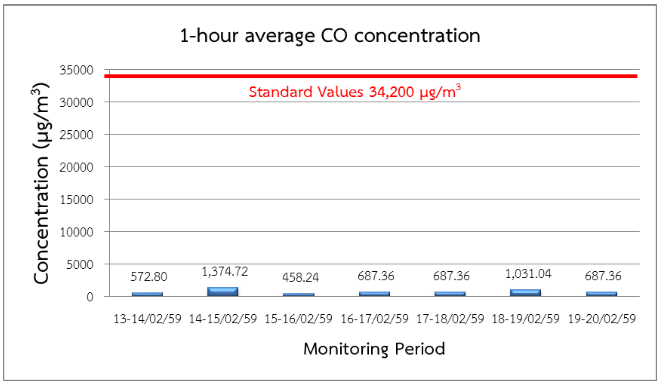


FIGURE 4.1.5-12 AIR QUALITY MONITORING RESULTS (DURING 13^{th}-20^{th} FEBRUARY 2016) AROUND PRASITTHARAM TEMPLE (A3)

- **Ban Map Toei School (A4)**

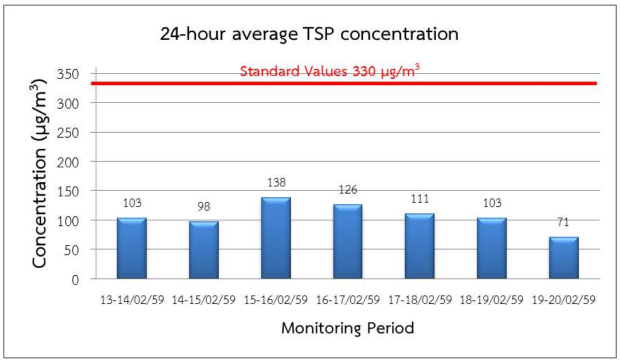
All air quality monitoring results do not exceed the established standards. The 24-hour average TSP concentration is in a range of 71-138 µg/m^3 or 21.52-41.82% of the national standard value at 330 µg/m^3. The 24-hour average PM-10 concentration ranges between 42 and 88 µg/m^3 or 35.00-73.33% of the national standard value at 120 µg/m^3. The 1-hour average NO_2 concentration is in a range of 24.28-34.44 µg/m^3 or 13.13-27.50% of the national standard value at 320 µg/m^3. The 24-hour and 1-hour average SO_2 concentrations are 3.93-5.24 µg/m^3 and 4.98-6.55 µg/m^3 or 1.31-1.75% and 0.64-0.84% of the national standard values at 300 µg/m^3 and 780 µg/m^3, respectively. The 8-hour and 1-hour average CO concentrations are 458.24-801.92 µg/m^3 and 687.36-1,145.60 µg/m^3 representing 4.47-7.82% and 2.01-3.35% of the national standard values at 10,260 and 34,200 µg/m^3, respectively as presented in **Table 4.1.5-6** and **Figure 4.1.5-13.**

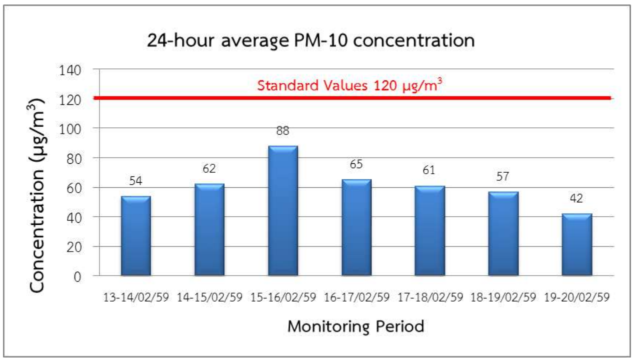
As for wind directions and wind speed around Ban Map Toei school, SE winds are the most common (9.5%), followed by SSW winds (5.4%). Calm winds occupy 70.2%. The wind speed ranges between 0.4 and 2.1 m/s as presented in **Figure 4.1.5-9**.

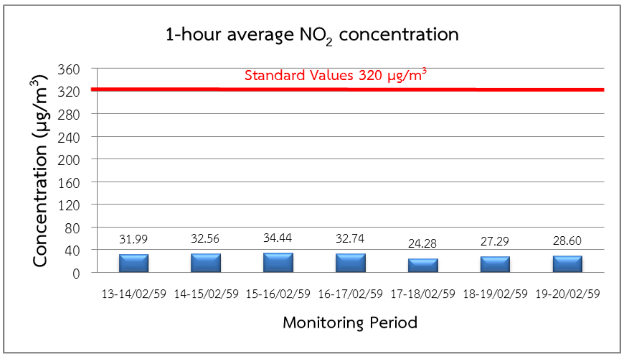
- **Western Community of the Project Site at Village no. 5, Map Yang Phon Sub-district (A5)**

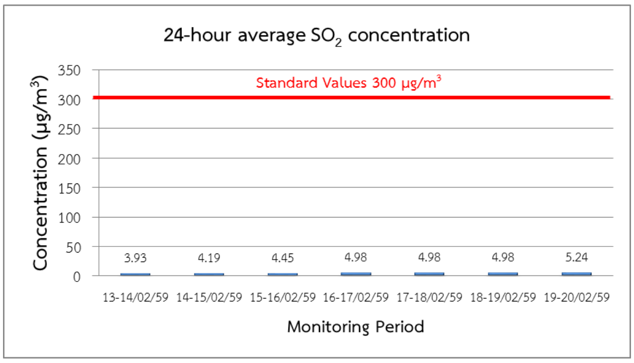
All air quality monitoring results do not exceed the established standards. The 24-hour average TSP concentration is in a range of 62-110 µg/m^3 or 18.79-33.33% of the national standard value at 330 µg/m^3. The 24-hour average PM-10 concentration ranges between 37 and 65 µg/m^3 or 30.83-54.17% of the national standard value at 120 µg/m^3. The 1-hour average NO_2 concentration is in a range of 19.38-48.36 µg/m^3 or 11.56-20.31% of the national standard value at 320 µg/m^3. The 24-hour and 1-hour average SO_2 concentrations are 4.72-5.50 µg/m^3 and 5.24-7.86 µg/m^3 or 1.57-1.83% and 0.67-1.01% of the national standard values at 300 µg/m^3 and 780 µg/m^3, respectively. The 8-hour and 1-hour average CO concentrations are 458.24-687.36 µg/m^3 and 458.24-916.48 µg/m^3 representing 4.47-6.70% and 1.34-2.68% of the national standard values at 10,260 and 34,200 µg/m^3, respectively as presented in **Table 4.1.5-6** and **Figure 4.1.5-14.**

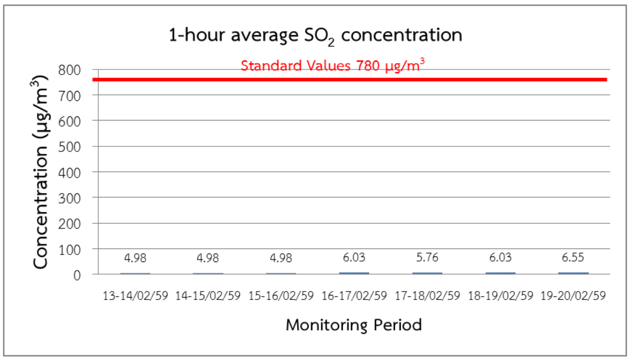
As for wind directions and wind speed around the western community of the project site at Village no. 5, Map Yang Phon sub-district, SSE winds are the most common (11.3%), followed by ENE winds (7.1%). Calm winds occupy 63.1%. The wind speed ranges between 0.4 and 2.1 m/s as presented in **Figure 4.1.5-9**.

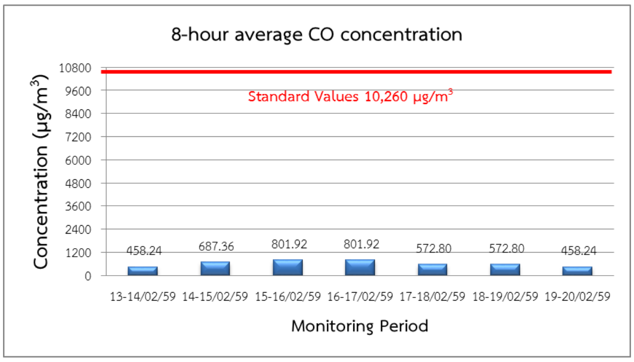












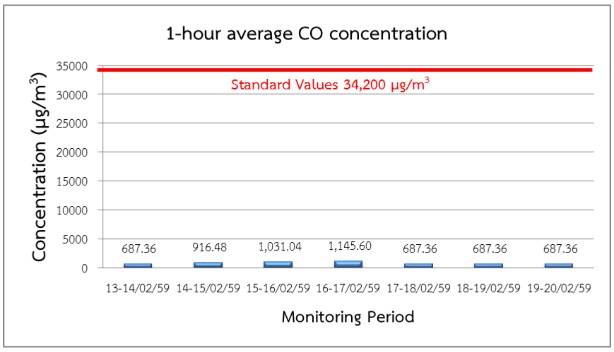


FIGURE 4.1.5-13 : AIR QUALITY MONITORING RESULTS (DURING 13th-20th FEBRUARY 2016) AROUND WAT MAP TOEI SCHOOL (A4)

FIGURE 4.1.5-14 : AIR QUALITY MONITORING RESULTS (DURING 13th-20th FEBRUARY 2016) IN THE WESTERN COMMUNITY OF THE PROJECT SITE (A5)

3) Comparison of Air Quality Monitoring Results and the WHO Standards (Table 4.1.5-8)

Continuous monitoring data from AQMS of Public Health Pluak Daeng District during 2015 compares with the National standard show that all of air quality parameters from Public Health Pluak Daeng District AQMS were in accordance with the National standard. It can be concluded that the airshed is non-degraded.

Comparison of ambient air quality measurement data from field survey for 7 consecutive days, covering both work days and holidays, at 5 stations, 2 times per station during 9^{th}-16^{th} September 2015, and 13^{th}-20^{th} February 2016 were in accordance with the National standard. Result of PM-10 24-hour average monitored at 5 stations of 2^{nd} measurement, exceeded WHO standard.

4.1.6 Noise

(1) Introduction

The study of noise levels in the project area and its vicinity reflected the quality of life of local people. The study results were used as the fundamental data to study the noise generated by the project activities, and to seek the suitable impact prevention and mitigation measures.

(2) Methodology

- Secondary data on noise levels in the surrounding areas of the project location were collected from the environmental impact prevention and mitigation measure and environmental impact monitoring measure reports of the Eastern Seaboard Industrial Estate (Rayong), Siam Eastern Industrial Park, GK. Land Industrial Park (Siam Green City), and Amata City Industrial Estate (Expansion) Phase 5, (No. 1).
- The existing noise levels (5-min Leq, 24-hr Leq, L_{dn}, L_{max}, and L_{90}) were measured around the project area. The noise monitoring stations were selected based on the sensitive receptors which will be most affected by the project. There are 4 stations: Pluak Daeng Power Plant (N1); western community of the project site, Village no. 2, Map Yang Phon sub-district (N2); southern community of the project site, Village no. 5, Map Yang Phon sub-district (N3); and northeastern community of the project site, Village no. 2, Map Yang Phon sub-district (N4). Noise level measurement was conducted at each station for 5 consecutive days covering weekdays and weekend during 13^{th}-18^{th} February 2016.

TABLE 4.1.5-8

COMPARISON OF AIR QUALITY MONITORING RESULTS AND THE WHO STANDARDS

Air Quality Monitoring Station		Concentration(µg/m³)								
		TSP		PM-10		NO_2		SO_2		
		24 hr.	1 year	24 hr.	1 year	1 hr.	1 year	1 hr.	24 hr.	1 year
Air Quality Monitoring System (AQMS)										
Public Health Pluak Daeng District	2015*	-	-	86.50	26.58	67.74	11.02	39.83	7.88	6.48
Field Survey: Ambient air quality measurement										
Pluak Daeng Power Plant (A1)	9th-16th/09/2015	26-41	-	15-27	-	12.04-27.47	-	4.45-5.24	4.19-4.98	-
	13th-20th/02/2016	71-106	-	36-63	-	16.37-40.65	-	6.03-11.01	4.19-6.03	-
Ban Noen Sawan Community, Village no. 2, Map Yang Phon Sub-district (A2)	9th-16th/09/2015	33-63	-	18-38	-	21.26-57.96	-	6.29-11.79	5.24-4.71	-
	13th-20th/02/2016	90-144	-	58-78	-	25.40-44.98	-	6.29-8.12	4.72-6.55	-
Prasittharam Temple (A3)	9th-16th/09/2015	30-42	-	17-28	-	10.35-24.84	-	4.98-5.50	4.72-4.98	-
	13th-20th/02/2016	73-128	-	42-88	-	24.28-34.44	-	4.98-6.55	3.93-5.24	-
Ban Map Toei School (A4)	9th-16th/09/2015	33-57	-	20-29	-	25.40-41.40	-	4.98-7.08	4.45-4.98	-
	13th-20th/02/2016	71-138	-	42-88	-	24.28-34.44	-	4.98-6.55	3.93-5.24	-
Western Community of the Project Site at Village no. 5, Map Yang Phon sub-district (A5)	9th-16th/09/2015	29-50	-	15-29	-	19.76-38.58	-	6.81-10.74	4.98-5.50	-
	13th-20th/02/2016	62-110	-	37-65	-	19.38-48.36	-	5.24-7.86	4.72-5.50	-
National Standard 1/		330	100	120	50	320	57	780	300	100
WHO Standard 2/		-	-	50	-	200	-	-	20	-

Remark : * The highest values registered by Pluak Daeng District Public Health Office's AQMS in 2015. In case of unusually high values, the second highest applicable values are to be used instead.

Source: 1/ Ambient air quality standard of Thailand

- Ambient air quality standard in accordance with the notification of National Environmental Committee Vol. 10 B.E.2538 (1995) and Vol. 24 B.E.2547 (2004)
- Ambient nitrogen dioxides in accordance with the notification of National Environmental Committee Vol. 33 B.E.2552 (2009)

3/ WHO Ambient Air Quality Guidelines in Environmental, Health, and Safety (EHS) Guidelines for International Finance Corporation (2007)

- The noise measurement have been done follows Notification of the National Environment Board, No.29, B.E.2550 (2007) re: Measurement methods of annoyance noise level, 24 hour A-weighted equivalent continuous sound level (Leq 24 hr), and Maximum sound level (Lmax) generated from plant operation are specified by the Department of Industrial Works. The regulation specified that "Sound level meter" means a sound level meter conforming with IEC 60804 or IEC 61672 standard of International Electrotechnical Commission (IEC). Both Type 1 and 2 sound level meter can be used for monitoring depending on monitoring's company, however; these monitoring were done in accordance with Thailand National Standard. According to the regulation of Department of Industrial Work of private laboratory registration in 2007, such laboratory must has certified document of calibration equipment. Calibration certificates of Air quality sampling and noise sampling used for this project are as shown in **Appendix 4C.**

(3) Study results

(a) Collection of Secondary Data

According to data on noise levels collected from the environmental impact prevention and mitigation measure and environmental impact monitoring measure reports of Siam Eastern Industrial Park (Expansion) (2015), Amata City Industrial Estate (Expansion) Phase 5, (No. 1) (2015), Eastern Seaboard Industrial Estate (2014), and GK. Land Industrial Park (Siam Green City) (2015), noise levels were measured at 6 stations around the study area. The 6 stations comprised the southern fence of the Siam Eastern Industrial Park (N1); Map Yang Phon Sub-district Health Promoting Hospital (N2); the western fence of the Siam Eastern Industrial Park (N3); the southern fence of the Eastern Seaboard Industrial Estate (Rayong) (N4); Ban Wang Ta Phin (N5); and communities in GK. Land Industrial Park (N6) **(Figure 4.1.5-1)**. The measurement results during 2013-2015 were not greater than the ambient noise standards in the Notification of the National Environment Board No. 15, B.E. 2540 (1997) which requires the 24-hr Leq shall not exceed 70 dB(A) as presented in **Table 4.1.6-1** and can be summarized below.

- **Southern Fence of the Siam Eastern Industrial Park (N1)**

According to the measurement results during 2013-2015, the 24-hr Leq was in a range of 46.9-62.4 dB(A) or 67.0-89.1% of the established standard (70 dB(A)). The L_{90} ranged from 41.0 to 68.5 dB(A) whereas L_{dn} ranged between 53.2 and 70.5 dB(A). L_{max} was in a range of 50.7-86.1 dB(A) or 44.1-74.9% of the established standard (115 dB(A)).

- **Map Yang Phon Sub-district Health Promoting Hospital (N2)**

The noise level measurement results during 2013-2015 revealed that the 24-hr Leq was in a range of 50.1-61.5 dB(A), representing 71.6-87.9% of the established standard (70 dB(A)). The L_{90} ranged from 38.5 to 61.1 dB(A) whereas L_{dn} ranged between 54.0 and 66.6 dB(A).

TABLE 4.1.6-1
NOISE LEVEL MEASUREMENT RESULTS IN THE STUDY AREA DURING 2013-2015

Station	Date	Noise Level (dB(A))			
		24-hr Leq	L_{90}	L_{dn}	L_{max}
Southern Fence of the Siam Eastern Industrial Park (N1)2/	26th-29th May 2013	46.9-48.3	41.0-48.9	53.2-55.8	50.7-86.0
	12th-15th Oct 2013	52.8-53.2	44.0-60.6	58.0-59.6	54.1-86.1
	16th-19th Jun 2014	54.1-62.4	40.2-68.5	60.0-70.5	55.1-79.0
	20th-23rd Dec 2014	52.9-57.2	43.6-59.4	58.4-59.3	54.5-84.1
	27th-30th Jun 2015	50.3-51.3	41.3-55.7	55.4-58.1	54.4-82.8
Map Yang Phon Sub-district Health Promoting Hospital (N2)3/	28th Jun-1st Jul 2013	50.1-51.6	38.5-53.3	54.0-56.2	-
	12th-15th Oct 2013	52.5-53.0	45.1-52.6	57.7-58.9	-
	24th-26th Jul 2014	60.3-61.3	38.6-58.8	64.7-65.4	-
	20th-23rd Dec 2014	61.1-61.5	44.2-60.4	65.5-66.0	-
	27th-30th Jun 2015	60.1-60.8	51.1-61.1	64.6-66.6	-
Western Fence of the Siam Eastern Industrial Park (N3)2/	26th-29th May 2013	60.7-61.2	57.4-61.1	66.0-67.3	65.1-96.3
	12th-15th Oct 2013	53.7-58.7	52.3-65.5	60.0-64.3	57.2-94.1
	16th-19th Jun 2014	60.3-61.5	54.6-61.4	65.0-66.6	64.9-85.1
	20th-23rd Dec 2014	62.7-63.1	58.7-64.4	68.6-69.1	63.3-85.1
	27th-30th Jun 2015	60.7-63.2	57.1-63.1	66.5-69.1	69.4-94.4
Southern Fence of the Eastern Seaboard Industrial Estate (Rayong) (N4)4/	21th-24th Mar 2013	59.6-61.8	41.9-56.6	-	80.8-91.7
	13th-16th Jun 2013	49.6-55.4	32.1-51.6	-	85.9-87.6
	26th-29th Sep 2013	52.9-53.3	44.1-59.3	-	75.9-86.5
	21th-24th Nov 2013	62.4-66.0	46.0-63.8	-	88.7-96.1
	11th-14th Mar 2014	54.8-56.0	38.0-49.9	-	88.8-96.6
	9th-12th Jun 2014	56.0-56.2	46.3-54.7	-	81.3-83.5
	8th-11th Sep 2014	55.6-57.0	44.9-51.9	-	90.4-98.1
	8th-11th Dec 2014	59.0-61.7	44.9-50.7	-	92.6-97.2
Ban Wang Ta Phin (N5)5/	15th-18th Dec 2013	57.0-66.9	-	-	87.1-93.9
	17th-20th Nov 2014	65.7-66.1	-	-	93.3-96.7
	24th-27th Sep 2015	60.6-60.9	-	-	86.0-96.2
Communities in GK. Land Industrial Park (N6)5/	15th-18th Dec 2013	58.2-62.5	-	-	86.2-96.8
	17th-20th Nov 2014	54.5-55.7	-	-	86.4-89.4
	24th-27th Sep 2015	53.8-54.7	-	-	84.2-86.4
Standard Values1/		**70**	**-**	**-**	**115**

Reamrk: 1/ Referring to Notification of the National Environment Board No. 15, B.E. 2540 (1997) Regarding Determination of Ambient Noise Standards

Sources: 2/ Environmental impact prevention and mitigation measure and environmental impact monitoring measure report of the Siam Eastern Industrial Park (Expansion) (2015)

3/ Environmental impact prevention and mitigation measure and environmental impact monitoring measure report of the Amata City Industrial Estate (Expansion) Phase 5, (No. 1) (2015)

4/ Environmental impact prevention and mitigation measure and environmental impact monitoring measure report of the Eastern Seaboard Industrial Estate (Rayong) (2014)

5/ Environmental impact prevention and mitigation measure and environmental impact monitoring measure report of GK. Land Industrial Park (Siam Green City) (2015)

- **Western Fence of the Siam Eastern Industrial Park (N3)**

The noise level measurement results during 2013-2015 revealed that the 24-hr Leq was in a range of 53.7-63.2 dB(A), equaling 76.7-90.3% of the established standard (70 dB(A)). The L_{90} ranged from 52.3 to 65.5 dB(A) whereas L_{dn} ranged between 60.0 and 69.1 dB(A). The L_{max} was in a range of 57.2-96.3 dB(A) or 49.7-83.7% of the established standard (115 dB(A)).

- **Southern Fence of the Eastern Seaboard Industrial Estate (Rayong) (N4)**

The noise level measurement results during 2013-2014 revealed that the 24-hr Leq was in a range of 49.6-66.0 dB(A), or 70.9-94.3% of the established standard (70 dB(A)). The L_{90} ranged between 32.1 and 63.8 dB(A). The L_{max} was in a range of 75.9-98.1 dB(A) or 66.0-85.3% of the established standard (115 dB(A)).

- **Ban Wang Ta Phin (N5)**

The noise level measurement results during 2013-2015 revealed that the 24-hr Leq was in a range of 57.0-66.9 dB(A), or 81.4-95.6% of the established standard (70 dB(A)). The L_{max} was in a range of 86.0-96.7 dB(A) or 74.8-84.1% of the established standard (115 dB(A)).

- **Communities in GK. Land Industrial Park (N6)**

The noise level measurement results during 2013-2015 revealed that the 24-hr Leq was in a range of 53.8-62.5 dB(A), or 76.9-89.3% of the established standard (70 dB(A)). The L_{max} was in a range of 84.2-96.8 dB(A) or 73.2-84.2% of the established standard (115 dB(A)).

(b) Field Survey

The Consultant conducted noise measurement, including 24-hr Leq, 5-min Leq, L_{dn}, L_{max}, and L_{90}, around the study area at 4 stations: (1) Pluak Daeng Power Plant; (2) western community of the project site, Village no. 2, Map Yang Phon sub-district; (3) southern community of the project site, Village no. 5, Map Yang Phon sub-district; and (4) northeastern community of the project site, Village no. 2, Map Yang Phon sub-district as illustrated in **Figure 4.1.6-1** and **Photo 4.1.6-1**. Noise level measurement was conducted at each station for 5 consecutive days covering weekdays and weekend during 13-18 February 2016. The noise measurement results are presented in **Table 4.1.6-2** and **Appendix 4E** and can be summarized below.

- **Pluak Daeng Power Plant (N1)**

The 24-hr Leq is in a range of 45.8-51.0 dB(A), or 65.4-72.9% of the established standard (70 dB(A)). The L_{max} ranges from 70.3 to 85.3 dB(A) or 61.1-74.2% of the established standard (115 dB(A)). The L_{dn} is in a range of 49.8-55.6 dB(A) and the L_{90} ranges from 41.6 to 46.3 dB(A) as presented in **Figure 4.1.6-2**.

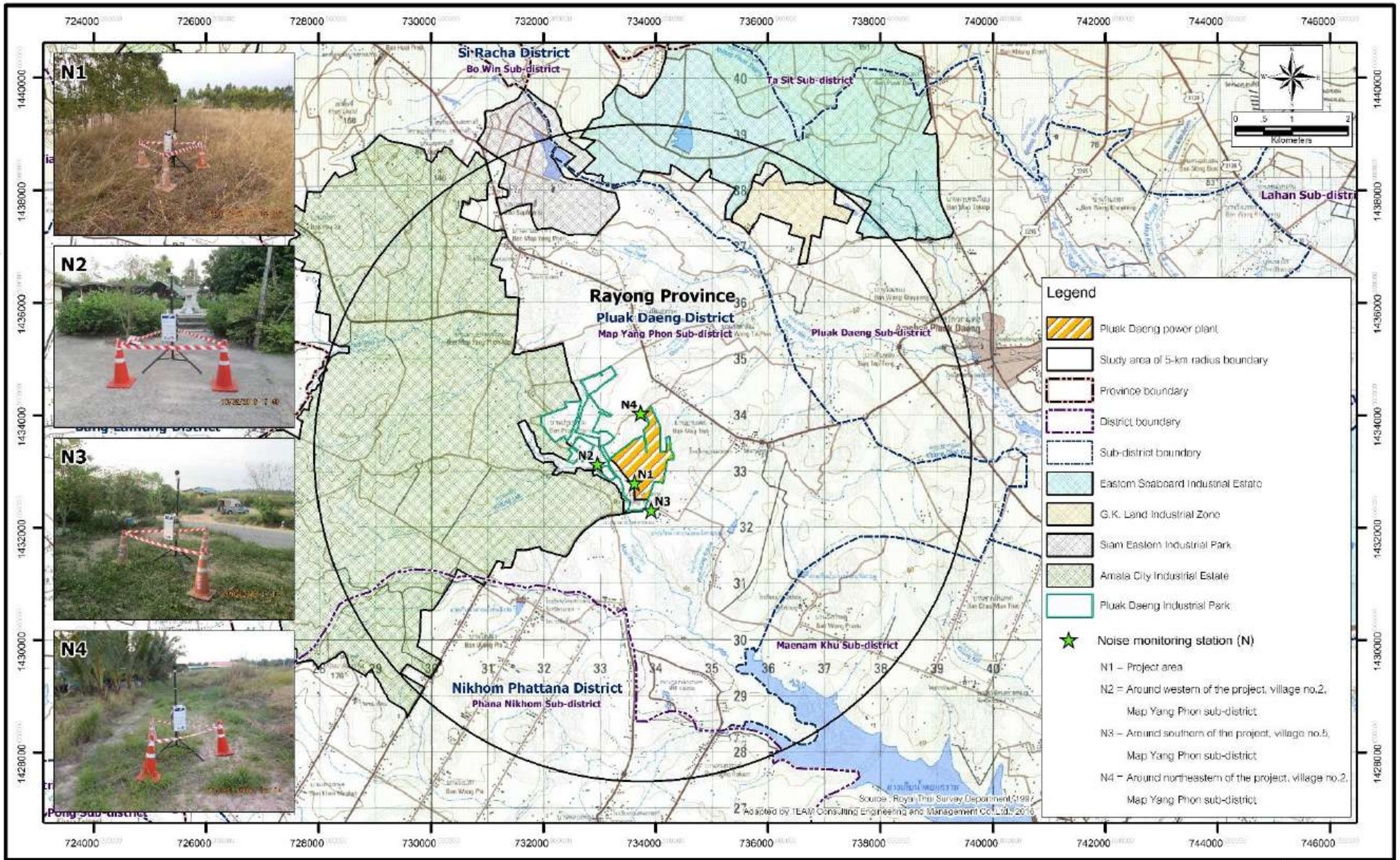


FIGURE 4.1.6-1 : MAP OF NOISE MONITORING STATIONS OF THE PROJECT

Station 1 : Pluak Daeng Power Plant (N1) Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province

Station 2 : Western Community of the Project Site (N2) Village no. 2, Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province

Station 3 : Southern Community of the Project Site (N3) Village no. 5, Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province

Station 4 : Northeastern Community of the Project Site (N4) Village no. 2, Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province

PHOTO 4.1.6-1 : NOISE MONITORING STATIONS OF THE PROJECT

TABLE 4.1.6-2
NOISE LEVEL MEASUREMENT RESULTS DURING 13th-18 th FEBRUARY 2016

Station	Date	24-hr Leq dB(A)	L_{max} dB(A)	L_{dn} dB(A)	L_{90} dB(A)
1. Project Area (N1) Coordinate: 47P 0733620E, 1432795N	13th-14th/02/2016	51.0	85.3	55.6	46.3
	14th-15th/02/2016	45.8	74.5	49.8	41.6
	15th-16th/02/2016	48.4	79.7	52.2	45.1
	16th-17th/02/2016	46.0	74.4	51.8	41.6
	17th-18th/02/2016	47.1	70.3	51.5	41.7
	Min-Max	**45.8-51.0**	**70.3-85.3**	**49.8-55.6**	**41.6-46.3**
2. Western Community of the Project Site, Village no. 2, Map Yang Phon Sub-district (N2) Coordinate: 47P 0732960E, 1433129N	13th-14th/02/2016	63.0	97.0	67.8	42.2
	14th-15th/02/2016	65.0	95.9	68.9	40.4
	15th-16th/02/2016	63.9	94.9	68.4	49.4
	16th-17th/02/2016	65.8	93.6	73.8	43.6
	17th-18th/02/2016	66.3	94.1	73.4	43.4
	Min-Max	**63.0-66.3**	**93.6-97.0**	**67.8-73.8**	**40.4-49.4**
3. Southern Community of the Project Site, Village no. 5, Map Yang Phon Sub-district (N3) Coordinate: 47P 0733920E, 1432313N	13th-14th/02/2016	64.4	96.6	67.0	45.7
	14th-15th/02/2016	65.6	93.6	68.7	48.4
	15th-16th/02/2016	66.1	100.0	69.3	49.6
	16th-17th/02/2016	65.6	92.9	68.4	47.7
	17th-18th/02/2016	65.9	93.6	69.2	47.6
	Min-Max	**64.4-66.1**	**92.9-100.0**	**67.0-69.3**	**45.7-49.6**
4. Northeastern Community of the Project Site, Village no. 2, Map Yang Phon Sub-district (N4) Coordinate: 47P 0733728E, 1434034N	13th-14th/02/2016	51.2	87.8	53.6	41.2
	14th-15th/02/2016	51.2	84.4	55.0	40.8
	15th-16th/02/2016	53.4	91.2	56.8	47.3
	16th-17th/02/2016	59.4	87.8	68.2	42.5
	17th-18th/02/2016	55.7	85.2	64.0	40.8
	Min-Max	**51.2-59.4**	**84.4-91.2**	**53.6-68.2**	**40.8-47.3**
Standard Values[1/]		**70.0**	**115.0**	**-**	**-**

Reamrk: [1/] Notification of the National Environment Board No. 15, B.E.2540 (1997) Regarding Determination of Ambient Noise Standards

Source: Field Survey by TEAM Consulting Engineering and Management Ltd., February 2016

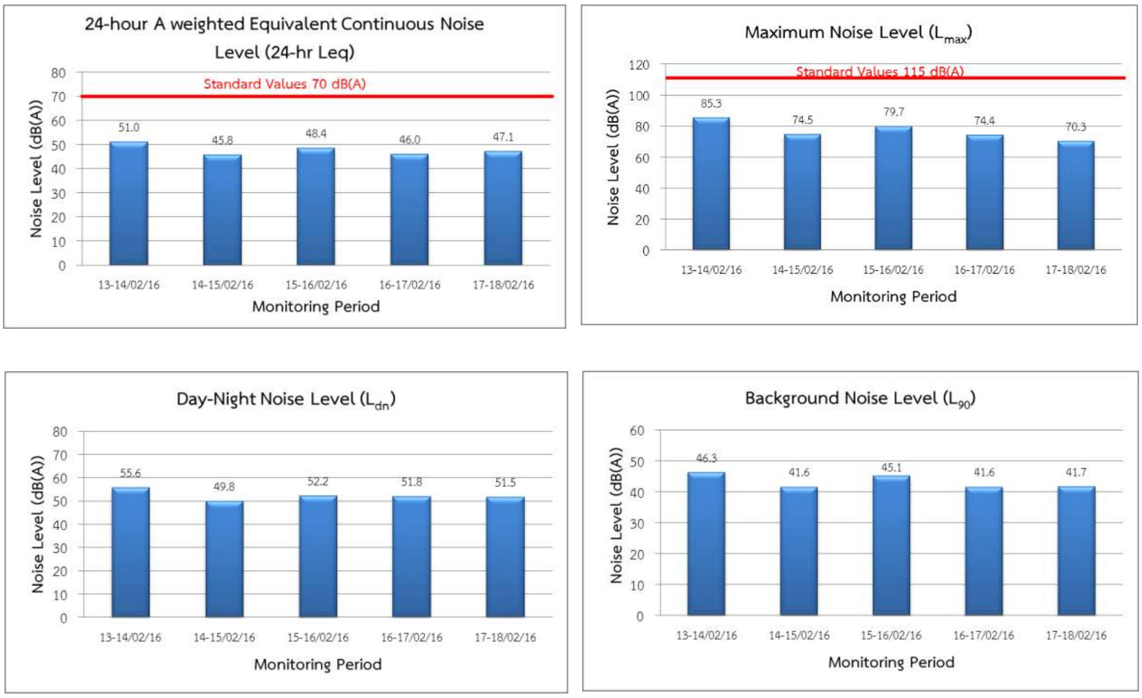


FIGURE 4.1.6-2: NOISE LEVEL MEASUREMENT RESULTS (DURING 13th-18th FEBRUARY 2016) PLUAK DAENG POWER PLANT (N1)

- **Western Community of the Project Site, Village no. 2, Map Yang Phon Sub-district (N2)**

The 24-hr Leq is in a range of 63.0-66.3 dB(A), or 90.0-94.7% of the established standard (70 dB(A)). The L_{max} ranges from 93.6 to 97.0 dB(A) or 81.4-84.3% of the established standard (115 dB(A)). The L_{dn} is in a range of 67.8-73.8 dB(A) and the L_{90} ranges from 40.4 to 49.4 dB(A) as presented in **Figure 4.1.6-3**.

- **Southern Community of the Project Site, Village no. 5, Map Yang Phon Sub-district (N3)**

The 24-hr Leq is in a range of 64.4-66.1 dB(A), or 92.0-94.4% of the established standard (70 dB(A)). The L_{max} ranges from 92.9-to 100.0 dB(A) or 80.8-87.0% of the established standard (115 dB(A)). The L_{dn} is in a range of 67.0-69.3 dB(A) and the L_{90} ranges from 45.7 to 49.6 dB(A) as presented in **Figure 4.1.6-4**.

- **Northeastern Community of the Project Site, Village no. 2, Map Yang Phon Sub-district (N4)**

The 24-hr Leq is in a range of 51.2-59.4 dB(A), or 73.1-84.9% of the established standard (70 dB(A)). The L_{max} ranges from 84.4 to 91.2 dB(A) or 73.4-79.3% of the established standard (115 dB(A)). The L_{dn} is in a range of 53.6-68.2 dB(A) and the L_{90} ranges from 40.8 to 47.3 dB(A) as presented in **Figure 4.1.6-5.**

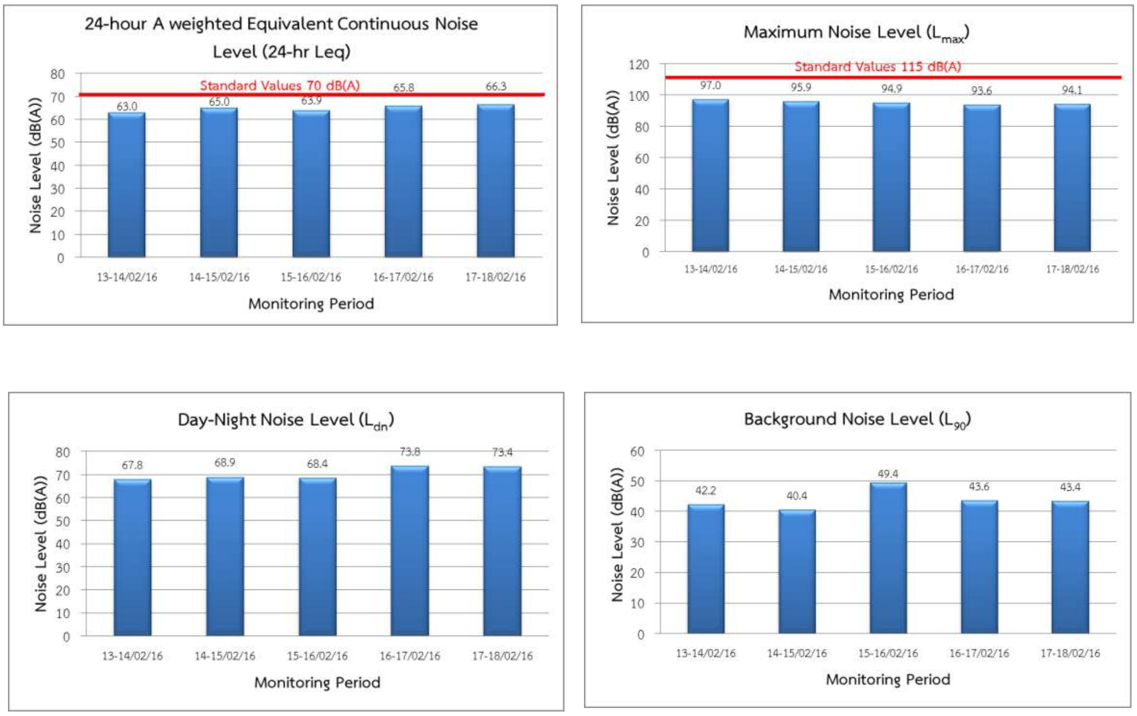


FIGURE 4.1.6-3: NOISE LEVEL MEASUREMENT RESULTS

(DURING 13th-18th FEBRUARY 2016)

WESTERN COMMUNITY OF THE PROJECT SITE, VILLAGE NO. 2 (N2)

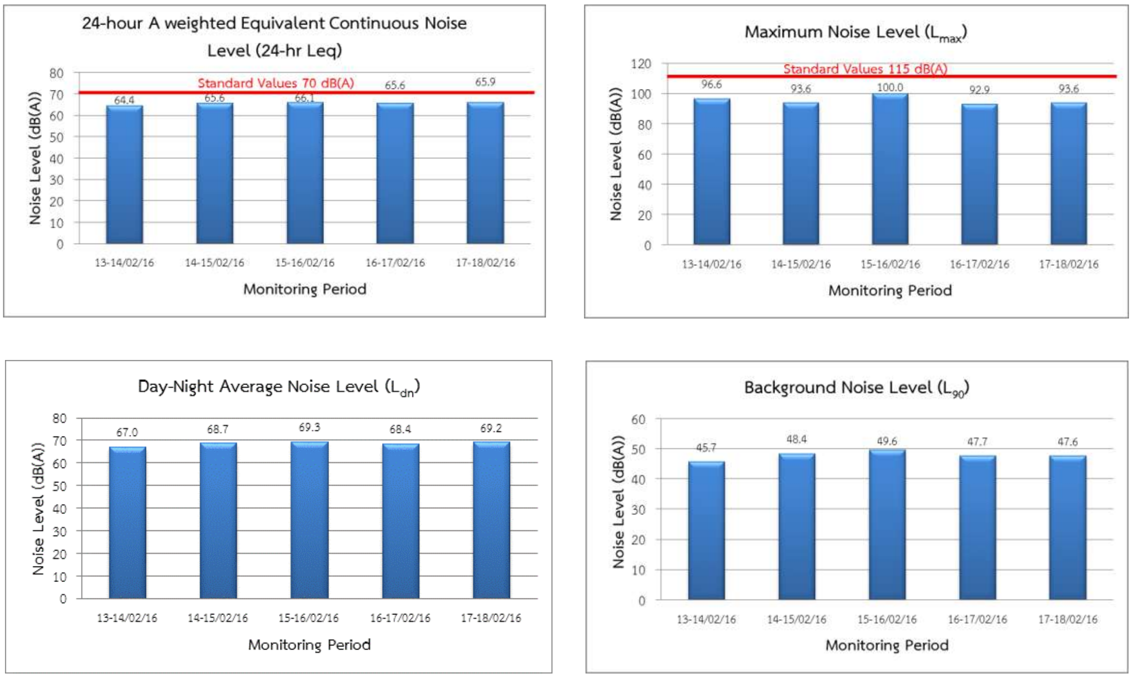


FIGURE 4.1.6-4: NOISE LEVEL MEASUREMENT RESULTS

(DURING 13th-18th FEBRUARY 2016)

SOUTHERN COMMUNITY OF THE PROJECT SITE, VILLAGE NO. 5 (N3)

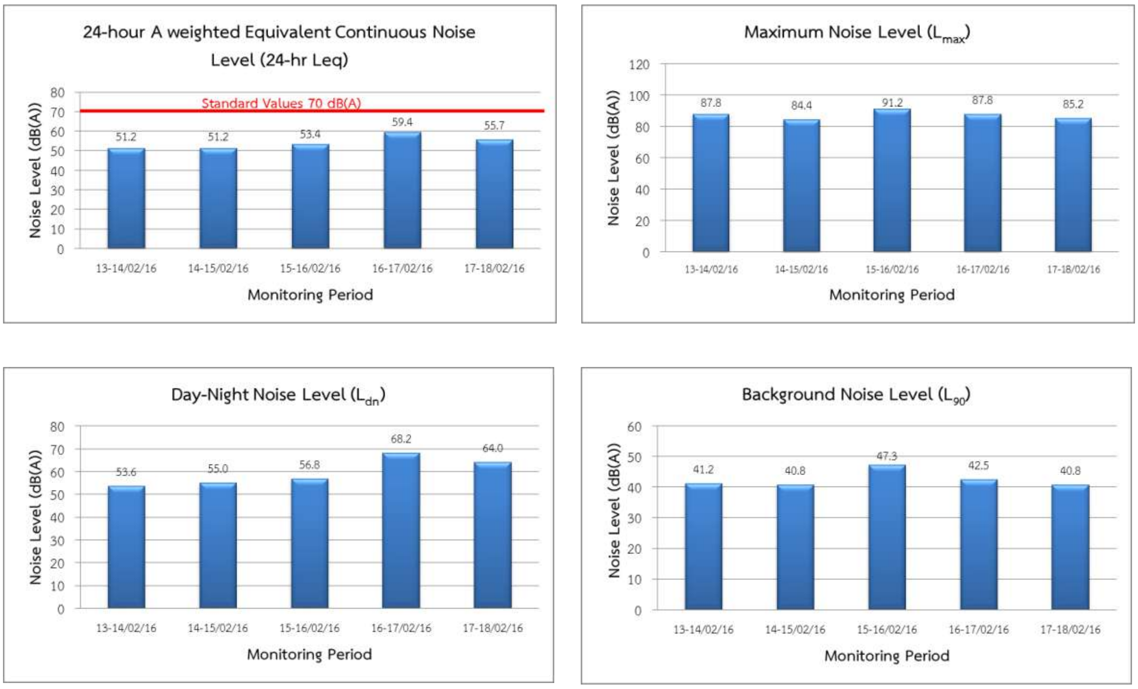


FIGURE 4.1.6-5: NOISE LEVEL MEASUREMENT RESULTS
(DURING 13th-18th FEBRUARY 2016)
NORTHEASTERN COMMUNITY OF THE PROJECT SITE, VILLAGE NO. 2 (N4)

According to the noise measurement results, noise levels at some stations exceed the established standards, especially in the western community of the project site. The Consultant conducted inspection of the environmental conditions at this station **(Photo 4.1.6-2)** and found that in the morning, the midday and the afternoon, motorcycles regularly passed the noise measurement tool installation. Besides, there were many dogs making loud noises at night. These might affect the noise level (L_{90}) in this area.

PHOTO 4.1.6-2 : ENVIRONMENTAL CONDITIONS AROUND THE WESTERN COMMUNITY OF THE PROJECT SITE

(c) Comparison of Noise Level Results and International Standard

Existing noise level measurement result during 13th-18th February 2016 compared with the National standard. (WHO standard and IFC standard) is as shown in **Table 4.1.6-3**. All of 24-hour average noise level (Leq 24 hr) were lower than the National standard. Comparing with the Guidelines for Community Noise of WHO (1999), the existing noise level was higher than that indicated in the guideline. The project will ensure that incremental values do not exceed 3dB as per the IFC guidelines.

TABLE 4.1.6-3

RESULT OF NOISE LEVEL MEASURMENT DURING 13th-18th FEBRUARY 2016

Station		Date	Leq 24 hr	Laeq 1 hr	
				Daytime (07.00-22.00)	Nighttime (22.00-07.00)
Project Area (N1)		13th-18th/02/2016	45.8-51.0	36.8-58.6	35.6-51.8
Western Community of the Project Site, Village no. 2, Map Yang Phon Sub-district (N2)		13th-18th/02/2016	63.0-66.3	54.4-69.9	47.8-70.7
Southern Community of the Project Site, Village no. 5, Map Yang Phon Sub-district (N3)		13th-18th/02/2016	64.4-66.1	60.5-70.7	51.3-68.4
Northeastern Community of the Project Site, Village no. 2, Map Yang Phon Sub-district (N4)		13th-18th/02/2016	51.2-59.4	47.3-62	35.9-66.2
National Standard			70 1/	-	-
Noise Level Guideline 2/	**Residential; institutional; education**		**-**	**55**	**45**
	Industrial; commercial		**-**	**70**	**70**

Source: 1/ Standard as prescribed in the National Environment Board's Notification No. 15 re: Prescribing Noise Level Standard, B.E. 2540.

2/ Guidelines for Community Noise, World Health Organization (WHO), 1999.

4.1.7 Surface Water Hydrology

(1) Introduction

The study results of surface water hydrology in the study area were used as the fundamental data for assessment of environmental impacts, and for determination of environmental impact prevention and mitigation measures, including environmental impact monitoring measures.

(2) Methodology

- Water use data were gathered from relevant documents or reports, such as executive summary and 3-year development plan of the Department of Local Administration, 1:50,000-scale topographic maps of the Royal Thai Survey Department, Sheets Nos. 5234I, 5237IV, 5235II and 5235III (L7018), year 2005, satellite images from Google Earth, etc.
- Field survey was carried out in the project area to study the existing conditions of surface water resources and water uses in order to estimate the probable impacts from the project development.

(3) Study Results

Rayong province is located in the eastern coast basin, which consists of 5 sub-basins: Khlong Yai, Eastern Rayong, Western Rayong, Prasae, and Phang Rat, covering a total basin area of 3,854.70 km^2 (in Rayong province only). The average annual runoff is 1,220.49 million m^3. The province is generally characterized by coastal plains around Rayong basin. Slopes are found alternating with hills and mountains. Two major water bodies are Rayong and Prasae rivers. There are also other canals as follows.

- **Rayong River or Khlong Yai**

Approximately 50 km long, the river begins in Kong Song and Phanomsat mountains, flowing to small canals, converging at Khlong Yai, and then draining into the sea at Pak Nam sub-district, Mueang Rayong district, Rayong province.

- **Prasae River**

The river is approximately 120 km long, originating from mountains: Khao Yai, Khao Ang Rue Nai, Khao Hin Rong, and Khao Ang Kraden. It passes different brooks and canals, e.g. Khlong Prasae, Khlong Pling, Khlong Bo Thong, Huai Hin Khom, Khlong Jawet, Khlong Ta Kluai, Khlong Chum Saeng, Khlong Phai Nuea-Tai, Khlong Tawat, Khlong Phang Whai, Khlong Chamka, Khlong Chai, Khlong Waen, Khlong Phlo, Khlong Tha Si Kaeo, and Khlong Nong Phlong, and then converging to form Prasae river which flows into the sea at Ban Pak Nam, Pak Nam Prasae sub-district, Klaeng district, Rayong province.

- **Khlong Dok Krai**

The 45-km long canal begins in Chak Kluai mountain in Bang Lamung district, Chon Buri province and flows into Khlong Nong Pla Lai before joining Khlong Yai.

- **Khlong Nong Pla Lai**

The 42-km long canal originates from Nam Jon, Chomphu, and Ruea Tok mountains in Chon Buri province, passing several brooks and canals (e.g. Khlong Rawoeng, Khlong Kram, and Khlong Pluak Daeng in Rayong province), converging to form Khlong Nong Pla Lai, and then flowing into Khlong Yai in Ban Hua Thung, Nong Bua sub-district, Ban Khai district, Rayong province.

- **Khlong Phlo**

The canal is about 38 km in length and originates from Chamun, Cha-em, and Plai mountains, flowing into Prasae river at Ban Tha Krachai, Klaeng district, Rayong province.

- **Khlong Thap Ma**

The canal is about 12 km in length and originates from Chom Hae, Ket, and Krabok mountains, passing Khlong Chak Yai, Khlong Nong La, and Khlong Chang Tai, converging at Khlong Thap Ma, and flowing into Rayong river at Ban Ko Kloi, Mueang district, Rayong province.

- **Khlong Ra-ok**

The 10-km long canal begins in Cha Mao mountain, passing Khlong Khao Chut, Klhong Sathon, and Khlong Nam Pen to converge at Khlong Ra-ok, and flowing into Khlong Phlo at Ban Noen Suk Samran, Klaeng district, Rayong province.

The important surface water body which is closest to the project site is Huai Phu Sai **(Figure 4.1.7-1)**. It originates from brooks and small canals, e.g. Huai Hang Kaeo, Huai Kra Baek Ang, Huai Lan, Huai Khai Nao, and Huai Map Wai Som in Bang Lamung district, Chon Buri province, joining Huai Phu Sai at Khao Mai Kaeo sub-district. Huai Phu Sai traverses Amata City Industrial Estate and the western side of the project area. It joins Khlong Lek and Huai Wang Krarok before flowing into Dok Krai reservoir. Huai Phu Sai is about 5-13 m in width and 1-3 m in depth. In the wet season, water is abundant in this water body. Grasses are found in some parts along both sides of Huai Phu Sai. Water is mainly used for agricultural purpose. About 26 million m^3 of water volume in the watershed of Huai Phu Sai flows into Dok Krai reservoir each year.

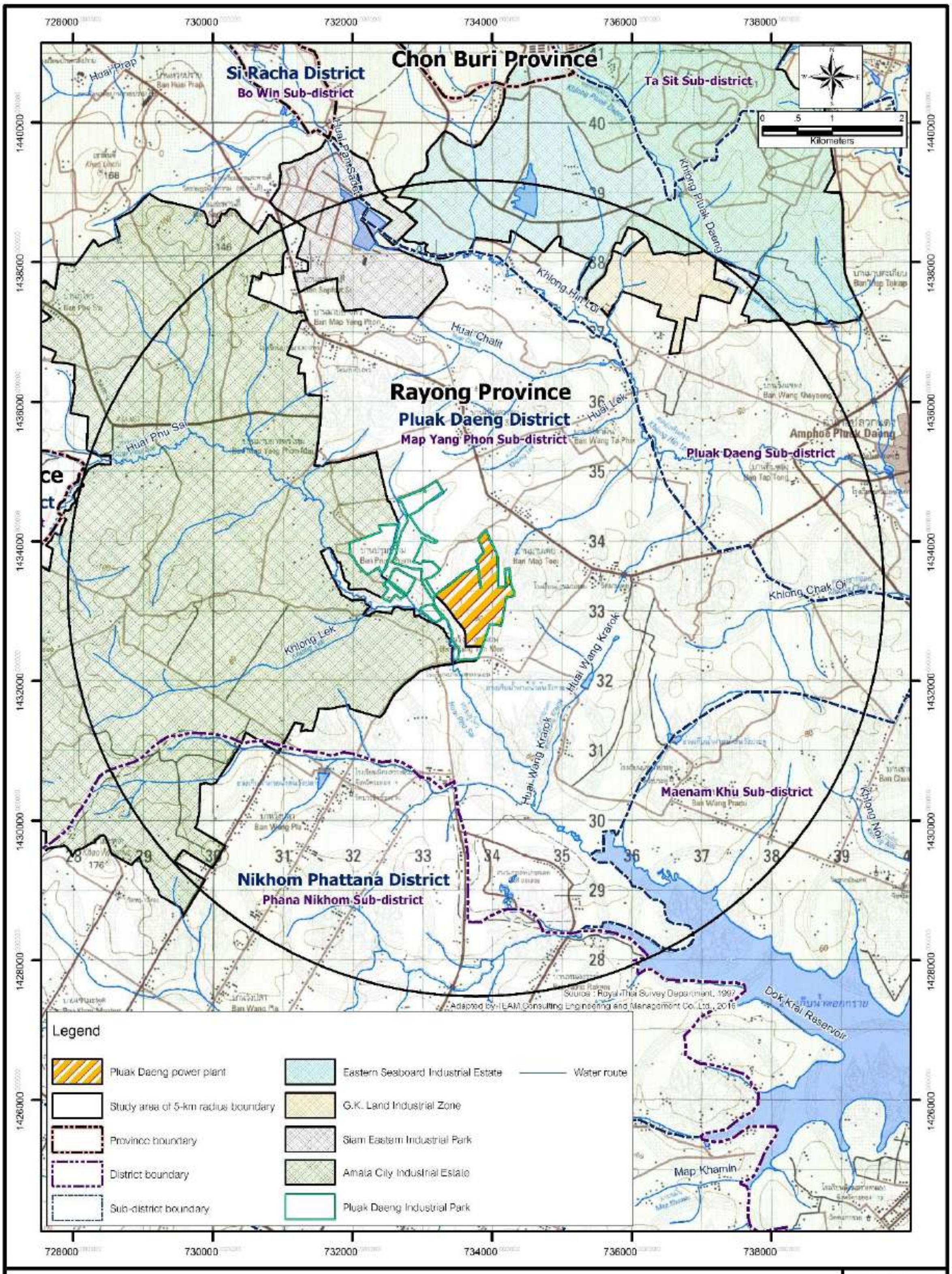


FIGURE 4.1.7-1 : SURFACE WATER RESOURCES AROUND THE PROJECT

TEAM

10P2809/Damrongsak.B/26-07-60/P2809-015 (English).mxd

4.1.8 Surface Water Quality

(1) Introduction

The construction and operation activities of the power plant will generate effluent which will probably cause direct impacts on surface water quality in the project area and its vicinity. As a consequence, study of the existing quality of water bodies near the project area in physical, chemical and biological aspects was crucial. The study results were considered to assess the probable impacts on water quality and to seek the solutions to the project impacts on surface water quality.

(2) Methodology

(a) Collection of Secondary Data

Secondary data on surface water quality in the project area and its vicinity were collected from the Cooling Water (BOD and TDS) Impact Assessment Report of the Power Plants in Pluak Daeng Industrial Park Project (December 2015).

(b) Field Survey

Surface water samples were gathered from the project area and its vicinity during the wet season and the dry season. The samples represent surface water that would be directly affected by the project development.

Surface water quality measurement was conducted in Huai Phu Sai which is the surface water body closest to the project area. There are 4 stations: about 1 km upstream of the discharge point No. 1 of Pluak Daeng Industrial Park (SW1); discharge point No. 1 of Pluak Daeng Industrial Park (SW2); discharge point No. 2 of Pluak Daeng Industrial Park (SW3); and about 500 m downstream of discharge point No. 2 of Pluak Daeng Industrial Park (SW4) **(Figure 4.1.8-1)**. Water sampling activities are presented in **Photo 4.1.8-1**.

Water sampling was conducted in the wet season (during 17^{th}-18^{th} September 2015) and in the dry season (on 17^{th} March 2016).

(c) Parameters, Sampling Method, and Analysis Method

18 parameters were considered for surface water analysis. The Standard Method for the Examination of Water and Wastewater, 22^{nd} Edition, 2012 was applied as presented in **Table 4.1.8-1**.

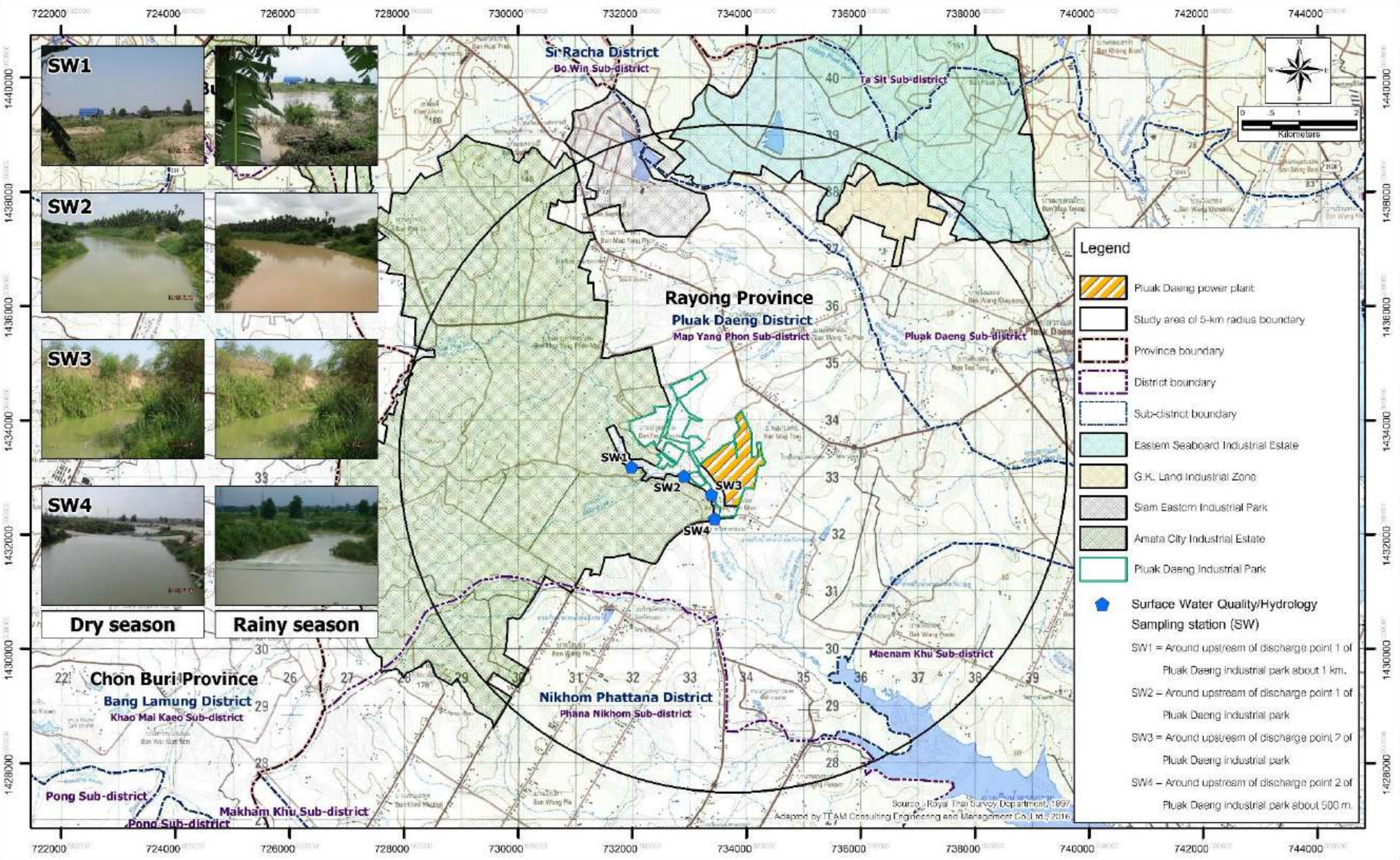


FIGURE 4.1.8-1 : SURFACE WATER QUALITY/HYDROLOGY SAMPLING STATIONS OF THE PROJECT


Station SW1: About 1 Km Upstream of the Discharge Point No. 1
of Pluak Daeng Industrial Park


Station SW2: Discharge Point No. 1 of Pluak Daeng Industrial Park


Station SW3: Discharge Point No. 2 of Pluak Daeng Industrial Park


Station SW4: About 500 M Downstream of Discharge Point No. 2 of Pluak Daeng Industrial Park

PHOTO 4.1.8-1 : SAMPLING ACTIVITIES FOR SURFACE WATER QUALITY/
HYDROLOGY ANALYSIS

TABLE 4.1.8-1
SURFACE WATER QUALITY PARAMETERS AND ANALYSIS METHODS

Properties	Surface Water Quality Parameters	Analysis Methods
1. Physical	1.1 Depth	Meter Stick
	1.2 Temperature	Thermometer on site
	1.3 Transparency	Secchi Disc
2. Chemical	2.1 Dissolved Oxygen	Dissolved Oxygen Meter
	2.2 BOD	5-day BOD Test
	2.3 pH	pH Meter
	2.4 Suspended Solids	Dried at 103-105^{o}C
	2.5 Nitrate-Nitrogen	Ultraviolet Spectrophotometric Screening
	2.6 Ammonia-Nitrogen	Titrimetric Method
	2.7 Total Kjeldahl Nitrogen	Macro-Kjeldahl Method
	2.8 Sodium	Inductively Coupled Plasma Method
	2.9 Calcium	Inductively Coupled Plasma Method
	2.10 Magnesium	Inductively Coupled Plasma Method
	2.11 Oil & Grease*	Soxhlet Exteaction
3. Biological	3.1 Total Coliform Bacteria	Multiple Tube Fermentation Technique
	3.2 Fecal Coliform Bacteria	Multiple Tube Fermentation Technique

Reamrk: * Surface water sampling

Composite sampling was employed in this study. However, 3 grab samplings were also used to prevent mistakes. Surface water analysis results at each station were compared with the established surface water quality standards in order to estimate the existing water quality and classify surface water quality by water usage according to the surface water quality standards stipulated in the Notification of the National Environment Board No. 8, B.E.2537 (1994) issued under the Enhancement and Conservation of National Environmental Quality Act, B.E.2535 (1992) regarding Establishment of Surface Water Quality Standards **(Table 4.1.8-2)**. Dissolved oxygen was compared with the established standards for DO level, water quality, and water usage **(Table 4.1.8-3)**.

The 5-day Biochemical Oxygen Demand (BOD_5) analysis results from the project were compared with the BOD_5 standards prepared by the Water Quality Management Division, Pollution Control Department **(Table 4.1.8-4)**.

TABLE 4.1.8-2
SURFACE WATER QUALITY STANDARDS

No.	Water Quality Index	Statistical Values	Unit	Water Quality Classification by Usage[1/, 2/]				
				Class 1	Class 2	Class 3	Class 4	Class 5
1.	Color, Odor and Taste		-	n	n	n	n	-
2.	Water Temperature		Degree Celsius	n	n’	n’	n’	-
3.	pH		-	n	5.0-9.0	5.0-9.0	5.0-9.0	-
4.	DO	P20	mg/l	n	<6.0	<4.0	<2.0	-
5.	BOD_5	P80	mg/l	n	>1.5	>2.0	>4.0	-
6.	NO_3		mg/l	5.0				
7.	Total Coliform Bacteria	P80	MPN/100 ml	n	>5,000	>20,000	-	-
8.	Fecal Coliform Bacteria	P80	MPN/100 ml	n	>1,000	>4,000	-	-

Remark: 1/ According to the established surface water quality standards, there are 5 classes of surface water resources as follows.

Class 1: Water resources with natural state of water quality, without effluent from all types of activities, and are used for (1) utilization and consumption through general disinfection process; (2) natural reproduction of living organisms; (3) conservation of aquatic ecosystem

Class 2: Water resources that contain effluent from some types of activities and are used for (1) utilization and consumption through general disinfection process and general treatment process; (2) conservation of aquatic animals; (3) fishery; and (4) swimming and water sports

Class 3: Water resources that contain effluent from some types of activities and are used for (1) utilization and consumption through general disinfection process and general treatment process; and (2) agriculture

Class 4: Water resources that contain effluent from some types of activities and are used for (1) utilization and consumption through general disinfection process and special treatment process: and (2) industry

Class 5: Water resources that contain effluent from some types of activities and are used for transportation

n = Naturally

n’ = Water temperature shall not be over 3°C higher than environmental temperature.

2/ Quality standards were established for water resources classes 2-4 only. Class 1 shall be based on its natural conditions, and no standard value shall be set for Class 5.

- = Not specified

< = not lower than; > = not greater than

P20 = 20 percentile from the total water samples continually collected for testing

P80 = 80 percentile from the total water samples continually collected for testing

MPN = Most probable number

Source: Notification of the National Environment Board, No. 8 (B.E. 2537) (1994), issued under the Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992) regarding Establishment of Surface Water Quality Standards, published in the Royal Government Gazette, Vol. 111, Part 16 D dated February 24th, 1994

TABLE 4.1.8-3
DISSOLVED OXYGEN LEVEL, WATER QUALITY, AND USAGE

Level of DO (mg/L)	Water Quality	Usage
9-8	Good	Utilization-Consumption
8-6.7	Slight contamination	Utilization
6.7-4.5	Medium contamination	Agricultural and industrial usage
Lower than 4.5	Heavy contamination	Aquatic plants and animals start to be exposed to hazard and water usages are limited.
Lower than 4	Critical status	Aquatic plants and animals are exposed to hazard and water cannot be used.
Lower than 2	Critical status	Aquatic plants and animals cannot live and water cannot be used.

Source: Noppawan Theeraphancharoen, 2007

TABLE 4.1.8-4
BOD_5 (WATER QUALITY INDICATOR)

Water Quality	BOD_5 (mg/l)
Pure water	0
Very clean water	1
Clean water	2
Fairly clean water	3
Unclean water	5
Contaminated water	10

Source: Water Quality Management Division, Pollution Control Department

(3) Study Result

(a) Collection of Secondary Data

According to the Cooling Water (BOD and TDS) Impact Assessment Report of the Power Plants in Pluak Daeng Industrial Park Project (December 2015), water samples were gathered from Huai Phu Sai and Dok Krai reservoir at 5 stations on 3rd August 2015 as illustrated in **Figure 4.1.8-2**. The parameters which were considered comprised pH, DO, BOD, total dissolved solids, conductivity, copper, zinc, sodium, calcium, magnesium, free chlorine, ammonia, total Kjeldahl nitrogen, nitrate, and phosphate. The measurement results are presented in **Table 4.1.8-5** and details of the study results in **Appendix 4F-1**. Measurement results can be summarized as follows:

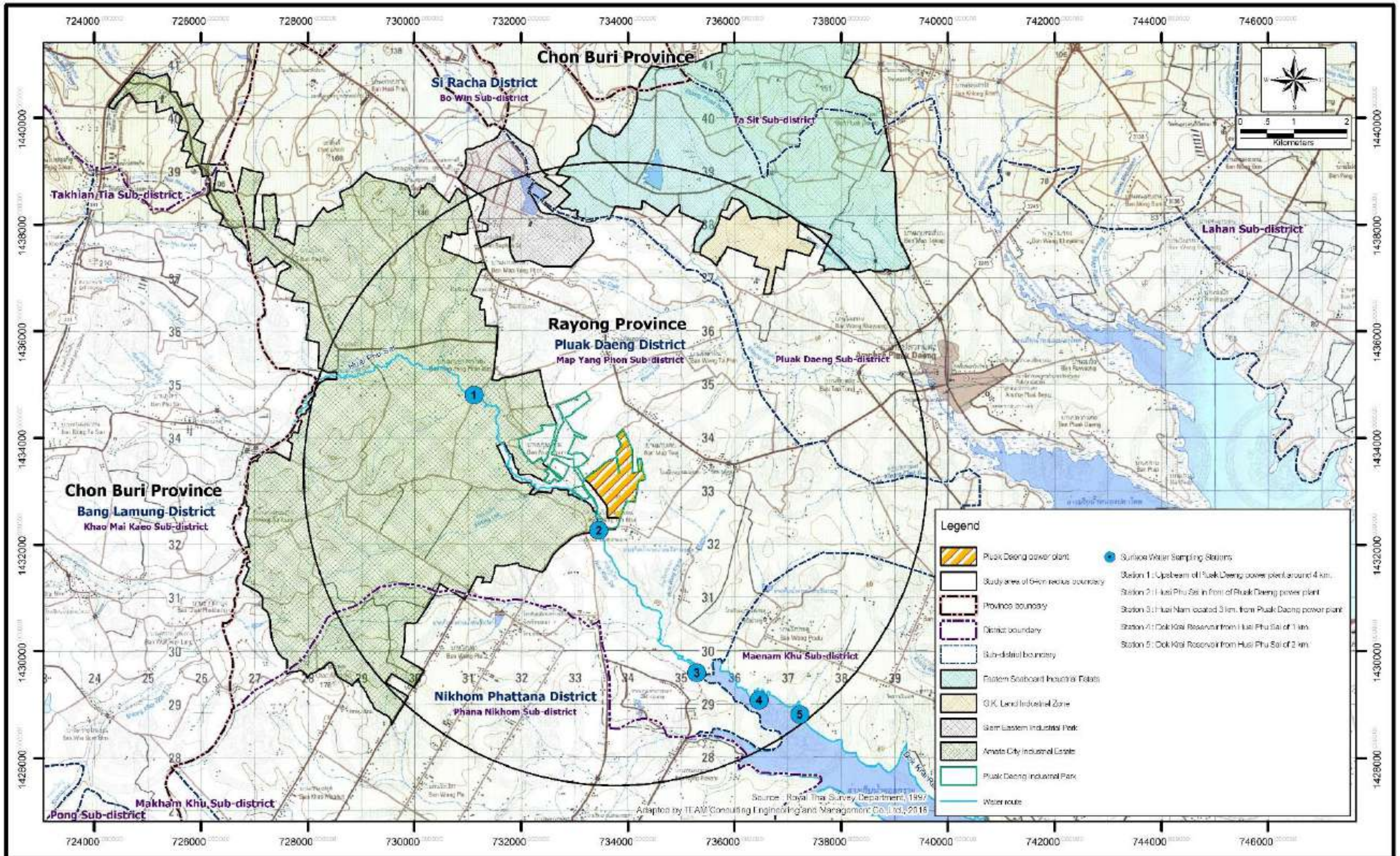


FIGURE 4.1.8-2 : LOCATIONS OF SURFACE WATER SAMPLING STATIONS IN HUAI PHU SAI AND DOK KRAI

TABLE 4.1.8-5

WATER QUALITY MEASUREMENT RESULTS IN HUAI PHU SAI AND DOK KRAI RESERVOIR OF THE COOLING WATER (BOD AND TDS) IMPACT ASSESSMENT REPORT OF THE POWER PLANTS IN PLUAK DAENG INDUSTRIAL PARK PROJECT

Properties	Parameters	Units	Monitoring Stations[2/]					Surface Water Quality Standards[1/]	
			Station 1	Station 2	Station 3	Station 4	Station 5	Class 3	Class 4
Physical	- Total Dissolved Solids	mg/l	114	236	202	202	194	-	-
	- Conductivity	1 µS/cm	132	280	298	301	293	-	-
Chemical	- pH	-	6.2	6.0	6.0	6.1	6.1	5-9	5-9
	- Dissolved Oxygen	mg/l	7.4	7.2	8.8	8.9	8.8	> 4	> 2
	- BOD_5	mg/l	1.7	2.2	3.0	3.1	3.3	< 2	< 4
	- Free Chlorine	mg/l	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	-	-
	- Total Kjeldahl Nitrogen (TKN)	mg/l	0.4	0.2	0.2	0.5	0.6	-	-
	- NH_3	mg/l	< 0.1	< 0.1	< 0.1	0.1	0.1	< 0.5	< 0.5
	- NO_3^-	mg/l	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 5	< 5
	- PO_4^{3-}	mg/l	0.09	1.01	< 0.03	< 0.03	< 0.03	-	-
	- Na	mg/l	3.54	12.90	15.64	14.06	13.90	-	-
	- Ca	mg/l	34.0	30.0	48.5	49.0	49.0	-	-
	- Mg	mg/l	2.27	1.72	2.48	2.26	2.32	-	-
	- Cu	mg/l	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.1	< 0.1
	- Zn	mg/l	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 1	< 1
Surface Water Quality Standards, Class			3	4	4	4	4		

Remark: Station 1: 4 km upstream of Pluak Daeng Power Plant
Station 2: Huai Phu Sai in front of Pluak Daeng Power Plant
Station 3: Huai Phu Sai–about 3 km downstream of Pluak Daeng Power Plant
Station 4: Dok Krai reservoir–about 1 km far from the mouth of Huai Phu Sai
Station 5: Dok Krai reservoir–about 2 km far from the mouth of Huai Phu Sai

Source: [1/] Notification of the National Environment Board, No. 8 (B.E. 2537) (1994), issued under the Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992) regarding Establishment of Surface Water Quality Standards, published in the Royal Government Gazette, Vol. 111, Part 16 D dated February 24th, 1994

[2/] The Cooling Water (BOD and TDS) Impact Assessment Report of the Power Plants in Pluak Daeng Industrial Park Project, (water samples gathered on 3rd August 2015)

Water quality analysis results were compared with the surface water (non-seawater) quality standards, Class 3: water resources used for agriculture and consumption which require general treatment process as stipulated in the Notification of the National Environment Board No. 8, B.E. 2537 (1994).

- pH values at all stations ranged between 6.0 and 6.2 which were not greater than the established standard of 5-9.
- DO levels at all stations were in a range of 7.2-8.9 mg/l which were not lower than the established standard of > 4 mg/l.
- BOD at Station 1 was less than 2 mg/l in compliance with the surface water quality standard, class 3. BOD values at other stations were higher than 2 mg/l and ranged between 2.2-3.3 mg/l probably due to the effluent from industrial area, community and farmland. BOD values around the mouth of Huai Phu Sai and Dok Krai reservoir near community area, agricultural area and golf course were especially high in a range of 3.0-3.3 mg/l.
- Cu, Zn, NH_3 and NO_3 values measured at all stations were not greater than the established standards. However, no standard value was set for PO_4^{3-}. PO_4^{3-} values measured at Station 1 and Station 2 were higher than those of Stations 3-5 located downstream of discharge point of the project. PO_4^{3-}might come from the effluent discharged from industrial area and high-density communities near Huai Phu Sai around Stations 1 and 2.
- No standard was set for Na, Ca, and Mg. However, Na, Ca, and Mg were studied as the fundamental data for assessment of the Specific Absorption Rate (SAR) when used in agriculture and watering. The measurement results revealed that Na and Ca at Stations 1 and 2 were lower than the downstream stations (Stations 3-5). Na values of Stations 1 and 2 were 3.54 and 12.9 mg/l whereas Na values of Stations 3 to 5 were between 13.9 and 15.64 mg/l. Ca values at Stations 1 and 2 were 34 and 30 mg/l whereas Ca values at Stations 3-5 in a range of 48.5-49 mg/l.
- Mg values at all stations were not much different, i.e. in a range of 1.72-2.48 mg/l. Na and Ca at Stations 3-5 which were more than those at Stations 1-2 might result from utilization of chemical fertilizer that contained sodium and soil conditioner (e.g. calcium carbonate) in farmland. These chemicals were carried by rainwater into Huai Phu Sai and Dok Krai reservoir.

(b) Field Survey

In this project, surface water samples were collected from 4 stations **(Figure 4.1.8-1)** during 17th-18th September 2015 to represent water quality in the dry season and on 17th March 2016 to represent water quality in the wet season. The analysis results which represent the water quality in the wet season are demonstrated in **Table 4.1.8-6 (Appendix 4F-2)** whereas the results for the dry season in **Table 4.1.8-7 (Appendix 4F-3)**. The measurement results can be summarized below.

- **Survey Results of the Wet Season**

Station 1 (SW1): about 1 km Upstream of the Discharge Point No. 1 of Pluak Daeng Industrial Park (Coordinate: 47P 0731985E 1433179N)

Water collected at SW1 is used for agriculture and fishery. As for physical properties, it is muddy brown and contains sediments. Water temperature is 27.3 ℃ which is in a general range of temperature for water resources in Thailand. Water depth is 1.5 m. Suspended solids are 268.9 mg/l.

As for chemical properties, pH is 6.4 and DO is 6.7 mg/l, indicating that water is slightly contaminated but can be consumed (Noppawan Theeraphancharoen, 2007). Other chemical properties are nitrate-nitrogen of 2.6 mg/l which is lower than the standard of <5.0 mg/l; ammonia-nitrogen of less than 0.5 mg/l; and BOD_5 of 2.0 mg/l. When compared to the established surface water quality standards by the Water Quality Management Division, Pollution Control Department, these measurement values indicate that water at this station is clean.

The measurement results obtained from SW1 were used to calculate WQI (calculation method in **Appendix 4G**). WQI at SW1 is in a range of 61-70 which indicates fair water quality and comparable to Class 3 of surface water quality standards **(Table 4.1.8-6)**.

Station 2 (SW2): Discharge Point No. 1 of Pluak Daeng Industrial Park (Coordinate: 47P 0732907E 1433023N)

Water collected at SW2 is used for agriculture and fishery. As for physical properties, it is muddy brown, and contains sediments. Water temperature is 27.7 ℃ which is in a general range of temperature for water resources in Thailand. Water depth is 3.5 m. Suspended solids are 302.1 mg/l.

As for chemical properties, pH is 7.0 and DO is 6.7 mg/l, indicating that water is slightly contaminated but can be consumed (Noppawan Theeraphancharoen, 2007). BOD_5 is 1.9 mg/l which indicates that water is clean when compared to the established surface water quality standards by the Water Quality Management Division, Pollution Control Department. Nitrate-nitrogen is 1.9 mg/l which is lower than the standard of <5.0 mg/l, and ammonia-nitrogen is less than 0.5 mg/l.

TABLE 4.1.8-6

SURFACE WATER QUALITY MEASUREMENT RESULTS OF THE PROJECT DURING THE WET SEASON (17th-18th SEPTEMBER 2015)

Properties	Parameters	Units	Monitoring Stations[2/]								Surface Water Quality Standards[1/]	
			SW1	WQI[3/]	SW2	WQI[3/]	SW3	WQI[3/]	SW4	WQI[3/]	3	4
Physical	- Depth	m	1.5		3.5		3.6		1.0		-	-
	- Temperature	°C	27.3		27.7		27.2		27.3		n	n
	- Salinity	ppt	0.1		0.1		0.1		0.1		-	-
	- Suspended Solids	mg/l	268.9		302.1		525.0		241.3		-	-
	- Turbidity	NTU	22.2		23.5		22.8		20.1		-	-
	- Transparency	m	0.15		0.10		0.10		0.10		-	-
Chemical	- pH	-	6.4		7.0		6.8		7.0		5-9	5-9
	- Dissolved Oxygen	mg/l	6.7	79	6.7	79	7.2	85	7.2	85	> 4	> 2
	- BOD_5	mg/l	2.0	61	1.9	63	1.8	65	2.0	61	< 2	<4
	- Oil & Grease	mg/l	<5.0		<5.0		<5.0		<5.0		-	-
	- Nitrate-Nitrogen	mg/l	2.6		1.9		2.0		2.0		<5.0	<5.0
	- Ammonia-Nitrogen	mg/l	<0.5	34	<0.5	34	<0.5	34	<0.5	34	<0.5	<0.5
Biological	- Total Coliform Bacteria	MPN/100 ml	2,400	86	16,000	63	7,900	69	7,900	69	<20,000	-
	- Fecal Coliform Bacteria	MPN/100 ml	1,300	70	2,800	65	2,400	66	3.900	61	<4,000	-
Surface Water Quality Standards, Class (Based on the Average WQI Index)			**3**	**66**	**4**	**51**	**4**	**54**	**4**	**52**		

Remark: SW1: About 1 km upstream of the discharge point No. 1 of Pluak Daeng Industrial Park
SW2: Discharge point No. 1 of Pluak Daeng Industrial Park
SW3: Discharge point No. 2 of Pluak Daeng Industrial Park
SW4: About 500 m downstream of discharge point No. 2 of Pluak Daeng Industrial Park

Source: 1/ Notification of the National Environment Board, No. 8 (B.E. 2537) (1994), issued under the Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992) regarding Establishment of Surface Water Quality Standards, published in the Royal Government Gazette, Vol. 111, Part 16 D dated February 24th 1994
2/ Measurement conducted by TEAM Consulting Engineering and Management Ltd. during 17th-18th September 2015
3/ New Water Quality Index calculation method by Freshwater Section, Water Quality Management Bureau, Pollution Control Department **(Appendix 4G)**

TABLE 4.1.8-7

SURFACE WATER QUALITY MEASUREMENT RESULTS OF THE PROJECT DURING THE DRY SEASON (17th MARCH 2016)

Properties	Parameters	Units	Monitoring Stations[2/]								Surface Water Quality Standards[1/]	
			SW1	WQI[3/]	SW2	WQI[3/]	SW3	WQI[3/]	SW4	WQI[3/]	3	4
Physical	- Depth	m	0.7		3.3		0.6		0.8		-	-
	- Temperature	°C	37.0		30.5		34.3		30.6		n	n
	- Suspended Solids	mg/l	45.5		46.2		20.7		34.1		-	-
	- Transparency	m	0.20		0.19		0.22		0.30		-	-
Chemical	- pH	-	8.8		7.4		8.7		7.5		5-9	5-9
	- Dissolved Oxygen	mg/l	12.4	22	5.6	69	12.5	21	6.1	72	> 4	> 2
	- BOD_5	mg/l	2.5	54	2.5	54	2.2	58	2.9	48	< 2	<4
	- Oil & Grease	mg/l	<5.0		<5.0		<5.0		<5.0		-	-
	- Nitrate-Nitrogen	mg/l	13.0		11.0		9.2		5.4		<5.0	<5.0
	- Ammonia-Nitrogen	mg/l	<0.5	34	<0.5	34	<0.5	34	<0.5	34	<0.5	<0.5
	- Total Kjeldahl Nitrogen	mg/l	3.5		3.8		3.2		3.8		-	-
	- Phosphate	mg/l	0.39		0.39		0.30		0.31		-	-
	- Na	mg/l	84.0		76.9		56.6		78.3		-	-
	- Ca	mg/l	50.0		38.1		23.4		34.7		-	-
	- Mg	mg/l	5.32		4.71		3.06		4.35		-	-
Biological	- Total Coliform Bacteria	MPN/100 ml.	450	97	780	95	790	95	1,600	91	<20,000	-
	- Fecal Coliform Bacteria	MPN/100 ml	200	69	200	69	240	67	200	69	<4,000	-
Surface Water Quality Standards, Class			**4**	**45**	**4**	**54**	**4**	**45**	**4**	**52**		

Remark: SW1: About 1 km upstream of the discharge point No. 1 of Pluak Daeng Industrial Park
SW2: Discharge point No. 1 of Pluak Daeng Industrial Park
SW3: Discharge point No. 2 of Pluak Daeng Industrial Park
SW4: About 500 m downstream of discharge point No. 2 of Pluak Daeng Industrial Park

Source:
[1/] Notification of the National Environment Board, No. 8 (B.E. 2537) (1994), issued under the Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992) regarding Establishment of Surface Water Quality Standards, published in the Royal Government Gazette, Vol. 111, Part 16 D dated February 24th, 1994
[2/] Measurement conducted by TEAM Consulting Engineering and Management Ltd. during 17th March 2016
[3/] New Water Quality Index calculation method by Freshwater Section, Water Quality Management Bureau, Pollution Control Department **(Appendix 4G)**

Station 3 (SW3): Discharge Point No. 2 of Pluak Daeng Industrial Park (Coordinate: 47P 0733386E 1432700N)

Water collected at SW3 is used for agriculture and fishery. As for physical properties, it is muddy brown, and contains sediments. Water temperature is 27.2 °C which is in a general range of temperature for water resources in Thailand. Water depth is 3.6 m. Suspended solids are 525.0 mg/l.

As for chemical properties, pH is 6.8 and DO is 7.2 mg/l, indicating that water is slightly contaminated but can be consumed (Noppawan Theeraphancharoen, 2007). BOD_5 is 1.8 mg/l which indicates that water is clean when compared to the established surface water quality standards by the Water Quality Management Division, Pollution Control Department. Nitrate-nitrogen is 2.0 mg/l which is lower than the standard of <5.0 mg/l, and ammonia-nitrogen is less than 0.5 mg/l.

Station 4 (SW4): about 500 M Downstream of Discharge Point No. 2 of Pluak Daeng Industrial Park (Coordinate: 47P 0733441E 1432280N)

Water collected at SW4 is used for agriculture and fishery. As for physical properties, it is muddy brown, and contains sediments. Water temperature is 27.3 °C which is in a general range of temperature for water resources in Thailand. Water depth is 1.0 m. Suspended solids are 241.3 mg/l.

As for chemical properties, pH is 7.0 and DO is 7.2 mg/l, indicating that water is slightly contaminated but can be consumed (Noppawan Theeraphancharoen, 2007). BOD_5 is 2.0 mg/l which indicates that water is clean when compared to the established surface water quality standards by the Water Quality Management Division, Pollution Control Department. Nitrate-nitrogen is 2.0 mg/l which is lower than the standard of <5.0 mg/l, and ammonia-nitrogen is less than 0.5 mg/l.

The measurement results obtained from SW2, SW3 and SW4 were used to calculate WQI (calculation method in **Appendix 4G**). WQI at the three stations is in a range of 31-60 which indicates deteriorated water quality and comparable to Class 4 of surface water quality standards **(Table 4.1.8-6)**.

- **Survey Results of the Dry Season**

Station 1 (SW1): about 1 km Upstream of the Discharge Point No. 1 of Pluak Daeng Industrial Park (Coordinate: 47P 0731985E 1433179N)

Water collected at SW1 is used for agriculture and fishery. As for physical properties, it is muddy brown, and contains sediments. Water temperature is 37.0 °C which is higher than the general range of temperature for water resources in Thailand (20.0-35.0 °C). Water temperature generally varies according to air temperature. Water temperature was conducted at 14.30 hrs. and air temperature was 28.0°C. Water depth is 0.7 m and suspended solids are 45.5 mg/l.

Chemical properties are pH of 8.8; DO of 12.4 mg/l; nitrate-nitrogen of 13 mg/l which exceeds the standard of <5.0 mg/l; ammonia-nitrogen of less than 0.5 mg/l; and BOD_5 of 2.5 mg/l. When compared to the established surface water quality standards by the Water Quality Management Division, Pollution Control Department, these measurement values indicate that water at this station is fairly clean.

Station 2 (SW2): Discharge Point No. 1 of Pluak Daeng Industrial Park (Coordinate: 47P 0732907E 1433023N)

Water collected at SW2 is used for agriculture and fishery. As for physical properties, it is muddy brown, and contains sediments. Water temperature is 30.5 °C which is in a general range of temperature for water resources in Thailand. Water depth is 3.3 m. Total dissolved solids are 707.5 mg/l and suspended solids are 46.2 mg/l.

As for chemical properties, pH is 7.7 and DO is 5.6 mg/l, indicating that water is moderately contaminated but can be used for agriculture and industrial activities (Noppawan Theeraphancharoen, 2007). BOD_5 is 2.5 mg/l which indicates that water is fairly clean when compared to the established surface water quality standards by the Water Quality Management Division, Pollution Control Department. Nitrate-nitrogen is 11 mg/l which is higher than the standard of <5.0 mg/l, and ammonia-nitrogen is less than 0.5 mg/l.

Station 3 (SW3): Discharge Point No. 2 of Pluak Daeng Industrial Park (Coordinate: 47P 0733386E 1432700N)

Water collected at SW3 is used for agriculture and fishery. As for physical properties, it is muddy brown, and contains sediments. Water temperature is 34.3 °C which is in a general range of temperature for water resources in Thailand. Water depth is 0.6 m. Total dissolved solids are 677.5 mg/l and suspended solids are 20.7 mg/l.

As for chemical properties, pH is 8.7 and DO is 12.5 mg/l. DO is high as the water depth at the sampling station is only 0.6 m and the quantity of phytoplankton at this station is higher than other stations **(Table 4.1.8-3)**. Both oxygen in atmosphere and oxygen from photosynthesis process bring about high level of DO at this station. BOD_5 is 2.2 mg/l which indicates that water is fairly clean when compared to the established surface water quality standards by the Water Quality Management Division, Pollution Control Department. Nitrate-nitrogen is 9.2 mg/l which is greater than the standard of <5.0 mg/l, and ammonia-nitrogen is less than 0.5 mg/l.

Station 4 (SW4): about 500 M Downstream of Discharge Point No. 2 of Pluak Daeng Industrial Park (Coordinate: 47P 0733441E 1432280N)

Water collected at SW4 is used for agriculture and fishery. As for physical properties, it is muddy brown, and contains sediments. Water temperature is 30.6°C which is in a general range of temperature for water resources in Thailand. Water depth is 0.8 m. Total dissolved solids are 691.2 mg/l and suspended solids are 34.1 mg/l.

As for chemical properties, pH is 7.5 and DO is 6.1 mg/l, indicating that water is moderately contaminated but can be used for agriculture and industrial activities (Noppawan Theeraphancharoen, 2007). BOD_5 is 2.9 mg/l which indicates that water is fairly clean when compared to the established surface water quality standards by the Water Quality Management Division, Pollution Control Department. Nitrate-nitrogen is 5.4 mg/l which is greater than the standard of <5.0 mg/l, and ammonia-nitrogen is less than 0.5 mg/l.

The measurement results obtained from 4 stations were used to calculate WQI (calculation method in **Appendix 4G**). WQI at the four stations is in a range of 31-60 which indicates deteriorated water quality and is comparable to Class 4 of surface water quality standards **(Table 4.1.8-7)**.

Considering the surface water quality in the dry season measured on 17th March 2016, nitrate-nitrogen at all stations is greater than the standard of <5.0 mg/l, but tends to be lower based on the distance from the Amata City Industrial Estate (Rayong) as illustrated in **Figure 4.1.8-1**.

The reason that causes the highest nitrate-nitrogen at Station 1 which is closest to the Amata City Industrial Estate (Rayong) is that water from the Amata City Industrial Estate (Rayong), communities, and farmland passes Station 1 **(Figure 4.1.8-1)**. Water may be contaminated by effluent discharged from communities and fertilizer from farmland. As for other stations which are located farther away, water passes vacant land, farmland, and Pluak Daeng Industrial Park which does not discharge effluent yet at the present time. Therefore, water at Stations 2 and 3 has lower nitrate-nitrogen. Besides, nitrate-nitrogen may be absorbed by stream bank vegetation before reaching Station 4. As a result, nitrate-nitrogen is the lowest at Station 4.

DO at each station is as follows:

- Station 1 (water depth of 0.7 m): DO is 12.4 mg/l.
- Station 2 (water depth of 3.3 m): DO is 5.6 mg/l.
- Station 3 (water depth of 0.6 m): DO is 12.5 mg/l.
- Station 4 (water depth of 0.8 m): DO is 6.1 mg/l.

Station 2 has the lowest DO probably because of the highest water depth and the largest amount of suspended solids. Consequently, the diffusion of atmospheric oxygen into water at this station is less than other stations and photosynthesis of phytoplankton is lower. Nevertheless, DO at this station is in the Class 3 of surface water quality standards in which DO shall not be less than 4 mg/l.

As for Stations 1, 3 and 4 where DO levels are higher than Station 2, transfer of atmospheric oxygen into water at the three stations is better than Station 2. Moreover, the amount of phytoplankton at Station 3 is higher than other stations (as presented in **Table 4.1.8-3**), therefore, Oxygen from photosynthesis of phytoplankton at this station is also higher than other stations.

4.1.9 Groundwater Hydrology and Groundwater Quality

4.1.9.1 Groundwater Hydrology

(1) Introduction

The existing groundwater hydrology was studied and the study results were used as the fundamental data for assessment of environmental impacts, and for determination of environmental impact prevention and mitigation measures, including environmental impact monitoring measures.

(2) Methodology

Secondary data were collected, including the 1:100,000-scale hydrogeological maps prepared by the Bureau of Hydrogeological Survey and Groundwater Mapping, Department of Groundwater Resources in order to analyze the hydrogeological conditions of the project area and the study area.

(3) Study results

(a) Aquifer

According to the 1:100,000-scale hydrogeological map of the Department of Groundwater Resources (2004) **(Figure 4.1.9-1)**, the hydrogeological conditions of the study area are Colluvium (Qcl) and Granitic Aquifer (Gr). The project area is located on Colluvium (Qcl).

Colluvium is the name of unconsolidated sediments that have been deposited at foothills or narrow valleys. Qcl is composed of weathered country rocks and loose rock fragments deposited in narrow valleys or at the bases of hillslopes. Colluvium accumulates as rolling hills of different heights from 20 m to 100 m. Colluvial deposits are typically loosely consolidated rock fragments and clay decayed from country rocks fallen rapidly from high mountains to the bases of hillslopes. Therefore, sediments are the combination between clay and rock fragments. Colluvium has low porosity and low water-holding capacity.

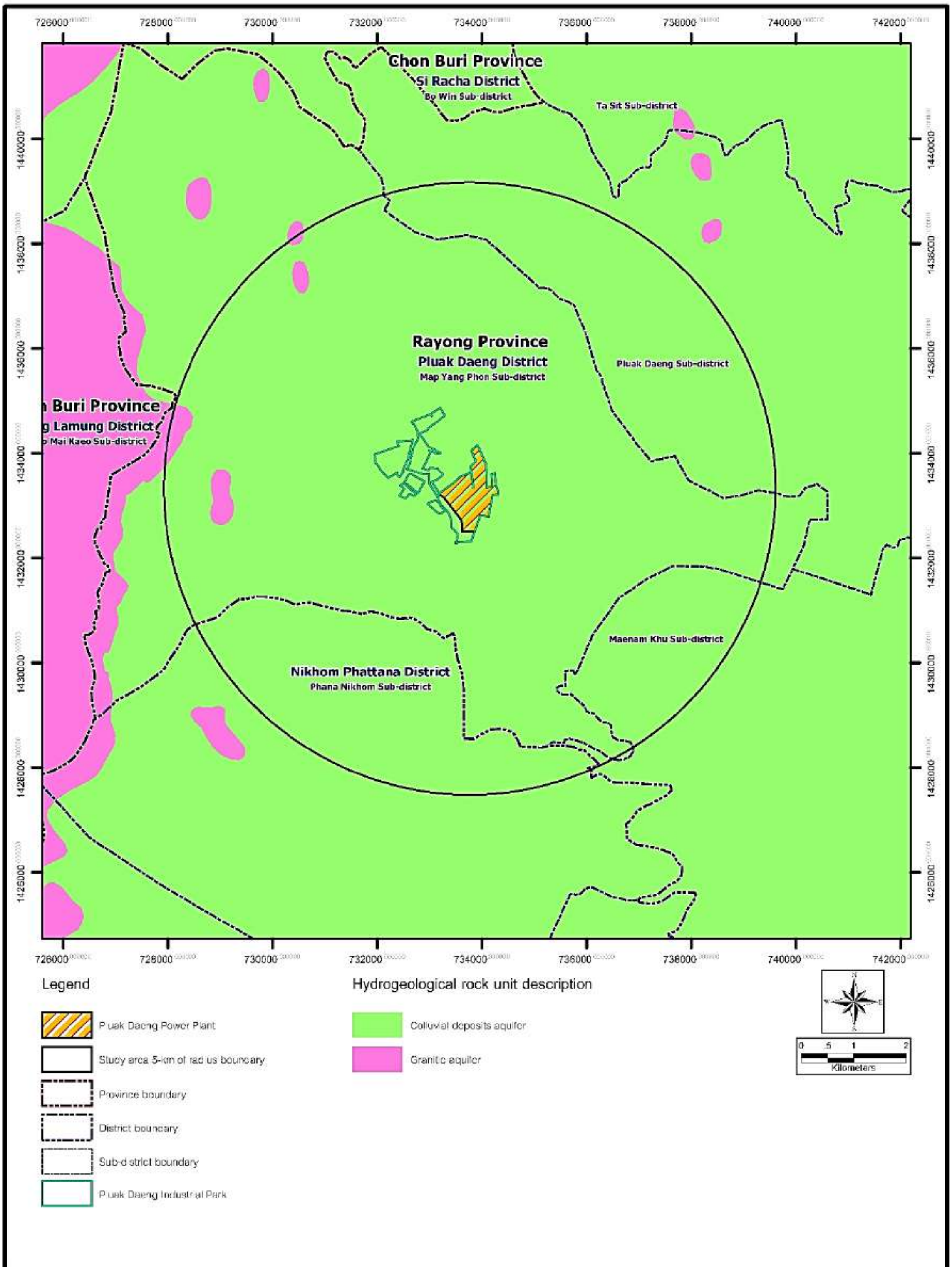


FIGURE 4.1.9-1 : HYDROGEOLOGICAL MAP OF THE STUDY AREA

10P2809/Damrongsak.B/15-08-60/P2809-024 (English).mxd

Granitic Aquifer in Cretaceous-Precambrian period is typically composed of granite, granodiorite, and granite interlayered with gneiss. Groundwater is found between rock fractures or faults which can be developed for use at the rate of 0-5 m^3/hr or higher in some areas.

(b) Direction of Groundwater Flow

Data on groundwater wells were considered to obtain directions of groundwater flows, including static water levels and well locations which are more than 1 km apart as presented in **Table 4.1.9-1** and **Figure 4.1.9-2**. Groundwater in the study area generally flows in the northwest-southeast direction. This is because mountainous terrains are common in the northwest of the study area whereas flat terrains and reservoir are found in the southeast.

4.1.9.2 Groundwater Quality

(1) Introduction

The existing groundwater quality was studied and the study results were used as the fundamental data for assessment of environmental impacts, and for determination of environmental impact prevention and mitigation measures, including environmental impact monitoring measures.

(2) Methodology

- Groundwater quality data were collected from the groundwater well database system of the Information Technology Center of Groundwater Resources, Department of Groundwater Resources (http://map.dgr.go.th), and from the Bureau of Groundwater Assessment, Department of Groundwater Resources.
- Groundwater samples were gathered at 2 stations: Station 1 (GW1) near Wang Tan Mon weir, house No. 203, Village no. 2, Map Yang Phon sub-district; and Station 2 (GW2) around Prasittharam Temple **(Figure 4.1.9-3)**, in the wet season and the dry season.

(3) Study results

(a) Secondary data

According to the groundwater well database of the Department of Groundwater Resources, in the study area which encompasses Map Yang Phon, Mae Nam Khu, and Pluak Daeng sub-districts in Pluak Daeng district, and Phana Nikhom sub-district in Nikhom Phatthana district, Rayong province, there are 22 groundwater wells of different depths (18.00-156.00 m) and water volumes of 0.00-22.85 m^3/hr. Referring to the water quality index, Cl is in a range of 4.00-13.00 mg/l, Fe in a range of 0.34-5.50 mg/l, NO_3 in a range of 0.00-15.00 mg/l, Total Dissolve Solid (TDS) in a range of 262.00-339.00 mg/l, and Total hardness (TH) in a range of 27.00-116.00 mg/l as presented in **Table 4.1.9-2**.

TABLE 4.1.9-1

GROUNDWATER WELLS AROUND THE PROJECT AREA TO FIND DIRECTIONS OF GROUNDWATER FLOWS

Well No.	Location	Static Water Level m	Depth m	Water Volume m^3/hr	Fe mg/l	Cl mg/l	Total hardness (TH) mg/l	Total dissolve solid (TDS) mg/l	Distance from the Project Area (km)	Direction from the Project Area
X0768	Ban Chak Oi	6.00	-	2.27	0.64	8.0	116.0	0.0	2.5	East
X0958	Ban Map Thao Wan	7.50	-	1.59	0.36	7.0	140.0	244.0	6.9	Northeast
X0960	Assadaram Temple	6.00	-	1.14	0.84	19.0	100.0	229.0	9.7	South
X0959	Ban Mae Nam Khu Mai	9.00	-	3.41	0.34	4.0	63.0	262.0	13.7	Southeast
X0853	Ban Nong Rakam	3.30	-	1.59	5.50	13.0	27.0	0.0	6.3	South
MF0053	Yan Krao Radio Station	7.50	36.00	2.27	2.10	28.0	242.0	428.0	11.4	North
X0687	Surasak Sub-district Police Station (Ban Surasak Montri)	1.20	36.00	3.41	0.68	23.0	117.0	0.0	11.4	North
DH0070	Ban Phan Samet Temple	4.50	30.00	1.59	0.00	0.0	0.0	0.0	10.6	Northwest towards North

Remark: - = No data

Source: Department of Groundwater Resources, 2015

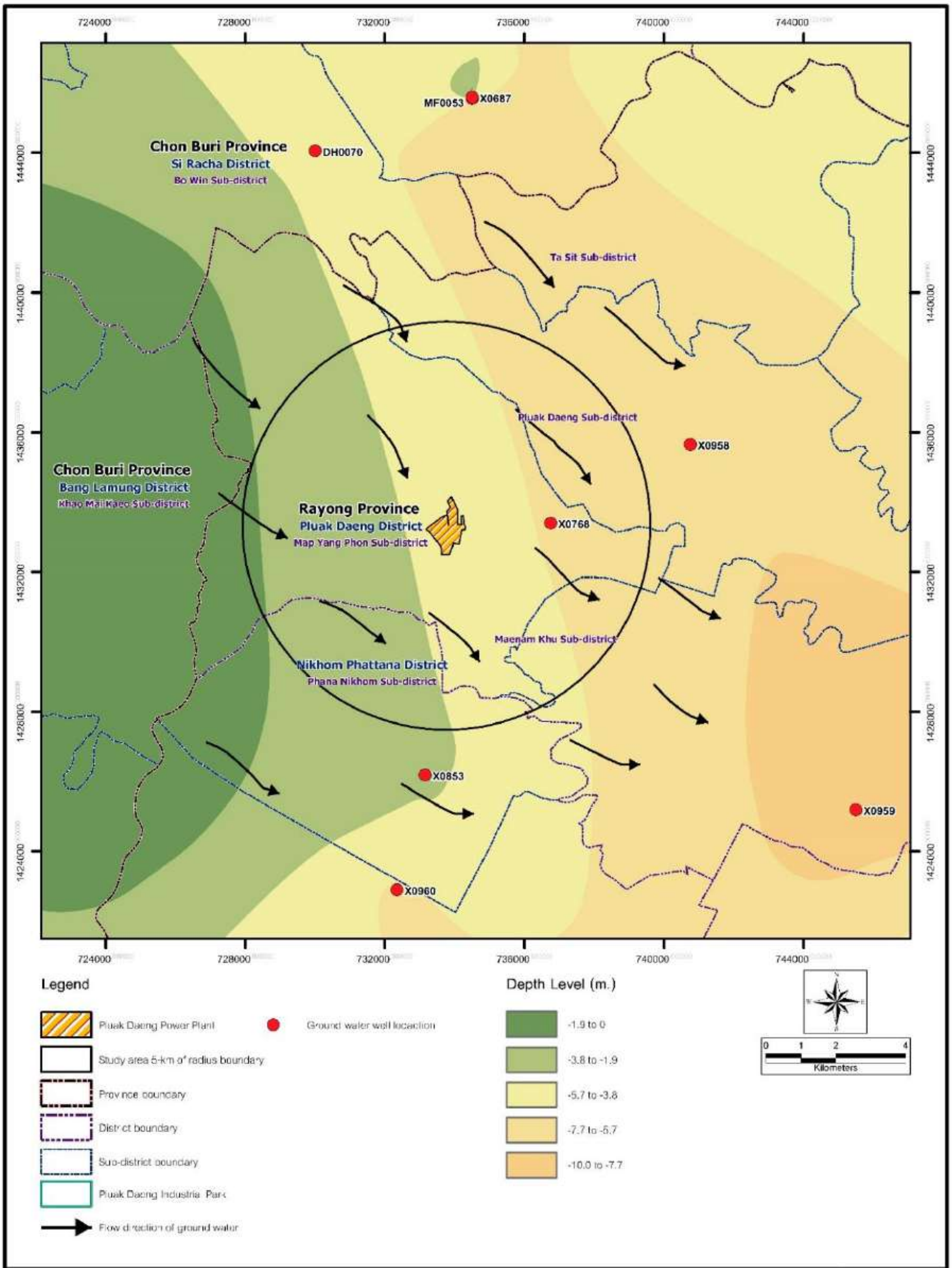


FIGURE 4.1.9-2 : LOCATIONS OF GROUNDWATER WELLS FOR FINDING DIRECTIONS OF GROUNDWATER FLOWS IN THE STUDY AREA

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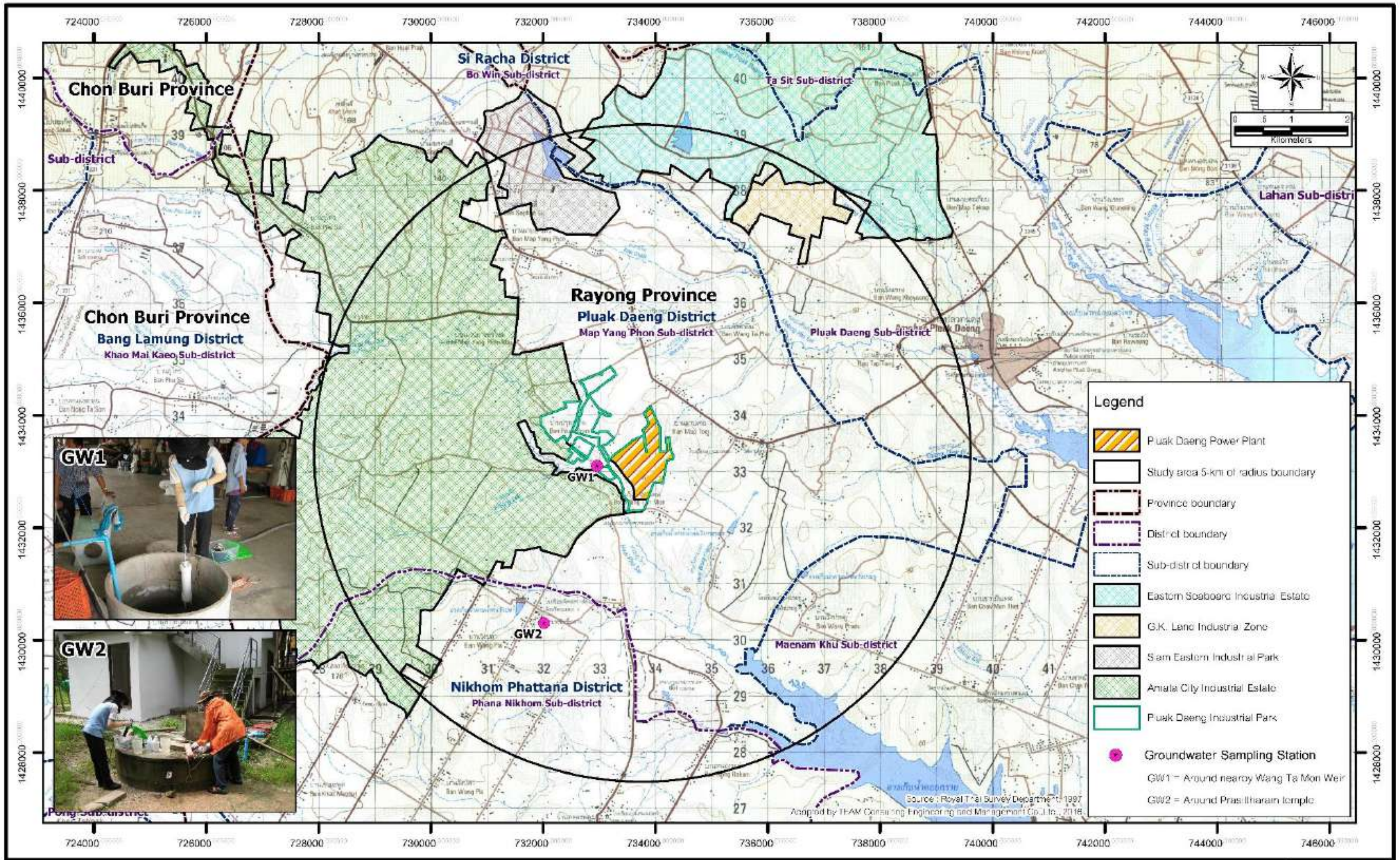


FIGURE 4.1.9-3 : LOCATIONS OF GROUNDWATER SAMPLING STATIONS

TABLE 4.1.9-2

DETAILS ABOUT GROUNDWATER WELLS IN THE STUDY AREA

No.	Well No.	Location	Village no.	Sub-district	District	Province	Depth (m)	Static Water Level (m)	Drawdown (m)	Water Volume (m^3/hr)	Water Conditions	Cl (mg/l)	Fe (mg/l)	NO_3 (mg/l)
1	X853	Ban Nong Rakam	6	Phana Nikhom	Nikhom Phatthana	Rayong	18.00	3.30	8.70	1.59	usable-freshwater	13	5.5	0
2	TD174	Nikhomsangtoneng School	1	Phana Nikhom	Nikhom Phatthana	Rayong	73.50	9.00	24.00	5.00	usable-freshwater	-	-	-
3	PW11849	Ban Nong Rakam School	6	Phana Nikhom	Nikhom Phatthana	Rayong	-	2.00		2.00	usable-freshwater	-	-	-
4	RY262	Map Luk Chan Temple (A23B11)	2	Pluak Daeng	Pluak Daeng	Rayong	-	-	-	-	usable-freshwater	-	-	-
5	RY198	Ban Chak Malai (Well 1) (A23B09)	2	Pluak Daeng	Pluak Daeng	Rayong	156.00	7.28	14.98	22.85	usable-freshwater	-	-	-
6	RY263	Ban Chak Malai (Village Headman House) (A23B12)	2	Pluak Daeng	Pluak Daeng	Rayong	-	-	-	-	usable-freshwater	-	-	-
7	RY212	Ban Chak Malai (Well 2) (A23B10)	2	Pluak Daeng	Pluak Daeng	Rayong	146.00	-	-	-	usable-freshwater	-	-	-
8	PW9007	Ban Thap Tong 11248/108-31	6	Pluak Daeng	Pluak Daeng	Rayong	21.30	0.00	0.00	0.00	usable-freshwater	-	-	-
9	TD264	Ban Thap Tong	6	Pluak Daeng	Pluak Daeng	Rayong	103.50	6.00	38.00	1.50	usable-freshwater	5.6	0.56	0
10	PW23273	Ban Wang Khayaeng	5	Pluak Daeng	Pluak Daeng	Rayong	18.50	4.80	8.20	2.00	usable-freshwater	-	-	-
11	5409F014	Map Luk Chan Temple	2	Pluak Daeng	Pluak Daeng	Rayong	130.00	15.20	45.00	9.00	usable-freshwater	-	-	-
12	TD113	Ban Map Yang Phon	7	Map Yang Phon	Pluak Daeng	Rayong	61.50	4.43	51.66	1.10	usable-freshwater	-	-	-
13	X768	Ban Chak Oi	7	Map Yang Phon	Pluak Daeng	Rayong	30.00	6.00	18.00	2.27	usable-freshwater	8	0.64	15
14	PW10923	Ban Soi 5	7	Map Yang Phon	Pluak Daeng	Rayong	-	4.00	8.00	2.00	usable-freshwater	-	-	-
15	X959	Ban Mae Nam Khu Mai	5	Mae Nam Khu	Pluak Daeng	Rayong	30.00	9.00	7.50	3.41	usable-freshwater	4	0.34	1.5
16	RY265	Inland Fisheries Research and Development Station (A21B08)	3	Mae Nam Khu	Pluak Daeng	Rayong	-	-	-	-	usable-freshwater	-	-	-
17	RY264	Royally Initiated Agricultural Extension Center (A21B07)	3	Mae Nam Khu	Pluak Daeng	Rayong	-	-	-	-	usable-freshwater	-	-	-
18	PW18255	Ban Mae Nam Khu Kao	1	Mae Nam Khu	Pluak Daeng	Rayong	30.92	8.00	7.00	3.00	usable-freshwater	-	-	-
19	PW22025	Pluak Daeng Community Development Center	6	Mae Nam Khu	Pluak Daeng	Rayong	24.30	4.00	14.00	1.50	usable-freshwater	-	-	-
20	PW22945	Pluak Daeng Animal Husbandry Station	6	Mae Nam Khu	Pluak Daeng	Rayong	42.40	4.00	16.00	2.00	usable-freshwater	-	-	-
21	RY362	Ban Dok Klai	3	Mae Nam Khu	Pluak Daeng	Rayong	132.00	10.00	54.00	3.00	usable-freshwater	-	-	-
22	RY363	Mae Nam Khu Sub-district Administrative Organization (New)	3	Mae Nam Khu	Pluak Daeng	Rayong	72.00	9.00	20.00	12.00	usable-freshwater	-	-	-

Remark: - = No data

Source: Department of Groundwater Resources (http://www.dgr.go.th/), 2015

(b) Measurement Result Data

Groundwater samples were gathered at 2 stations near the project area **(Figure 4.1.9-3)** on 18th September 2015 in the wet season (groundwater analysis results in **Appendix 4H-1**) and on 17th March 2016 in the dry season (groundwater analysis results in **Appendix 4H -2**). The groundwater quality measurement results are presented in **Table 4.1.9-3** and details are described below.

- **Groundwater Quality Survey Result in the Wet Season**

Station 1 (GW1) Near Wang Tan Mon Weir
(Coordinate 47P 0732958E 1433100N)

At station 1 (GW1), the measurement results revealed that all parameters do not exceed the groundwater quality standards stipulated in the Notification of the National Environment Board No. 20, B.E. 2543 (2000) regarding Establishment of Groundwater Quality Standards. However, when compared to the standards of groundwater for drinking, pH at Station 1 is 6.3 which does not meet the maximum allowable concentration in a range of 6.5-9.2 as stipulated in the Notification of the Ministry of Natural Resources and Environment regarding Determination of Technical Standards for Protection of Public Health and Prevention of Polluted Environment, B.E. 2551 (2008). The total dissolved solids (TDS) are 333.3 mg/l which are suitable according to the standards of groundwater for drinking which require that TDS shall not exceed 600 mg/l. *E.Coli* is 350 MPN/100 ml and Total Coliform Bacteria is 1,300 MPN/100 ml which do not meet the maximum allowable concentrations for *E.Coli* and Total Coliform Bacteria which shall be none and <2.2 MPN/100 ml, respectively.

Station 2 (GW2) around Prasittharam Temple
(Coordinate 47P 0732018E 1430304N)

At station 2 (GW2), the measurement results revealed that all parameters do not exceed the groundwater quality standards stipulated in the Notification of the National Environment Board No. 20, B.E. 2543 (2000) regarding Establishment of Groundwater Quality Standards. When compared to the standards of groundwater for drinking, pH at Station 2 is 7.4 which meets the maximum acceptable concentration in a range of 7.0-8.5 as stipulated in the Notification of the Ministry of Natural Resources and Environment regarding Determination of Technical Standards for Protection of Public Health and Prevention of Polluted Environment, B.E. 2551 (2008). The total dissolved solids (TDS) are 160 mg/l which are suitable according to the standards of groundwater for drinking which require that TDS shall not exceed 600 mg/l. *E.Coli* is 340 MPN/100 ml and Total Coliform Bacteria is 1,300 MPN/100 ml which do not meet the maximum allowable concentrations for *E.Coli* and Total Coliform Bacteria which shall be none and <2.2 MPN/100 ml, respectively.

TABLE 4.1.9-3
GROUNDWATER QUALITY FROM FIELD SURVEY IN THE PROJECT AREA

No.	Parameters	Unit	Station				Standard		
			GW1		GW2		(1)	(2)	(3)
			18 Sep 2015	17 Mar 2016	18 Sep 2015	17 Mar 2016			
1.	pH	-	6.3	5.8	7.4	6.6	-	7.0-8.5	6.5-9.2
2.	Water Temperature	°C	27.8	28.7	27.4	30.2	-	-	-
3.	Conductivity	µS/cm	288.9	194.3	237.2	377.5	-	-	-
4.	Salinity	ppt	0.1	0.1	0.1	0.2	-	-	-
5.	Turbidity	NTU	-	2.5	-	1.2	-	5	20
6.	TDS	mg/l	333.3	166.3	160.0	227.3	-	600	1,200
7.	SS	mg/l	287.5	<5.0	4.4	<5.0	-	-	-
8.	Total Hardness	Mg/L as $CaCO_3$	-	46.7	-	150.5	-	300	500
9.	Carbonate Hardness	Mg/L as $CaCO_3$	-	18.0	-	149.0	-	-	-
10.	SO_4	mg/l	-	19.2	-	10.5	-	200	250
11.	Mn	mg/l	-	0.431	-	<0.001	0.5	0.3	0.5
12.	Fe	mg/l	-	<0.03	-	<0.03	-	0.5	1.0
13.	Cu	mg/l	-	<0.003	-	<0.003	1.0	1.0	1.5
14.	Zn	mg/l	-	0.016	-	0.005	5.0	5.0	15
15.	Mg	mg/l	-	4.06	-	3.39	-	-	-
16.	Ca	mg/l	-	9.68	-	43.4	-	-	-
17.	*E.Coli*	MPN/100 ml	350	<1.1	340	23	-	None	-

TABLE 4.1.9-3

GROUNDWATER QUALITY FROM FIELD SURVEY IN THE PROJECT AREA (Cont'd)

No.	Parameters	Unit	Station				Standard		
			GW1		GW2		(1)	(2)	(3)
			18 Sep 2015	17 Mar 2016	18 Sep 2015	17 Mar 2016			
18.	Total Coliform Bacteria	MPN/100 ml	1,300	>23	1,300	>23	-	<2.2	-
19.	Fecal Coliform Bacteria	MPN/100 ml	-	<1.1	-	23	-	<2.2	-

Standards: (1) Groundwater quality standards according to the Notification of the National Environment Board No. 20, B.E. 2543 (2000) regarding Establishment of Groundwater Quality Standards

(2) Standards of groundwater for drinking according to the Notification of the Ministry of Natural Resources and Environment regarding Determination of Technical Standards for Protection of Public Health and Prevention of Polluted Environment, B.E. 2551 (2008): Maximum Acceptable Concentration

(3) Standards of groundwater for drinking according to the Notification of the Ministry of Natural Resources and Environment regarding Determination of Technical Standards for Protection of Public Health and Prevention of Polluted Environment, B.E. 2551 (2008): Maximum Allowable Concentration

Remark: Station 1 (GW1): near Wang Tan Mon Weir, house No 203, Village no.2, Map Yang Phon sub-district, Pluak Daeng district, Rayong province

Station 2 (GW2): around Prasittharam Temple, Village no. 7, Phana Nikhom Sub-district, Nikhom Phatthana district, Rayong province

- in "Unit" column means no unit has been specified.

- in measurement result columns means no measurement was conducted.

- in "Standard" columns means no standard value has been set according to the Notification of the National Environment Board No. 20, B.E. 2543 (2000) regarding Establishment of Groundwater Quality Standards, and the Notification of the Ministry of Natural Resources and Environment regarding Determination of Technical Standards for Protection of Public Health and Prevention of Polluted Environment, B.E. 2551 (2008).

Source: TEAM Consulting Engineering and Management Ltd., September 2015 and March 2016

- **Groundwater Quality Survey Result in the Dry Season**

Station 1 (GW1) Near Wang Tan Mon Weir
(Coordinate 47P 0732958E 1433100N)

At station 1 (GW1), the measurement results revealed that all parameters meet the groundwater quality standards stipulated in the Notification of the National Environment Board No. 20, B.E. 2543 (2000) regarding Establishment of Groundwater Quality Standards. However, when compared to the standards of groundwater for drinking, pH at Station 1 is 5.8 which does not meet the maximum allowable concentration in a range of 6.5-9.2 as stipulated in the Notification of the Ministry of Natural Resources and Environment regarding Determination of Technical Standards for Protection of Public Health and Prevention of Polluted Environment, B.E. 2551 (2008). The total dissolved solids (TDS) are 166.3 mg/l which are suitable according to the standards of groundwater for drinking which require that TDS shall not exceed 600 mg/l. *E.Coli* is 1.1 MPN/100 ml and Total Coliform Bacteria is >23 MPN/100 ml which do not meet the maximum allowable concentrations for *E.Coli* and Total Coliform Bacteria which shall be none and <2.2 MPN/100 ml, respectively.

Station 2 (GW2) around Prasittharam Temple
(Coordinate 47P 0732018E 1430304N)

At station 2 (GW2), the measurement results revealed that all parameters meet the groundwater quality standards stipulated in the Notification of the National Environment Board No. 20, B.E. 2543 (2000) regarding Establishment of Groundwater Quality Standards. When compared to the standards of groundwater for drinking, pH at Station 2 is 6.6 which meets the maximum allowable concentration in a range of 6.5-9.2 as stipulated in the Notification of the Ministry of Natural Resources and Environment regarding Determination of Technical Standards for Protection of Public Health and Prevention of Polluted Environment, B.E. 2551 (2008). The total dissolved solids (TDS) are 227.3 mg/l which are suitable according to the standards of groundwater for drinking which require that TDS shall not exceed 600 mg/l. *E.Coli* is 23 MPN/100 ml and Total Coliform Bacteria and Fecal Coliform Bacteria are >23 and 23 MPN/100 ml respectively which do not meet the maximum allowable concentrations for *E.Coli*, Total Coliform Bacteria and Fecal Coliform Bacteria which shall be none and <2.2 MPN/100 ml, respectively.

The concentrations of Total Coliform Bacteria and *E.Coli* from both measurements are much different due to change in fermentation technique as presented in **Appendix 4I.** For the first measurement of groundwater quality (in the wet season on 18th September 2015), only parameters for drinking water were measured because the groundwater wells where measurement was conducted are in the house and the temple and used for drinking. Besides, the project activities do not directly relate to groundwater. For the second collection of groundwater samples from the well in the house (in the dry season on 17th March 2016), the house owner was interested in the measurement and inquired about the groundwater quality measured in September 2015. The project considered that the house owner would benefit from additional measurement of groundwater quality parameters. The Consultant, therefore, conducted measurement of additional parameters. For some parameters, such as Total Coliform Bacteria and *E.Coli*, the Consultant adjusted the analysis method so that the obtained result could be compared with the standard for drinking water pursuant to the Notification of the Ministry of Natural Resources and Environment regarding Determination of Technical Standards for Protection of Public Health and Prevention of Polluted Environment, B.E. 2551 (2008). By this way, the house owner could easily understand the measurement results.

4.2 BIOLOGICAL RESOURCES

4.2.1 Terrestrial Ecology

4.2.1.1 Forest ecological

(1) Introduction

Forest ecological methods were employed to study the existing conditions of the forest resources around the project area and within the 5-km radius area. The study results were used to assess the environmental impacts from the project development, and to suggest the environmental impact prevention and mitigation measures, including environmental impact monitoring measures.

(2) Methodology

- Collection and study of secondary data, including the topographic maps at 1:50,000 scale and other data from relevant organizations, e.g. the Royal Forest Department, the National Park, Wildlife and Plant Conservation Department, etc.
- Survey of forest resources during 24th-26th February 2016 by using two methods

  - In case the project area has no large plant community or some forests and the surrounding areas are farmland, water resources, abandoned land, communities and sparse vegetation, the survey team records all plant varieties and ecological conditions. As for the study area of 5-km radius from the project location, if it is covered by forests, both secondary data and record of plant varieties and ecological conditions will be taken into account to evaluate the impacts in order to ensure the project will not cause impacts on forest resources.

- If plant community is found in the project area, the survey team will conduct both quantitative and qualitative study. Plant community analysis method will be used to conduct quantitative study. Plots will be set up in the area by random sampling, taking into consideration the existing conditions of the area.

(3) Result

(a) Secondary Data

According to the Forest Land Management Bureau, the Royal Forest Department (2015), the total forest area in Rayong province in 2014 is 176,427.14 rai (accounting for 7.95% of the total provincial area), reduced by 10.23% from the total forest area of 196,527.18 rai (or 8.85% of the total provincial area) in 2013.

- **Nine national forests** cover a combined area of 513,743 rai as presented in **Table 4.2.1-1**.
- **Two national parks** (Department of National Park (2015); www.dnp.go.th) comprise the following.

- Khao Laem Ya–Samet Island National Park: It is covered by the mixed deciduous forest, comprising various plants such as Thai Bungor, Khae Yot Dam *(tereospermum fimbriatum*), Iron Wood (*Xylia xylocarpa (Roxb.) Taub.)*, Samo Phiphek *(Terminalia bellirica),* Sathip *(Phoebe paniculata)*, Ka Sam Pik *(Moghania sootepensis)*, Plao Yai *(Croton roxberghii N.P.Balakr.)*, Lai *(Grewia paniculata)*, Wa *(Syzygium cumini (L.) Skeels)*, Luk Ding *(Parkia sumatrana)*, Tao Rang *(Caryota urens Linn.)*, Khem Pa *(Greenia wightiana Wall. ex Wight & Arn.)*, Climbing Wattle, Meuad Lod *(Aporosa villosa (Wall. ex Lindl.) Baill.)*, etc. Other plants grown in abandoned area and deteriorated forest are Plao Yai *(Croton roxberghii N.P.Balakr.),* Wa *(Syzygium cumini (L.) Skeels)*, U-lok *(Hymenodictyon excelsum (Roxb.) Wall),* Kho Laen *(Nephelium hypoleucum Kurz)*, etc. Not less than 268 species of wildlife are found, such as barking deer, white-handed gibbon, palm civet, oriental small-clawed otter, black giant squirrel, grey-bellied squirrel, Indochinese ground squirrel, greater short-nosed fruit bat, hill long-tongued fruit bat, cave fruit bat, puff-throated babbler, white-crested laughingthrush, collared babbler, black-crested bulbul, striated bulbul, black bulbul, greater flameback, bamboo woodpecker, heart-spotted woodpecker, collared falconet, raffles' malkoha, red-headed trogon, red-throated barbet, variable skink, common forest skink, orange-winged flying lizard, red-headed lizard, forest lizard, tokay gecko, banded krait, red-necked keelback snake, paddy field green frog, dark-sided frog, marsh frog, tree frog (chiromantis nongkhorensis), twin-spotted tree frog, common black-spinned toad, common burrowing frog, painted chorus frog, inornate chorus frog, ornated chorus frog, etc.

TABLE 4.2.1-1

AREA OF NATURAL FORESTS IN RAYONG PROVINCES

Rayong Province			
Name of National Park	Coverage area	Area (rai)	Distance from the project site (km.)
1. Kached, Pae and Klaeng Forests	Mueang Rayong and Ban Khai Districts	28,937	38.15
2. Khao Huai Ma Hat, Khao Nang Yong and Khao Khrok Forest	Ban Chang and Mueang Rayong Districts	17,811	26.95
3. Khlong Rawerng-Khlong Samed Forest	Ban Khai and Pluak Daeng Districts	137,500	2.38
4. Cha Wae, Ta Sit and Wang Sai Forests	Ban Khai and Klaeng Districts	-	19.72
5. Ban Na and Thung Khwai Kin Forest	Klaeng District	313,500	40.44
6. Ban Pae Forest	Mueang Rayong District	625	53.35
7. Phu Khao Hin Tang Forest	Mueang Rayong and Klaeng Districts	5,700	49.30
8. Len Pra Sae and Pang Rad Forest	Klaeng District	9,090	61.50
9. Nong Sanom Forest	Mueang Rayong District	580	39.91
Total		**513,743**	

Source : Office of Planing and Information, Royal Forest Department, 2015 (http://forestinfo.forest.go.th/55/National_Forest.aspx)

- Khao Chamao-Khao Wong National Park: It is generally covered by hill evergreen forest, dry evergreen forest, tropical rain forest, and limestone forest. There are a variety of plants, such as wild almond *(Irvingia malayana)*, Som Pong *(Tetrameles nudiflora R. Br.),* Ma Kha *(Afzelia xylocarpa (Kurz) Craib)*, Burma padauk, hog plum, etc. Not less than 137 species of wildlife reside in the national park, for example, wild boar, loris, snake, monitor, elephant, banteng, tiger, etc.

- **Two arboretums**

- Phe Arboretum: It is the place for recreation where coniferous forests are naturally grown along the beach. Australian pine trees are common. Rare wild animal is not found but birds are mostly discovered.

- Nong Sanom Arboretum: Beach forests are found. Plants grown in this arboretum comprise Yang Na *(Dipterocarpus alatus)*, Ma Hat *(Artocarpus cf. Gomezianus)*, Chamuang *(Garcinia cowa)*, Gruay Pa *(Casearia grewiaefolia Vent.),* Ma Muang Pa *(Mangifera caloneura Kurz)*, Lam Duan (*Melodorum fruticosum),* Khun Thong Paya Bad *(Suregada multiflorum Baill.)*, etc.

(b) Forest Survey Result

Survey of forest resources was undertaken during 24th-26th February 2016 in the project area and the study area (within the 5-km radius of the project site). The survey results are as follows:

- **Project Area**

The project area was leveled and no plant community exists as shown in **Photo 4.2.1-1**. As for plants in the project area, most of large trees were planted, including Son Pradi Phat *(Casuarina junghuhniana Mig.)*, Australian pine tree *(Casuarina equisetifaliaJ.R. & C. Forst.)*, White Cheesewood *(Alstonia scholaris R. Br.)*, and Eucalyptus *(Eucalyptus globulus Labill.)*. Fruit tree comprises jackfruit (Artocarpus heterophyllus Lamk.). Ornamental plants are Cape of Good Hope (Dracaena fragrans Ker-Gawl.), Tree Jasmine (Radermachera ignea Steenis), Croton (Codiaeum variegatum Bl.).

The local plants naturally grown in the project area are Khun Thong Phaya Bad *(Suregada multiflorum Baill.), Mi Men* (*Litsea glutinosa* C.B. Robinson), Khoi (*Streblus asper* Lour.) etc. They are not less than 3 m high. Also discovered are undergrowth, grasses, local plants and alien plants (e.g. Sap Suea (*Eupatorium odoratum* Linn.), Ya Nang Daeng (*Bauhinia strychnifolia* Craib), Maiyarap Loei (*Mimosa pigra* Linn.), Ya Oo (*Arundo donax* Linn.), Ya Kha (*Imperata cylindrica* Beauv.), Tong Kong (*Thysanolaena maxima* Ktze.), etc.) List of plants in the project area is presented in **Table 4.2.1-2** and examples of plants found in the project area in **Photo 4.2.1-2**.

PHOTO 3.9-1 : GENERAL CONDITIONS OF CONSTRUCTION SITE FOR PLUAK DAENG POWER PLANT PROJECT

Kra Thin Thepha *(Acacia mangium Wild.)*

Kra Thin Yak *(Leucaena leucocepphala (Lam.) de Wit)*

Eucalyptus

Jack Fruit (Khanun Ban)
(*Artocarpus heterophyllus* Lamk)

PHOTO 4.2.1-2 : SPECIES FOUND IN THE PROJECT AREA AND STUDY AREA

TABLE 4.2.1-2

LIST OF FLORA IN THE PROJECT AREA AND THE STUDY AREA

No.	Family	Common Name	Scientific Name	Habit	Survey Area		Type of Prohibited Wood	Rare and Near Threatened Wood
					Project Area	Study Area		
1	AGAVACEAE	Cape of Good Hope	*Dracaena fragrans* Ker-Gawl.	ExS/ST	/			
2	ANACARDIACEAE	Cashew Tree	*Anacardium occidentale* L.	T		/		
3		Mango	*Mangifera indica* Linn.	T		/		
4		Olive	*Spondias pinnata* Kurz	T		/		
5	ANNONACEAE	Custard Apple	*Annona squamosa* Linn.	ExS/ST		/		
6		Po Khi Haed	*Miliusa lineata* Alston	T		/		
7		Yang On	*Polyalthia viridis* Craib	T		/	A	
8	APOCYNACEAE	White Cheesewood	*Alstonia scholaris* R. Br.	T	/	/		
9		Crown Flower	*Calotropis gigantea* (Linn.) R.Br.ex Ait.)	S	/	/		
10		Plumeria	*Plumeria acutifolia* Poir.	ExST		/		
11		Wrightia	*Wrightia tomentosa* Roem. & Schult.	ST		/	A	
12	ARALIACEAE	Phoei Fan	*Macropanax dispermus* Ktze.	S		/		
13	BIGNONIACEAE	Khae Hang Khang	*Fernandoa adenophylla* Steenis	T	/	/		
14		Indian Cork Tree	*Millingtonia hortensis* Linn. f.	T	/	/		
15		Phe Ka	*Oroxylum indicum* Vent.	ST		/		
16		Tree Jasmine	*Radermachera ignea* Steenis	T	/			
17		Khae Foi	*Stereospermum cylindricum* Pierre ex P. Dop.	T		/		
18		Khae Sai	*Stereospermum neuranthum* Kurz	T		/		
19	BOMBACACEAE	Ngiew	*Bombax anceps* Pierre	T		/		
20		Durian	*Durio zibethinus* Linn.	ExT		/		
21	CAPPARIDACEAE	Ching Chi	*Capparis micracantha* DC.	S/ST		/		
22	CARICACEAE	Papaya	*Carica papaya* Linn.	ExST		/		
23	CASUARINACEAE	Son Pradi Phat	*Casuarina junghuhniana* Mig.	T	/	/		
24		Australian pine tree	*Casuarina equisetifalia* J. R. & C. Forst.	T		/		

TABLE 4.2.1-2

LIST OF FLORA IN THE PROJECT AREA AND THE STUDY AREA (Cont'd)

No.	Family	Common Name	Scientific Name	Habit	Survey Area		Type of Prohibited Wood	Rare and Near Threatened Wood
					Project Area	Study Area		
25	COMBRETACEAE	Samo Phiphek	*Terminalia bellerica* Roxb.	T		/	A	
26		Hu Kwang	*Terminalia catappa* Linn.	T		/		
27		Tabaek Lueat	*Terminalia corticosa* Pierre ex Laness.	T		/	A	
28		Hu Krachong	*Terminalia ivoriensis* A. Chev.	T		/		
29	COMPOSITAE	Sap Suea	*Eupatorium odoratum* Linn.	ExH	/			
30	DIPTEROCARPACEAE	Yang Na	*Dipterocarpus alatus* Roxb.	T		/		
31		Phayom	*Shorea roxburghii* G. Don	T		/	A	
32	EUPHORBIACEAE	Croton	*Codiaeum variegatum* Bl.	ExS	/			
33		Nam Nom Ratchasi	*Euphorbia hirta* Linn.	H		/		
34		Para Rubber	*Hevea brasiliensis* Muell. Arg.	ExT		/		
35		Makai Khat	*Mallotus philippensis* Muell. Arg.	ST		/		
36		Cassava	*Manihot esculenta* Crantz	ExS/ST	/	/		
37		Khun Thong Paya Bad	*Suregada multiflorum* Baill.	S/ST	/	/		
38	FABACEAE	Kra Thin Narong	*Acacia auriculaeformis* Cunn.	ExT	/			
39		Kra Thin The Pha	*Acacia mangium* Wild.	T	/	/		
40		Phak Lae	*Acacia megaladena* Desv.	C		/		
41		Maklam Ton	*Adenanthera pavonina* Linn.	T		/	A	
42		Makha Mong	*Afzelia xylocarpa* Craib	T		/	A	
43		Siao Khruea	*Bauhinia glauca* Wall. ex Benth. subsp. tenuiflora K. & S. Larsen	C		/		
44		Ya Nang Daeng	*Bauhinia strychnifolia* Craib	C	/			NT
45		Hang Nok Yung Thai	*Caesalpinia pulcherrima* Sw.	ExS	/			
46		Chumhet Thet	*Cassia alata* Linn.	ExS		/		
47		Khun	*Cassia fistula* Linn.	T		/	A	
48		Khi Lek American	*Cassia floribunda* Cav.	ExT		/		

TABLE 4.2.1-2

LIST OF FLORA IN THE PROJECT AREA AND THE STUDY AREA (Cont'd)

No.	Family	Common Name	Scientific Name	Habit	Survey Area		Type of Prohibited Wood	Rare and Near Threatened Wood
					Project Area	Study Area		
49		Sano Noi	Cassia mimosoides Linn.	US		/		
50		Khi Lek Thai	Cassia siamea Britt.	T	/	/		
52		Khi Lek Lueat	Cassia timoriensis DC.	ST		/		
53		Butterfly Pea	Clitoria ternatea Linn.	ExC	/			
54		Hang Nok Yung Farang	Delonix regia Raf.	ExT		/		
55		Siao	Desmodium renifolium Schindl. var. oblatum Ohashi	US		/		
56		Kra Thin Yak	Leucaena leucocephala de Wit	S/ST	/	/		
57		Maiyarap Loei	Mimosa pigra Linn.	ExH	/			
58		A Rang	Peltophorum dasyrachis Kurz	T		/	A	
59		Nonsi	Peltophorum pterocarpum Back. ex Heyne	T		/	A	
60		Makham Thet	Pithecellobium dulce Benth.	ExT		/		
61		Pra Du	Pterocarpus macrocarpus Kurz	T	/	/	A	
62		Cham Churi	Samanea saman Merr.	T		/		
63		Khae Ban	Sesbania grandiflora Desv.	ExST	/			
64		Sano Lek	Smithia sensitiva Ait.	H		/		
65		Tamarind	Tamarindus indica Linn.	T	/	/		
66	FLACOURTIACEAE	Krabao	Hydnocarpus calvipetalus Craib	T		/		
67	GRAMINEAE	Ya Oo	Arundo donax Linn.	G	/			
68		Ya Kha	Imperata cylindrica Beauv.	G	/			
70		Tong Kong	Thysanolaena maxima Ktze.	G	/			
71	GUTTIFERAE	Tiew	Cratoxylum cochinchinense Bl.	T		/		
72		Chamuang	Garcinia cowa Roxb.	ST		/	A	
73		Mangosteen	Garcinia mangostana Linn.	ExT		/		
74	IXONANTHACEAE	Kra Bok	Irvingia malayana Oliv. ex A. Benn.	T		/	A	
75	LAMIACEAE	Teak	Tectona grandis Linn. f.	T		/		

TABLE 4.2.1-2
LIST OF FLORA IN THE PROJECT AREA AND THE STUDY AREA (Cont'd)

No.	Family	Common Name	Scientific Name	Habit	Survey Area		Type of Prohibited Wood	Rare and Near Threatened Wood
					Project Area	Study Area		
76		Tin Nok	Vitex pinnata Linn.	T		/	A	
77		Maduk	Beilschmiedia roxburghiana Nees	ST		/		
78		Mi Men	Litsea glutinosa C.B. Robinson	T	/	/	A	
79		Sathip Dong	Phoebe paniculata Nees	T		/		
80	LYTHRACEAE	Inthanin Bok	Lagerstroemia macrocarpa Wall.	T		/		
81		Inthanin Nam	Lagerstroemia speciosa Pers.	T		/		
82		Salao	Lagerstroemia tomentosa Presl	T		/		
83	MALVACEAE	Roselle	Hibiscus sabdariffa Linn.	ExH		/		
84		Ya Khat Mon	Sida rhombifolia Linn.	US		/		
85	MELIACEAE	Long Kong	Aglaia dookkoo Griff.	T		/		
86		Sadao	Azadirachta indica Juss. var. siamensis Valeton	T	/	/	A	
87	MORACEAE	Sa Ke	Artocarpus altilis Fosberg	ExT		/		
88		Khanun Ban	Artocarpus heterophyllus Lamk.	ExT	/	/		
89		Hat	Artocarpus lakoocha Roxb.	T		/		
90		Khanun Pa	Artocarpus lanceifolius Roxb.	T		/	A	
91		Krang	Ficus altissima Bl.	T		/		
92		Sai Yoi	Ficus benjamina Linn.	T		/		
93		Maduea Plong	Ficus hispida Linn. f.	ST		/		
94		Maduea Uthumphon	Ficus racemosa Linn.	T		/		
95		Khoi	Streblus asper Lour.	T	/	/		
96	MUSACEAE	Banana	Musa acuminata Colla	H		/		
97	MYRISTICACEAE	Kruai Pa	Horsfieldia macrocoma Warb. var. canariodes Sincl.	T		/		
98	MYRSINACEAE	Lep Muea Nang	Aegiceras corniculatum Blanco	S		/		
99	MYRTACEAE	Eucalyptus	Eucalyptus globulus Labill.	T	/	/		
100		Wa	Eugenia cumini Druce	T	/		A	

TABLE 4.2.1-2

LIST OF FLORA IN THE PROJECT AREA AND THE STUDY AREA (Cont'd)

No.	Family	Common Name	Scientific Name	Habit	Survey Area		Type of Prohibited Wood	Rare and Near Threatened Wood
					Project Area	Study Area		
101		Rose Apple	Eugenia siamensis Craib	T		/		
102		Guava	Psidium guajava Linn.	ExST		/		
103	OXALIDACEAE	Maiyarap Ton	Biophytum sensitivum DC.	H	/			
104	PALMAE	Toddy Palm	Borassus flabellifer Linn.	ExP	/			
105		Whai	Calamus diepenhorstii Miq.	CP		/		
106		Mak Lueang	Chrysalidocarpus lutescens Wendl.	ExP		/		
107		Coconut	Cocos nucifera Linn.	ExP		/		
108		Oil Palm	Elaeis guineensis Jacq.	P		/		
109		Khueang	Wallichia caryotoides Roxb.	P		/		
110	PASSIFLORACEAE	Ka Thok Rok	Passiflora foetida Linn.	HC	/			
111	POACEAE	Phai Si Suk	Bambusa blumeana Schult.	B		/		
112		Phai Bong	Bambusa nutans Wall. Ex Munro	B		/		
113		Phai Tong	Dendrocalamus asper Back.	B		/		
114		Phai Chang	Dendrocalamus strictus (Roxb.) Nees	B		/		
115		Phai Rai	Gigantochloa albociliata Munro	B		/		
116		Phai Ruak	Thyrsostachys siamensis Gamble	B		/		
117	RHAMNACEAE	Monkey Apple	Zizyphus mauritiana Lamk.	ST	/	/		
118	RHIZOPHORACEAE	Chiang Phra Nang Ae	Carallia brachiata Merr.	T		/	A	
119	ROSACEAE	Ma Phok	Parinari anamense Hance	T		/	A	
120	RUBIACEAE	Ta Ku	Anthocephalus chinensis Rich. ex Walp.	T		/		
121		Yo Ban	Morinda citrifolia Linn.	ST		/		
122	RUTACEAE	Kaffir Lime	Citrus hystrix DC.	ST		/		
123		Kaeo	Murraya paniculata Jack	S/ST		/		
124	SAPINDACEAE	Mahuat	Lepisanthes rubiginosa Leenh.	ST		/		
125		kho Laen	Nephelium hypoleucum Kurz	T		/	A	

TABLE 4.2.1-2

LIST OF FLORA IN THE PROJECT AREA AND THE STUDY AREA (Cont'd)

No.	Family	Common Name	Scientific Name	Habit	Survey Area		Type of Prohibited Wood	Rare and Near Threatened Wood
					Project Area	Study Area		
126		Lam Yai Pa	Paranephelium longifoliolatum Lec.	T		/		
127		Takhro	Schleichera oleosa Merr.	T		/	A	
128	SAPOTACEAE	Phikun	Mimusops elengi Linn.	T		/	A	
129	SOLANACEAE	Ma Khuea Ton	Solanum wrightii Benth.	ExST		/		
130	STERCULIACEAE	Khanan	Pterospermum acerifolium Willd.	T		/		
131		Ma Mao Sai	Antidesma sootepense Craib	S/ST		/		
132	TILIACEAE	Kra Chao	Corchorus aestuans Linn.	H		/		
133		Phlap Phla	Grewia paniculata Roxb.	T		/		
134	ULMACEAE	Phang Rae	Trema angustifolia Bl.	ST	/	/		
135	VERBENACEAE	Phakha Krong	Lantana camara Linn.	ExC		/		

Remark: / = Plant found during survey

Habit

AgH : Aquatic Herb
AgF : Aquatic Fern
B : Bamboo
C : Climber
G : Grass
H : Herb ไ
P : Palm
S : Shrub
T : Tree
CP : Climbing Palm
CrH : Creeping Herb

Ex : Exotic
ExH : Exotic Herb
ExT : Exotic Tree
ST : Shrubby Tree
HC : Herbaceous Climber
PaHC : Parasitic Herbaceous Climber
PaS : Parasitic Shrub
US : Undershrub

Source: Survey by TEAM Consulting Engineering and Management Ltd. During 24-26 February 2016

- **Study Area (within 5-km Radius from the Project Area)**

No plant community exists in the study area (within 5-km radius from the project area). Land uses comprise community, government offices, industrial estates, reservoirs, agricultural area, etc. Wild plants which are sparsely grown along roadsides only include Kra Bok (*Irvingia malayana* Oliv. ex A. Benn.), Hog Plum (*Spondias pinnata* Kurz), Wrightia (*Wrightia tomentosa* Roem. & Schult.), Khae Hang Khang (*Fernandoa adenophylla* Steenis), Phe Ka (*Oroxylum indicum* Vent.), Ngiew (*Bombax anceps* Pierre), Khun Thong Phaya Bad (*Suregada multiflorum* Baill.), Maklam Ton (*Adenanthera pavonina* Linn.), Chamuang (*Garcinia cowa* Roxb.), etc. Economic crops are Para Rubber (*Hevea brasiliensis* Muell. Arg.), Coconut (*Cocos nucifera* Linn.), and Cashew (*Anacardium occidentale* L.). Fruit trees cultivated around households are Durian (*Durio zibethinus* Linn.), Papaya (*Carica papaya* Linn.), Tamarind (*Tamarindus indica* Linn.), Mangosteen (*Garcinia mangostana* Linn.), Jack Fruit (Khanun Ban) (*Artocarpus heterophyllus* Lamk.), Rose Apple (*Eugenia siamensis* Craib), Guava (*Psidium guajava* Linn.), etc. Ornamental plants are Plumeria (*Plumeria acutifolia* Poir.), Hu Kwang (*Terminalia catappa* Linn.), Hu Kra Chong (*Terminalia ivoriensis* A. Chev.), Khun (*Cassia fistula* Linn.), Non Si (*Peltophorum pterocarpum* Back. ex Heyne), etc. Five species of bamboos in the study area are Phai Bong (*Bambusa nutans* Wall. Ex Munro), Phai Si Suk (*Bambusa blumeana* Schult.), Phai Sang (*Dendrocalamus strictus* (Roxb.) Nees), Phai Rai (*Gigantochloa albociliata* Munro), and Phai Ruak (*Thyrsostachys siamensis* Gamble). The undergrowth and grasses are Garden spurge (*Euphorbia hirta* Linn.), Ya Khat Mon (*Sida rhombifolia* Linn.), etc. List of plants in the project area is presented in **Table 4.2.1-2** and examples of plants found in the project area in **Photo 4.2.1-2**.

(c) Plant Status in Study Area

The survey of plant status in the project area and within the 5-km radius from the project location was conducted based on the rare and near threatened plants in the Thailand pursuant to the Royal Decree on Determination of Prohibited Wood B.E. 2530 (1987). The survey results are summarized below.

- **Rare and Near Threatened Plants in Thailand**: In the project area and its radius of 5 km, Ya Nang Daeng (*Bauhinia strychnifolia* Craib) is the only one near threatened plant found.

- **Pursuant to the Royal Decree on Determination of Prohibited Wood B.E. 2530 (1987),** 23 species of prohibited wood Type A, no species of prohibited wood Type B, and 112 species of other wood types are found. Some of prohibited wood Type A discovered in the study area include Yang On (*Polyalthia viridis* Craib), Mok Man (*Wrightia tomentosa* Roem. & Schult.), Samo Phiphek (*Terminalia bellerica* Roxb.), Phayom (*Shorea roxburghii* G. Don), Makha Mong (*Afzelia xylocarpa* Craib), Pra Du (*Pterocarpus macrocarpus* Kurz), Kra Bok (*Irvingia malayana* Oliv. ex A. Benn.), Ma Phok (*Parinari anamense* Hance), Phikun (*Mimusops elengi* Linn.), Takhro (*Schleichera oleosa* Merr.), etc.

4.2.1.2 Wildlife Resources

(1) Introduction

The project implementation may impact on wild animals, which are a component of ecosystem. As a consequence, apart from the importance of forest resources, it is necessary to study wildlife resources in aspects of diversity, population size, habitat, and distribution in order to analyze and estimate probable impacts on wildlife which will be used as a guideline to minimize the impacts on wildlife and to develop the impact mitigation measures.

(2) Methodology

Survey of wild animals and study of ecological conditions in the project area and the 5-km radius study area were undertaken during 24^{th}-26^{th} February 2016. The study focused on four classes of vertebrates, i.e. mammal, bird, reptile, and amphibian, covering diversity of species, population size, abundance, habitat, and distribution in the project area and the 5-km radius study area. Status of wildlife residing or using resources in the study area was also studied by using the following methods.

(a) Collection of Field Data: Direct searching method and indirect inquiring method were employed.

- **Direct Searching Method**: This method was conducted by walking throughout the survey locations during daytime to record wildlife species discovered in the study area, as well as encounter rates of individual animals and their traces, e.g. tracks, feces, hair, eggs, nests, hollows, carcasses, and sounds.
- **Indirect Inquiring Method**: Local people living near the project area were inquired about animal species and the period of the day wild animals coming to the project area. These data would be used to complement the direct searching data. Inquiries also covered hunting and uses of wild animals by local people.

(b) Population Size: Population size is estimated in the form of percentage of relative abundance. The number of encounters is compared with the number of surveys according to the method of Pettingill (1970) as follows:

$$\text{Abundance percentage} = \frac{\text{Number of Encounter}}{\text{Number of Survey}} \times 100$$

Three levels of abundance are as follows.

Abundance percentage	67-100	very common
	34-66	common
	1-33	uncommon

(c) **Survey of Wildlife Status:** There are legal status and conservation status.

Legal status refers to the following two types of wild animals protected by the Wild Animal Reservation and Protection Act B.E. 2535 (1992).

- **Reserved animals** refer to wild animals which are rare and endangered or extinct as appearing on the list attached to the Wild Animal Reservation and Protection Act B.E. 2535 (1992) (Government Gazette, 1992).
- **Protected animals** refer to wild animals which should be protected and are specified on the list attached to the Ministerial Regulations No. 4 issued under the Wild Animal Reservation and Protection Act B.E. 2535 (1992) (Government Gazette, 1994).

Other wild animals which are not included in the above two types are non-protected animals which are raised for commercial purpose. Non-protected animals also refer to those that cause economic damage or naturally are plenty in terms of quantity.

Conservation status

- According to the conservation status of biological resources in Thailand by the Office of Natural Resources and Environmental Policy and Planning (2005), this study focuses on the following five categories of threatened wild animals.
    - Critically endangered (CR)
    - Endangered (EN)
    - Vulnerable (VU)
    - Near threatened (NT)
    - Endemic (E)
- According to the IUCN Red List (2011), wild animals with decline in population number and limited degree of distribution are referred to as threatened animals. There are 3 categories as follows.
    - Critically endangered – extremely high risk of extinction in the wild in the near future
    - Endangered – high risk of extinction in the wild in the future
    - Vulnerable – high risk of endangerment in the wild

Besides, IUCN (2011) also specifies the near threatened category for the wild animals which are likely to become endangered in the near future.

(3) Study Result

(3.1) General Conditions

(a) Project Area

The project area is located in Pluak Daeng Industrial Park where no plant community is found. The project area is leveled and perennial trees, fruit trees, ornamental plants are grown. Small wild animals are common, particularly birds. However, reptiles and amphibians are also discovered. Most wild animals have low species diversity and are accustomed to human activities. They are able to adapt themselves to the changing environment. Some wild animals that are discovered in the project area are illustrated in **Photo 3.9-3**.

(b) 5-km Radius Study Area

Land uses in the study area comprise communities, built-up area, government offices, industrial estate, reservoir, farmland, etc. Small wild animals are common, particularly birds. However, reptiles and amphibians are also discovered. Most wild animals have low species diversity and are accustomed to human activities. They are able to adapt themselves to the changing environment. Some wild animals that are discovered in the 5-km radius study area are illustrated in **Photo 4.2.1-3**.

(3.2) Wildlife Diversity

As for wildlife found in the project area and the study area, there are 63 species from 37 families and 12 orders: 2 species of mammals, 45 species of birds, 10 species of reptiles, and 6 species of amphibians. List of wildlife found in the project area and the 5-km radius study area are presented in **Table 4.2.1-3**.

- **Mammals:** There are two species: variable squirrel (*Callosciurus finlaysoni*) on treetops in forests, and roof rat (*Rattus rattus*) in abandoned area and farmland.
- **Birds:** There are totally 45 species, out of which 44 species are found in every survey, especially Greater Coucal (*Centropus sinensis*), and Black Drongo (*Dicrurus macrocercus*). White-rumped Munia (*Lonchura striata*) and Scaly-breasted Munia (*Lonchura punctulata*) generally look for food in paddy fields and the project area. In addition, there are Zebra Dove (*Geopelia striata*), Indian Roller (*Coracias benghalensis*), Eurasian Tree-sparrow (*Passer montanus*), and White-vented Myna (*Acridotheres grandis*) pearching on overhead power lines.
- **Reptiles:** There are totally 10 species, 6 out of which are often found, e.g. Common Frilly Gecko (*Cosymbotus platyurus*) generally encountered in households, Variable Skink (*Mabuya macularia*), and Malayan Sun Skink (*Mabuya multifasciata*) found around households and abandoned area. The remaining 4 species are rarely found as they look for food at night, comprising Indochinese Rat Snake (*Ptyas korros*), Checkered Keelback (*Xenochrophis piscator*), Cobra (*Naja spp.*), etc.


Green Bee-eater


Red-wattled Lapwing


Rock Dove


White-vented Myna


Black-capped Shrike


Little Egret and Chinese Pond-Heron


Carcass of Indochinese Rat Snake


Garden Lizard

PHOTO 4.2.1-3 : SOME WILD ANIMALS DISCOVERED IN THE PROJECT AREA AND THE 5-KM RADIUS STUDY AREA

TABLE 4.2.1-3

LIST OF SPECIES, ABUNDANCE, AND CONSERVATION STATUS OF WILDLIFE IN THE PROJECT AREA AND THE 5-KM RADIUS STUDY AREA

No.	Order, Family, Species (Scientific Name)	Conservation Status			Data Source		Abundance in Study Area					
							Project Area			5-km Radius Area		
		Act	ONEP	IUCN	Inquiry	Encounter	Vc	Co	Un	Vc	Co	Un
Mammal												
	Rodentia											
	Sciuridae (Squirrels)											
1.	Variable squirrel (*Callosciurus finlaysoni*)	-	-	-	-	X	-	-	X	-	-	X
	Muridae (Rats and Mice)											
2.	Roof rat (*Rattus rattus*)	-	-	-	X	-	-	-	X	-	-	X
	Total (2 Species)	0	0	0	1	1	0	0	2	0	0	2
	Percentage	0.00	0.00	0.00	50.00	50.00	0.00	0.00	100.00	0.00	0.00	100.00
Bird												
	Ciconiiformes											
	Ardeidae (Herons, Bitterns, Egrest)											
1.	Little Egret (*Egretta garzetta*)	PR	-	-	-	X	-	-	X	-	X	-
2.	Chinese Pond-Heron (*Ardeola bacchus*)	PR	-	-	-	X	-	-	X	-	X	-
3.	Eastern Cattle Egret (*Bubulcus ibis*)	PR	-	-	-	X	-	-	X	-	-	X
	Ciconiidae (Storks)											
4.	Asian openbill (*Anastomus oscitans*)	PR	-	-	-	X	-	-	X	X	-	-
	Falconiformes											
	Accipitridae (Hawks, Kites, Eagles, Vultures)											
5.	Brahminy Kite (*Haliastur indus*)	PR	-	-		X	-	-	X	-	-	X
6.	Shikra (*Accipiter badius*)	PR	-	-	X	-	-	-	X	-	-	X
	Charadriiformes											
	Charadriidae (Plovers)											
7.	Red-wattled Lapwing (*Vanellus indicus*)	PR	-	-	-	X	-	-	X	-	X	-

TABLE 4.2.1-3

LIST OF SPECIES, ABUNDANCE, AND CONSERVATION STATUS OF WILDLIFE IN THE PROJECT AREA AND THE 5-KM RADIUS STUDY AREA

No.	Order, Family, Species (Scientific Name)	Conservation Status			Data Source		Abundance in Study Area					
							Project Area			5-km Radius Area		
		Act	ONEP	IUCN	Inquiry	Encounter	Vc	Co	Un	Vc	Co	Un
	Columbiformes											
	Columbidae (Doves, Pigeons)											
8.	Rock dove (*Columba livia*)	-	-	-	-	X	X	-	-	X	-	-
9.	Spotted Dove (*Streptopelia chinensis*)	-	-	-	-	X	-	X	-	-	X	-
10.	Red Collared Dove (*Streptopelia tranquebarica*)	PR	-	-	-	X	-	-	X	-	-	X
11.	Zebra dove (*Geopelia striata*)	-	-	-	-	X	-	X	-	-	-	X
	Cuculliformes											
	Cuculidae (Cuckoos)											
12.	Asian koel (*Eudynamys scolopaceus*)	PR	-	-	-	X	-	-	X	-	-	X
13.	Greater Coucal (*Centropus sinensis*)	PR	-	-	-	X	-	X	-	-	X	-
14.	Green-billed Malkoha (*Phaenicophaeus tristis*)	PR	-	-	-	X	-	-	X	-	-	X
	Coraciiformes											
	Aicedinidae (Kingfishers)											
15.	White-throated Kingfisher (*Halcyon smyrnensis*)	PR	-	-	-	X	-	X	-	-	X	-
	Meropidae (Bee-eaters)											
16.	Green Bee-eater (*Merops orientalis*)	PR	-	-	-	X	-	X	-	X	-	-
	Coraciidae (Rollers)											
17.	Indian Roller (*Coracias benghalensis*)	PR	-	-	-	X	-	-	X	-	X	-
	Piciformes											
	Megalaimidae (Barbets)											
	Lineated Barbet (*Megalaima lineata*)	PR	-	-	-	X	-	-	X	-	X	-
	Apodiformes											
	Apodidae											
19.	House Swift (*Apus nipalensis*)	PR	-	-	-	X	-	X	-	-	X	-
20.	Asian Palm Swift (*Cypsiurus balasiensis*)	PR	-	-	-	X	-	X	-	-	X	-

TABLE 4.2.1-3

LIST OF SPECIES, ABUNDANCE, AND CONSERVATION STATUS OF WILDLIFE IN THE PROJECT AREA AND THE 5-KM RADIUS STUDY AREA

No.	Order, Family, Species (Scientific Name)	Conservation Status			Data Source		Abundance in Study Area					
							Project Area			5-km Radius Area		
		Act	ONEP	IUCN	Inquiry	Encounter	Vc	Co	Un	Vc	Co	Un
	Hirundinidae (Swallows)											
21.	Barn Swallow (*Hirundo rustica*)	PR	-	-	-	X	-	-	X	X	-	-
	Artamidae											
22.	Woodswallows (Artamus fuscus)	PR	-	-	-	X	-	-	X	X	-	-
	Estrildidae											
23.	White-rumped Munia (*Lonchura striata)*	PR	-	-	-	X	-	X	-	X	-	-
24.	Scaly-breasted Munia (*Lonchura punctulata*)	PR	-	-	-	X	-	X	-	X	-	-
	Oriolidae											
25.	Common Iora (*Aegithina tiphia*)	PR	-	-	-	X	-	-	X	-	-	X
	Pycnonotidae (Bulbuls)											
	Streak-eared Bulbul *(Pycnonotus blanfordi*)	PR	-	-	-	X	-	-	X	X	-	-
	Soothy-headed Bulbul (*Pycnonotus aurigaster*)	PR	-	-	-	X	-	-	X	X	-	-
	Dicruridae (Drongos)											
28.	Balck Drongo (*Dicrurus macrocercus*)	PR	-	-	-	X	-	-	X	-	-	X
29.	Hair-crested Drongo (*Dicrurus hottentottus*)	PR	-	-	-	X	-	-	X	X	-	-
30.	Ashy Drongo (*Dicrurus leucophaeus*)	PR	-	-	-	X	-	-	X	-	-	X
	Corvidae (Crows, Jays, Magpies)											
31.	Large-billed Crow (*Corvus macrorhynchos*)	PR	-	-	-	X	-	-	X	-	-	X
32.	Pied Fantail *(Rhipidura javanica)*	PR	-	-	-	X	-	-	X	-	-	X
	Sylviidae (Old World Warblers)											
33.	Plain Prinia (Prinia inornata)	PR	-	-	-	X	-	-	X	-	X	-
34.	Common Tailorbird (Orthotomus sutorius)	PR	-	-	-	X	-	-	X	-	X	-
35.	Dark-necked Tailorbird (Orthotomus atrogularis)	PR	-	-	-	X	-	-	X	X	-	-
36.	Inornate Warbler (Phylloscopus inornatus)	PR	-	-	-	X	-	-	X	-	-	X
	Turdidae (Thrushes)											
	Oriental Magpie Robin (Copsychus saularis)	PR	-	-	-	X	-	X	-	-	-	X

TABLE 4.2.1-3

LIST OF SPECIES, ABUNDANCE, AND CONSERVATION STATUS OF WILDLIFE IN THE PROJECT AREA AND THE 5-KM RADIUS STUDY AREA

No.	Order, Family, Species (Scientific Name)	Conservation Status			Data Source		Abundance in Study Area					
							Project Area			5-km Radius Area		
		Act	ONEP	IUCN	Inquiry	Encounter	Vc	Co	Un	Vc	Co	Un
	Sturnidae (Starlings, Mynas)											
38.	Common Myna (Acridotheres tristis)	PR	-	-	-	X	-	-	X	X	-	-
39.	White-vented Myna (Acridotheres javanicus)	PR	-	-	-	X	-	-	X	X	-	-
	Nectariniidae (Sunbirds, Spiderhunters)											
40.	Olive-backed Sunbird (Nectarinia jugularis)	PR	-	-	-	X	-	-	X	-	X	-
	Dicaeidae (Flowerpeckers)											
41.	Scarlet-backed Flowerpecker (Dicaeum cruentatum)	PR	-	-	-	X	-	-	X	-	X	-
	Passeridae (Spallows)											
42.	Eurasian Tree-Sparrow (Passer montanus)	-	-	-	-	X	-	X	-	X	-	-
43.	Eastern Stonechat (Saxicola maurus)	PR	-	-	-	X	-	-	X	-	X	-
	Motacillidae											
	Paddyfield Pipit (Anthus rufulus)	PR	-	-	-	X	-	-	X	-	X	-
	Laniidae											
45.	Black-capped Shrike (Lanius schach)	PR	-	-	-	X	-	-	X	-	-	X
	Total (45 species)	**41**	**0**	**0**	**1**	**44**	**1**	**11**	**33**	**14**	**16**	**15**
	Percentage	**91.11**	**0.00**	**0.00**	**2.22**	**97.78**	**2.22**	**24.44**	**73.33**	**31.11**	**35.56**	**33.33**
Reptile												
	Squamata - Suborder Sauria (Lacertilia)											
	Gekkonidae (Geckos)											
1.	Garnot's House Gecko (*Hemidactylus garnotii*)	-	-	-	-	X	-	X	-	-	X	-
2.	Common Frilly Gecko (*Cosymbotus platyurus*)	-	-	-	-	X	-	-	X	X	-	-
	Agamidae (Agamid Liazrds)											
3	Garden Lizard (*Calotes mystaceus*)	PR	-	-	-	X	-	-	X	-	-	X
4	Butterfly lizard (*Leiolepis belliana*)	-	-	-	-	X	-	-	X	-	-	X
	Scincidae (Skinks)											
5.	Variable Skink (*Mabuya macularia*)	-	-	-	-	X	-	X	-	-	X	-

TABLE 4.2.1-3

LIST OF SPECIES, ABUNDANCE, AND CONSERVATION STATUS OF WILDLIFE IN THE PROJECT AREA AND THE 5-KM RADIUS STUDY AREA

No.	Order, Family, Species (Scientific Name)	Conservation Status			Data Source		Abundance in Study Area					
							Project Area			5-km Radius Area		
		Act	ONEP	IUCN	Inquiry	Encounter	Vc	Co	Un	Vc	Co	Un
6.	Malayan Sun Skink (*Mabuya multifasciata*)	-	-	-	-	X	-	X	-	-	X	-
	Varanidae (Monitor Lizards)											
7.	Water monitor (*Varanus salvator*)	PR	-	-	X	-	-	-	X	-	-	X
	Squamata - Suborder Serpentes (Ophidia)											
	Colubridae (Colubrid Snakes)											
8.	Indochinese rat snake (*Ptyas korros*)	PR	-	-	X	-	-	X	-	-	X	-
9.	Checkered Keelback (*Xenochrophis piscator*)	-	-	-	X	-	-	-	X	-	-	X
	Elapidae (Elapid Snakes)											
10.	Cobra (*Naja kaouthia*)	-	-	-	X	-	-	-	X	-	-	X
	Total (10 species)	**3**	**0**	**0**	**4**	**6**	**0**	**4**	**6**	**1**	**4**	**5**
	Percentage	**30.00**	**0.00**	**0.00**	**40.00**	**60.00**	**0.00**	**40.00**	**60.00**	**10.00**	**40.00**	**50.00**
Amphibian												
	Anutra (Salientia)											
	Bufonidae (Typical Toads)											
1.	Asian common toad (*Duttaphrynus melanostictus*)	-	-	-	-	X	-	-	X	-	X	-
	Microhylidae											
2.	Asiatic burrowing frog (*Kaloula pulchra*)	-	-	-	-	X	-	-	X	-	X	-
	Ranidae (Typical Frogs)											
3.	Common puddle frog (*Occidozyga lima*)	-	-	-	-	X	-	-	X	-	-	X
4.	Green paddy frog (*Hylarana erythraea*)	-	-	-	-	X	-	-	X	-	-	X
5.	Dark-sided Frog (*Hylarana nigrovittata*)	-	-	-	-	X	-	-	X	-	-	X
	Rhacophoridae (Old World Tree Frogs)											
6.	Common tree frog (*Polypedates leucomystax*)	-	-	-	-	X	-	-	X	-	-	X
	Total (6 species)	**0**	**0**	**0**	**0**	**6**	**0**	**0**	**6**	**0**	**2**	**4**

TABLE 4.2.1-3

LIST OF SPECIES, ABUNDANCE, AND CONSERVATION STATUS OF WILDLIFE IN THE PROJECT AREA AND THE 5-KM RADIUS STUDY AREA

No.	Order, Family, Species (Scientific Name)	Conservation Status			Data Source		Abundance in Study Area					
							Project Area			5-km Radius Area		
		Act	ONEP	IUCN	Inquiry	Encounter	Vc	Co	Un	Vc	Co	Un
	Percentage	0.00	0.00	0.00	0.00	100.00	0.00	0.00	100.00	0.00	33.33	66.67
	Grand Total (63 species)	44	0	0	6	57	1	15	47	15	22	26
	Percentage	69.84	0.00	0.00	9.52	90.48	1.59	23.81	74.60	23.81	34.92	41.27

Remark: **Data Source** 1. Indirect inquiring method and secondary data collection 2. Data from direct searching method

Wildlife Abundance 1. Vc : Very common 2. Co : Common 3. Un : Uncommon

Wildlife Migration 1. R : Resident Bird 2. M : Migrtion Bird

Impact on Wildlife 1. Negative impact 2. Positive impact 3. Adaptable wild animal

Wildlife Status 1.) Legal status pursuant to the Wild Animal Reservation and Protection Act B.E. 2535 (1992)

1. PR : Protected animal 2. RE : Reserved animal 3. - : Non-Protected animal

2.) Conservation status according to IUCN 2011

Cr : Critical Endangered species En : Endangered species Vu : Vulnerable species

Nt : near threatened - : Non-Protected animal

3.) Conservation status according to ONEP, 2005

Cr : Critical Endangered species En : Endangered species Vu : Vulnerable species

Nt : Near threatened - : Non-Protected animal

Source: Field survey by TEAM Consulting Engineering and Management Ltd., February 2016

- **Amphibians:** There are totally 6 species usually found in open area, abandoned area, forest area, and small water bodies. Some amphibians discovered in the study area include Common Puddle Frog (*Occidozyga lima*), Asian Common Toad (*Duttaphrynus melanostictus*), Common Tree Frog (*Polypedates leucomystax*), Asiatic Burrowing Frog (*Kaloula pulchra*), etc. Diversity of wild animals in the project area and the study area can be summarized in **Table 4.2.1-4**.

TABLE 4.2.1-4

DIVERSITY AND ABUNDANCE OF WILD ANIMALS IN THE PROJECT AREA AND THE 5-KM RADIUS STUDY AREA

Class	Species	Family	Order	Level of Abundance (Species) in the Project Area			Level of Abundance (Species) in the 5-km Radius Study Area		
				Uncommon	Common	Very Common	Uncommon	Common	Very Common
Mammal	2	2	1	2	0	0	2	0	0
Bird	45	26	8	33	11	1	15	16	14
Reptile	10	6	2	6	4	0	5	4	1
Amphibian	6	4	1	6	0	0	4	2	0
Total	**63**	**38**	**12**	**47**	**15**	**1**	**26**	**22**	**15**

Source: Field survey by TEAM Consulting Engineering and Management Ltd. during 24th-26th February 2016

(3.3) Level of Abundance

Wildlife abundance in the project area and the 5-km radius study area can be summarized in **Table 4.2.1-4** and details are narrated below.

(a) Project Area

- Rock Dove *(Columba livia)* is the only one species which is very common in the project area.
- Fifteen species of animals are common in the project area, including 11 species of birds (e.g. Zebra Dove *(Geopelia striata)*, Greater Coucal (*Centropus sinensis*), Green Bee-eater (*Merops orientalis*), and House Swift *(Apus nipalensis)*), and 4 species of reptiles (e.g. Garnot's House Gecko (*Hemidactylus garnotii*), Variable Skink (*Mabuya macularia*), and Malayan Sun Skink (*Mabuya multifasciata*)).
- 47 species of animals are uncommon in the project area, comprising 2 species of mammals (e.g. variable squirrel (*Callosciurus finlaysoni*), and roof rat (*Rattus rattus*)); 33 species of birds (e.g. Asian Koel (*Eudynamys scolopaceus*), Green-billed Malkoha (*Phaenicophaeus tristis*), Indian Roller (*Coracias benghalensis*), Lineated Barbet (*Megalaima lineata*), Streak-eared Bulbul (*Pycnonotus blanfordi*), etc.); 6 species of reptiles (e.g. Common Frilly Gecko (*Cosymbotus platyurus*), Garden Lizard (*Calotes mystaceus*), Cobra *(Naja*

kaouthia), etc.); and 6 species of amphibians (e.g. Asian Common Toad (*Duttaphrynus melanostictus*), Asiatic Burrowing Frog (*Kaloula pulchra*), and Common Tree Frog (*Polypedates leucomystax*)).

(b) 5-km Radius Study Area

- 15 species of birds are very common in the study area, e.g. Asian Openbill (*Anastomus oscitans*), Spotted Dove (*Streptopelia chinensis*), Green Bee-eater (*Merops orientalis*), Woodswallow (Artamus fuscus), etc. Common Frilly Gecko (*Cosymbotus platyurus*) is the only species of reptile that is very common in the study area.
- 22 species of animals are common in the study area, including 16 species of birds (e.g. Little Egret (*Egretta garzetta*), Chinese Pond-Heron (*Ardeola bacchus*), Red-wattled Lapwing (*Vanellus indicus*), etc.); 4 species of reptiles (e.g. Garnot's House Gecko (*Hemidactylus garnotii*), Variable Skink (*Mabuya macularia*), Malayan Sun Skink (*Mabuya multifasciata*), etc.); and 2 species of amphibians (e.g. Asian Common Toad *(Duttaphrynus melanostictus)* and Asiatic Burrowing Frog (*Kaloula pulchra*).
- 26 species of animals are common in the study area, including 15 species of birds (e.g. Eastern Cattle Egret (*Bubulcus ibis*), Brahminy Kite (*Haliastur indus*), Shikra (*Accipiter badius*), and Green-billed Malkoha (*Phaenicophaeus tristis*); 5 species of reptiles (e.g. Garden Lizard (*Calotes mystaceus*), Water Monitor (*Varanus salvator*), Butterfly Lizard (Leiolepis belliana), etc.); 4 species of amphibians (e.g. Common Puddle Frog (*Occidozyga lima*), Green Paddy Frog (*Hylarana erythraea*), Dark-sided Frog (*Hylarana nigrovittata*), etc.); and 2 species of mammals (e.g. variable squirrel (*Callosciurus finlaysoni*), and roof rat (*Rattus rattus*)).

(3.4) Wildlife Status

There are 3 categories of wildlife status: legal status pursuant to the Wild Animal Reservation and Protection Act B.E. 2535 (1992); conservation status based on the criteria of the International Union Conservation of Nature; IUCN (2011); and status of biological resources in Thailand by the Office of Natural Resources and Environmental Policy and Planning. No reserved or endangered animal is found.

As for the legal status of the total four classes of vertebrates in the project area and the 5-km radius study area, 44 species of wildlife are protected animals, 41 of which are birds (e.g. Indian Roller (*Coracias benghalensis*), White-throated Kingfisher (*Halcyon smyrnensis*), Barn Swallow (*Hirundo rustica*), Streak-eared Bulbul (*Pycnonotus blanfordi*), and Soothy-headed Bulbul (*Pycnonotus aurigaster*)); and 3 are reptiles (e.g. Garden Lizard (*Calotes mystaceus*), Water Monitor (*Varanus salvator*), and Indochinese Rat Snake (*Ptyas korros*)). Six species of amphibians and 3 species of mammals are non-protected animals according to the Wild Animal Reservation and Protection Act B.E. 2535 (1992). Wildlife status is presented in **Table 4.2.1-5**.

TABLE 4.2.1-5
CONSERVATION STATUS AND LEGAL STATUS OF WILD ANIMALS IN THE PROJECT AREA AND THE 5-KM RADIUS STUDY AREA

Class	Conservation Status (Species)								Legal Status (P) (Species)
	ONEP				IUCN				
	CR	EN	VU	NT	CR	EN	VU	NT	
Mammal	0	0	0	0	0	0	0	0	0
Bird	0	0	0	0	0	0	0	0	41
Reptile	0	0	0	0	0	0	0	0	3
Amphibian	0	0	0	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**44**
Grand Total	**0**				**0**				**44**

Remark: Legal Status (Wild Animal Reservation and Protection Act B.E. 2535 (1992))
P : Protected Animal
Conservation Status (Red Data of Thailand, by Office of Natural Resources and Environmental Policy and Planning)
CR : Critically endangered
EN : Endangered
VU :Vulnerable
NT : Near Threatened
Conservation Status by International Union Conservation of Nature; IUCN (2011)
CR : Critically endangered
EN : Endangered
VU :Vulnerable
NT :Near Threatened

Regarding the conservation status of vertebrates according to the Thailand Red Data by the Office of Natural Resources and Environmental Policy and Planning, no animal in the project area and the 5-km radius study area falls into this status as presented in **Table 4.2.1-5**.

No animal in the project area and the 5-km radius study area falls into the conservation status of IUCN (2011) as presented in **Table 4.2.1-5**.

(3.5) Relationship with Habitat

The distribution of four classes of vertebrates in the project area is not regular. The species distribution of amphibians and mammals is narrow and they can be found at water bodies, wasteland, and open area. Distribution of reptiles is widespread as they are highly adaptable to the changing environment and thus found in nearly everywhere. Birds are the most common in the project area as they have high mobility. They can easily move from the project area to the surrounding area. Other classes of vertebrates have lower mobility than birds but they have higher reproductive rates and their species distribution is found throughout the area.

4.2.2 Aquatic Ecology

(1) Intruduction

The project construction activities will impact on water resources in the form of turbidity, further affecting aquatic organisms. Therefore, it is necessary to study the existing conditions of water resources and biological resources in the project area in order to assess the project impacts and to suggest suitable environmental impact prevention and mitigation measures.

(2) Methodology

(a) Collection of Secondary Data

Secondary data on aquatic ecology of surface water in the project area and its surroundings were collected from the Cooling Water Impact Assessment Report of the Power Plants in Pluak Daeng Industrial Park Project (December 2015).

(b) Field Survey

Aquatic ecology sampling was conducted at 4 stations which were the same stations for surfacewater sampling to represent the wet and dry seasons, using the following methods.

Plankton Sampling

20 liters of water were collected at the depth of 0-30 cm from the water surface via the plankton net with the mesh size of 70 µm for phytoplankton and the mesh size of 120 µm for zooplankton. The collected samples were contained in the bottles. 5% formalin solution was added to preserve the samples for further analysis of species and abundance at the laboratory of the Faculty of Fisheries, Kasetsart University (Bang Khen Campus).

Plankton density was reported in cell/m^3 unit and analysis of plankton species was made with reference to the documents prepared by Ladda Wongrat (1999), Smith (1950), Mizuno (1969), Carr and Whitton (1973), and Bold and Wynne (1978).

Diversity of plankton was computed by using the formula of Schannon-Weiner Diversity Index (1963) as follows.

$$H' = -\sum_{i=1}^{s}(n_i / n)\ell n(n_i / n)$$

Where H' = Diversity Index
s = Number of species
n = Total density of all species
n_i = Density of each species

The result of plankton diversity indicated water quality according to the following standards (Wilhm and Dorris, 1968).

H′	<	1.0	Water quality is low and not suitable for aquatic organisms to live.
H′	=	1.0-3.0	Water quality is at medium level and fairly suitable for aquatic organisms to live.
H′	>	3.0	Water quality is high to very high, and very suitable for aquatic organisms to live.

Benthos Sampling

Ekman dredge with a sampling area of 0.25 square foot was used in benthos sampling in Huai Phu Sai. Sampling was conducted three replications at each station, totaling 0.75 square feet of sampling area. The collected samples were then sorted out through the sieves with 450 µm and 850 µm mesh sized. The retained organisms were contained in the bottles and preserved with 7% formalin solution for further analysis of species and density at the laboratory of the Faculty of Fisheries, Kasetsart University (Bang Khen Campus).

Benthos density was reported in a unit of individual/square meter. Analysis of benthic fauna was made with reference to the documents prepared by Prachuab Lamubol (1982), Suphavadee Jullasorn (1982), Saowapha Angsuphanich (1985), Brinkurst (1971), Brandt (1974), Merritt and Cummins (1984), and Williams and Felmate (1992).

(c) Fishery Activity Survey

Survey of fishery activities was conducted at water resources in the project area, including fish cage aquaculture.

(3) Study Result

(a) Collection of Secondary Data

According to the aquatic ecology survey in the Cooling Water Impact Assessment Report of the Power Plants in Pluak Daeng Industrial Park Project (December 2015), samples were collected for analysis of phytoplankton, zooplankton, benthos, fish eggs and larvae. APHA-AWWA-WEE (1995) standard methods were used in sampling.

Sampling was carried out at the following 5 stations which were the same stations for surface water sampling as presented in **Figure 4.1.8-2**.

Station 1: Huai Phu Sai-4 km upstream of Pluak Daeng Power Plant
Station 2: Huai Phu Sai in front of Pluak Daeng Power Plant
Station 3: Huai Phu Sai-3 km downstream of Pluak Daeng Power Plant
Station 4: Dok Krai reservoir-about 1 km far from the mouth of Huai Phu Sai

Station 5: Dok Krai reservoir-about 2 km far from the mouth of Huai Phu Sai

The study results are summarized below.

(a1) Phytoplankton

Station 1 Huai Phu Sai-4 km upstream of Pluak Daeng Power Plant: 12 species of phytoplankton were found with the total density of 423,000 cells/m^3 and the diversity index of 0.91. Based on the phytoplankton abundance, *Oscillatoria sp.* was the most common species, followed by *Lyngbya sp.* and *Navicula sp.,* respectively.

Station 2 Huai Phu Sai in front of Pluak Daeng Power Plant near Ban Nong Krarok Weir: 6 species of phytoplankton were found with the total density of 29,760 cells/m^3 and the diversity index of 1.58. *Oscillatoria sp.* was the most common species, followed by *Aulacoseira granulata* and *Navicula sp.,* respectively.

Station 3 Huai Phu Sai-3 km downstream of Pluak Daeng Power Plant: 12 species of phytoplankton were discovered with the total density of 4,800,000 cells/m^3 and the diversity index of 0.12. *Oscillatoria sp.* was the most common species, followed by *Mycocysits aeroginosa* and *Merimopedia sp.,* respectively.

Station 4 Dok Krai reservoir-about 1 km far from the mouth of Huai Phu Sai: 8 species of phytoplankton were discovered with the total density of 1,662,820 cells/m^3 and the diversity index of 0.12. *Oscillatoria sp.* was the most common species, followed by *Raphidiopsis sp.*

Station 5 Dok Krai reservoir-about 2 km far from the mouth of Huai Phu Sai: 6 species of phytoplankton were found with the total density of 825,000 cells/m^3 and the diversity index of 0.42. *Oscillatoria sp.* was the most common species, followed by *Microcystis sp.*

According to the survey results at 5 stations, the diversity indices at Station 1 and Station 2 were higher than those of Stations 3-5. Based on the standards of Wilhm and Dorris (1968), water quality at Station 1 and Stations 3-5 was not suitable for phytoplankton. Water quality at Station 2 was suitable as the diversity index was greater than 1. The diversity index at Station 1 was less than 1 as it is located near communities and industrial zone and affected by effluent discharged therefrom. However, the diversity index at Station 1 was higher than that at Stations 3-5 which are located near farmland, communities, and golf courses and might be affected by pesticides. The diversity index at Station 2 in front of the Pluak Daeng Power Plant was higher than 1 as it is near the weir where water is abundant throughout the year. Besides, Station 2 is far from communities and industrial area, therefore, discharge water from upstream may be revived to be the better quality before reach this area.

(a2) Zooplankton

Station 1 Huai Phu Sai-4 km upstream of Pluak Daeng Power Plant: 5 species of zooplankton were found with the total density of 39,360 individuals/m^3 and the diversity index of 1.37. *Centropyxis aculeate* (Protozoa) was the most common species.

Station 2 Huai Phu Sai in front of Pluak Daeng Power Plant near Ban Nong Krarok Weir: 4 species of zooplankton were found with the total density of 9,920 individuals/m^3 and the diversity index of 1.39. All species had similar density. The most common species at this station comprised *Polyarthra* sp. and *Rotaria* sp of Phylum Rotifer; Cyclopoid Copepod of Phylum Arthropoda, and 1 species of bivalve larvae.

Station 3 Huai Phu Sai-3 km downstream of Pluak Daeng Power Plant: 11 species of zooplankton were found with the total density of 76,800 individuals/m^3 and the diversity index of 2.04. Copepod (Nauplius) and *Brachionus diversicomis* were common.

Station 4 Dok Krai reservoir-about 1 km far from the mouth of Huai Phu Sai: 12 species of zooplankton were found with the total density of 101,220 individuals/m^3 and the diversity index of 2.02. Copepod (Nauplius) was the most common, followed by *Brachionus calyciflorus.*

Station 5 Dok Krai reservoir-about 2 km far from the mouth of Huai Phu Sai: 13 species of zooplankton were found with the total density of 267,000 individuals/m^3 and the diversity index of 2.12. Copepod (Nauplius) was the most common, followed by *Brachionus falcatus.*

According to the survey results at 5 stations, the diversity indices at Huai Phu Sai and Dok Krai reservoir were greater than 1 but lower than 3 which indicated that water quality was fairly suitable for zooplankton to live (Wilhm and Dorris (1968). Zooplankton density in Dok Krai reservoir (Stations 4 and 5) was higher than that in Huai Phu Sai. Probably this was because the reservoir had high water volume throughout the year and there were dense phytoplankton and organic matters which were diet sources for zooplankton.

(a3) Benthos

Station 1 Huai Phu Sai-4 km upstream of Pluak Daeng Power Plant: 3 species of benthic fauna were discovered: Naididae of Phylum Annelida; *Melanoides* sp. of Phylum Mollusca; and *Chironomus* sp. of Phylum Arthropoda. Naididae was the most common at the station. The total density of benthos was 150 organisms/sq.m., and the diversity index was 0.90.

Station 2 Huai Phu Sai in front of Pluak Daeng Power Plant near Ban Nong Krarok Weir: 4 species of benthic fauna were discovered. The most common species was *Chironomus* sp., followed by Annelids of Naididae. The total density of benthos was 240 organisms/sq.m., and the diversity index was 0.99.

Station 3 Huai Phu Sai-3 km downstream of Pluak Daeng Power Plant: 4 species of benthic fauna were found. *Macrobrachium* sp. was the most common at this station. The total density of benthos was 75 organisms/sq.m., and the diversity index was 1.33.

Station 4 Dok Krai reservoir-about 1 km far from the mouth of Huai Phu Sai: 3 species of benthic fauna were found. *Macrobrachium* sp. was the most common at this station. The total density of benthos was 60 organisms/sq.m., and the diversity index was 1.04.

Station 5 Dok Krai reservoir-about 2 km far from the mouth of Huai Phu Sai: 3 species of benthic fauna were found. *Filopaludina* sp. was the most common at this station. The total density of benthos was 60 organisms/sq.m., and the diversity index was 1.04.

The diversity indices of benthic fauna were lower than 1 at Station 1 and Station 2 due to shallow streambed at Station 1 and coarse sand on streambed at Station 2, making it unsuitable habitat for benthos. The diversity indices of benthic fauna were greater than 1 at Stations 3-5 probably because at downstream side of Huai Phu Sai and Dok Krai reservoir there were fine sand and organic matters which were sources of diet for benthic fauna.

(a4) Fish Eggs and Larvae

Neither fish egg nor larvae were found at Station 1. This was due to shallow channel bottom, rapidly flowing current, and coarse sand, making it unsuitable for fish to deposit eggs and larval fish to inhabit. Moreover, densely-populated communities and Amata Nakorn Industrial Estate are located upstream of Huai Phu Sai. Effluent discharged from communities and the industrial estate would affect water quality at this station. According to the interview with local people, there were some fish in Huai Phu Sai such as Minnows, and Gouramis. At Station 2, fish eggs and larvae were found since it is near Wang Krarok weir which had plentiful water throughout the year and was suitable for fish to deposit eggs and inhabit. At Station 3, there was abundant water. However, due to the rapidly flowing current, fish egg was not found but only larval fish from upstream side. Both fish eggs and larval fish were found at Station 4 and Station 5. That was, 100 fish eggs per 1,000-m^3 water and 248 fish larvae per 1,000-m^3 water at Station 4; and 100 fish eggs per 1,000-m^3 water and 495 fish larvae per 1,000-m^3 water at Station 5. Both fish eggs and larvae at Station 4 and Station 5 were higher than in Huai Phu Sai. This was because of plentiful water at the two stations and abundance of phytoplankton and zooplankton for fish to feed on. It was suitable for fish to live and to deposit eggs in standing water around the edges of the reservoir.

(b) Field Survey

The Consultant conducted field survey and gathered aquatic ecology samples during 17-18 September 2015 to represent the rainy season and on 17th March 2016 to represent the dry season. The analysis results in the wet season are presented in **Tables 4.2.2-1** and **4.2.2-2**, and the analysis results in the dry season in **Tables 4.2.2-3** and **4.2.2-4**. The field survey results are summarized below.

- **Survey Results in the Wet Season**

Station 1 (SW1): about 1 km Upstream of the Discharge Point No. 1 of Pluak Daeng Industrial Park (Coordinate: 47P 0731985E 1433179N)

Phytoplankton

Phytoplankton found at this station consisted of 2 divisions (Cyanophyta and Chlorophyta), 2 classes (Cyanophycaea (blue-green algae) and Chlorophycaea (green algae)), and 9 species **(Table 4.2.2-1)**. *Eudorina elegans* was the most common species with the density of 8,400 cells/m^3, followed by *Chlamydomonas angulosa*, *Pleodorina* sp., *Oscillatoria* sp., and *Microcystis aeruginosa* with the density of 5,600 cells/m^3. The total density of phytoplankton was 42,000 cells/m^3.

Zooplankton

There were ten species of zooplankton belonging to three phyla (Arthropoda, Protozoa, and Rotifera) as shown in **Table 4.2.2-1**. Unidentified Cyclopoids and *Arcella vulgaris* in Phylum Protozoa were the most abundant with the density of 14,000 cells/m^3, followed by Copepod larvae (Nauplius) with the density of 8,400 cells/m^3. The total density of zooplankton at this station was 61,600 cells/m^3.

According to Schannon-Weiner Diversity Index (1963), phytoplankton had the diversity index of 2.12 whereas that of zooplankton was 2.08, indicating that water quality was at medium level and fairly suitable for aquatic organisms to live.

Benthic Fauna

Macrobrachium sp. in Phylum Arthropoda was found with the density of 88 organisms/sq.m. **(Table 4.2.2-2)**.

Station 2 (SW2): Discharge Point No. 1 of Pluak Daeng Industrial Park (Coordinate: 47P 0732907E 1433023N)

Phytoplankton

Phytoplankton found at this station consisted of 2 divisions (Cyanophyta and Chlorophyta), 3 classes (Cyanophycaea (blue-green algae), Chlorophycaea (green algae), and Euglenophyceae), and 10 species **(Table 4.2.2-1)**. *Volvox tertius* was the most common species with the density of 54,000 cells/m^3, followed by *Pleodorina* sp. with the density of 32,400 cells/m^3. The total density of phytoplankton was 137,700 cells/m^3.

TABLE 4.2.2-1
SPECIES COMPOSITION AND DENSITY OF PHYTOPLANKTON AND ZOOPLANKTON FROM FIELD SURVEY IN THE WET SEASON

Density (cells/m^3)

Species	Station			
	SW 1	SW 2	SW 3	SW 4
Phytoplankton				
Division Cyanophyta				
Lyngbya sp.		2,700		
Oscillatoria sp.	5,600	24,300	26,950	14,750
Rhaphidiopsis sp.	2,800		4,900	5,900
Microcystis aeruginosa	5,600	5,400		
Merismopedia tenuissima				5,900
Division Chlorophyta				
Class Chlorophyceae (Green Algae)				
Chlamydomonas angulosa	5,600			2,950
Eudorina elegans	8,400	2,700		5,900
Pandarina morum	5,600			
Pleodorina sp.		32,400	29,400	5,900
Volvox tertius		54,000	41,650	14,750
Spondylomorum quaternarium	2,800			
Pediastrum duplex			4,900	
P. simplex		2,700	2,450	
Coelastrum microporum	2,800			2,950
Closterium gracile	2,800		2,450	
C. moniliferum				2,950
Actinastrum hantzschii		5,400	4,900	
Ulothrix aequalis			2,450	
Class Euglenophyceae (Euglenoid)				
Euglena acus			2,450	
E. caudatus			4,900	2,950
E. deses			2,450	
E. fusca		2,700	4,900	
E. oxyuris		5,400	2,450	
Phacus pleuronectres			2,450	
Trachelomonas crebea				2,950
T. volvocina				11,800
Division Chromophyta				
Frustulia vulgaris				2,950
Gyrosigma sp.				2,950
Family Bacillariaceae				
Nitzschia longissima			4,900	5,900
Total Density	42,000	137,700	144,550	91,450
Number of Species	9	10	16	15
Diversity Index	**2.12**	**1.70**	**2.17**	**2.51**

TABLE 4.2.2-1
SPECIES COMPOSITION AND DENSITY OF PHYTOPLANKTON AND ZOOPLANKTON FROM FIELD SURVEY IN THE WET SEASON (Cont'd)

Density (cells/m^3)

Species	Station			
	SW 1	SW 2	SW 3	SW 4
Zooplankton				
Phylum Arthropoda				
Class Crustacea (Crustaceans)				
*Copepod larva (Nauplius)	8,400	8,100	12,250	8,850
*Unidentified Cyclopoids	14,000	2,700	2,450	
Phylum Protozoa				
Class Sarcodina				
Arcella vulgaris	14,000	2,700		5,900
A. megastoma			2,450	5,900
Centropyxis ecornis	2,800	13,500		
C. aculeata	5,600	2,700	2,450	2,950
Difflugia lobostoma	2,800		2,450	2,950
Phylum Rotifera (Rotifer)				
Class Monogononta				
Asplanchna priodonta	5,600	2,700		
Ascomorpha ecaudis			4,900	
Polyarthra vulgaris	2,800			2,950
Brachionus angularis			2,450	2,950
B. calyciflorus			2,450	
Lepadella acuminata				
Trichocerca capucina		2,700		2,950
Filinia terminaris	2,800			
F. opoliensis	2,800	2,700	2,450	
Pompholyx complanata				2,950
Horaella sp.				2,950
Class Digononta				
Rotaria sp.			2,450	
Total Density	**61,600**	**37,800**	**36,750**	**41,300**
Number of Species	**10**	**8**	**10**	**10**
Diversity Index	**2.08**	**1.83**	**2.08**	**2.21**

Remark: *Unidentified
Station SW1: About 1 km Upstream of the Discharge Point No. 1 of Pluak Daeng Industrial Park
Station SW2: Discharge Point No. 1 of Pluak Daeng Industrial Park
Station SW3: Discharge Point No. 2 of Pluak Daeng Industrial Park
Station SW4: About 500 M Downstream of Discharge Point No. 2 of Pluak Daeng Industrial Park

Source: Field Survey by TEAM Consulting Engineering and Management Ltd., September 2015

TABLE 4.2.2-2

SPECIES COMPOSITION AND DENSITY OF BENTHOS FROM FIELD SURVEY IN THE WET SEASON

Abundance (organism/sq.m.)

Species	Station			
	SW1	SW2	SW3	SW4
PHYLUM ANNELIDA				
Class Oligochaeta				
Order Plesiopora				
Family Tubificidae				
Tubifex sp.		22		
PHYLUM ARTHROPODA				
Class Insecta				
Order Diptera				
Family Chironomidae				
Ablabesmyia sp.				22
Order Hemiptera				
Family Notonectidae				
Notonecta sp.		22		
Class Malacostraca				
Order Decapoda				
Family Palaemonidae				
Macrobrachium sp.	88	88		22
Family Parathelpusidae				
Siamthelphusa sp.		66		22
PHYLUM MOLLUSCA				
Class Gastropoda				
Order Mesogastropoda				
Family Viviparidae				
Filopaludina sp.		22		
Family Bithyniidae				
Bithynia sp.		88		
Total Density	88	308	0	66
Number of Species	1	6	0	3

Remark: Channel bottom composed of clay and gravel

Source: Field Survey by TEAM Consulting Engineering and Management Ltd., September 2015

TABLE 4.2.2-3
SPECIES COMPOSITION AND DENSITY OF PHYTOPLANKTON AND ZOOPLANKTON FROM FIELD SURVEY IN THE DRY SEASON

Density (cells/m^3)

Species	Station			
	SW 1	SW 2	SW 3	SW 4
<u>Phytoplankton</u>				
Division Cyanophyta				
Oscillatoria sp.	67,200	41,700	12,800	31,800
Spirulina laxissima	16,800	6,950		
Rhaphidiopsis sp.			12,800	10,600
Microcystis aeruginosa		34,750		
Division Chlorophyta				
Class Chlorophyceae (Green Algae)				
Chlamydomonas angulosa	58,800	201,550		31,800
Eudorina elegans		90,350	115,200	21,200
Pandarina morum	688,800	3,342,950	4,492,800	31,800
Gonium pectorale	1,688,400	10,286,000	5,900,800	
Pleodorina sp.	16,800	27,800		
Spondylomorum quaternarium	16,800		6,400	
Pediastrum duplex	8,400		12,800	
P. simplex		6,950		
Coelastrum microporum	16,800	403,100	160,000	254,400
Chlororella sp.	84,000	13,900	96,000	116,600
Dictyosphaerium pluchellum		173,750	192,000	21,200
Micractinium quadrisetum		20,850		
Actinastrum hantzschii			908,800	
Scenedesmus quadricauda		6,950	249,600	
S. armatus	8,400		25,600	
S. acuminatus		34,750	1,907,200	
S. denticulatus			12,800	
S. disciformis	8,400	20,850	12,800	
Closterium acerosum	243,600	97,300	25,600	
C. gracile		6,950		
C. moniliferum	67,200	6,950	6,400	
C. praelongum	126,000	6,950		
Cosmarium laeve	8,400			

TABLE 4.2.2-3
SPECIES COMPOSITION AND DENSITY OF PHYTOPLANKTON AND ZOOPLANKTON FROM FIELD SURVEY IN THE DRY SEASON (Cont'd)

Density (cells/m^3)

Species	Station			
	SW 1	SW 2	SW 3	SW 4
Class Euglenophyceae (Euglenoid)				
Lepocinclis ovum	50,400	28,495,000	12,556,800	7,653,200
Euglena acus		486,500	19,200	678,400
E. caudatus		1,146,750	38,400	657,200
E. deses		264,100		
E. fusca		97,300		689,000
E. ehrenbergii	8,400	69,500		
E. oxyuris	8,400	76,450		63,600
E. proxima	8,400	173,750		106,000
E. rostrifera			12,800	116,600
E. spirogyra		69,500		63,600
Phacus angulatus		6,950		
P. helikoides				10,600
P. longicauda		55,600		106,000
P. pleuronectes		493,450		233,200
P. ranula		62,550		10,600
P. myersi		27,800		53,000
Strombomonas australica			12,800	
S. fluviatilis	42,000	674,150	1,030,400	3,010,400
Trachelomonas crebea	58,800	681,100	102,400,000	11,448,000
T. ovalis	201,600	1,125,900	32,640,000	14,649,200
T. volvocina	75,600	173,750	128,000	2,978,600
Division Chromophyta				
Synedra ulna	16,800	6,950	25,600	21,200
Fragilaria capucina			38,400	
F. construens				10,600
Frustulia vulgaris	8,400			10,600
Surirella elegans		6,950	19,200	
S. robusta			19,200	10,600
S. striatula	8,400		25,600	
Stephanodiscus hanzschii		5,156,900	105,472,000	41,552,000
Class Dinophyceae (Dinoflagellates)				
Peridinium sp.	16,800	13,900		42,400
Total Density	**3,628,800**	**54,196,100**	**268,588,800**	**84,694,000**
Number of Species	**28**	**42**	**33**	**31**
Diversity Index	**2.28**	**1.93**	**2.25**	**1.53**

TABLE 4.2.2-3
SPECIES COMPOSITION AND DENSITY OF PHYTOPLANKTON AND ZOOPLANKTON FROM FIELD SURVEY IN THE DRY SEASON (Cont'd)

Density (cells/m^3)

Species	Station			
	SW 1	SW 2	SW 3	SW 4
Zooplankton				
Phylum Arthropoda				
Class Crustacea (Crustaceans)				
*Copepod larva (Nauplius)	8,400	27,800	6,400	74,200
*Unidentified Calanoids		62,550		10,600
*Unidentified Cyclopoids			12,800	21,200
Moina sp.				10,600
*Unidentified Ostracods			6,400	
Class Insecta				
Chironomus sp.		6,950		
Phylum Protozoa				
Class Ciliata				
Tintinnidium sp.	16,800	62,550	19,200	148,400
Coleps sp.	25,200		6,400	21,200
Didinium nasutum	16,800	6,950		
Class Sarcodina				
Arcella vulgaris	8,400		38,400	
A. megastoma	8,400		12,800	
Centropyxis ecornis	8,400			
Difflugia lobostoma	25,200		12,800	
D. lebes		6,950		
D. urceolata		6,950		
Phylum Rotifera (Rotifer)				
Class Monogononta				
Polyarthra vulgaris	8,400		38,400	
Brachionus angularis				10,600
B. plicatilis			12,800	
Lepadella acuminata			6,400	
Lecane hastata	8,400			
L. furcata		6,950		
Trichocerca capucina	8,400	13,900		
Filinia terminaris		6,950		10,600
Pompholyx complanata		6,950		
Class Digononta				
Rotaria sp.			6,400	
Total Density	**142,800**	**215,450**	**179,200**	**307,400**
Number of Species	**11**	**11**	**12**	**8**
Diversity Index	**1.97**	**1.66**	**1.40**	**1.60**

Remark: * Unidentified.
Source: Field Survey by TEAM Consulting Engineering and Management Ltd., March 2016

TABLE 4.2.2-4
SPECIES COMPOSITION AND DENSITY OF BENTHOS FROM FIELD SURVEY IN THE DRY SEASON

Abundance (organism/sq.m.)

Species	Station			
	SW1	SW2	SW3	SW4
PHYLUM ANNELIDA				
Class Oligochaeta				
Order Plesiopora				
Family Tubificidae				
Tubifex sp.	110	66		
PHYLUM ARTHROPODA				
Class Insecta				
Order Diptera				
Family Chironomidae				
Ablabesmyia sp.		484	22	66
Family Ceratopogonidae				
Culicoides sp.		88		
PHYLUM MOLLUSCA				
Class Gastropoda				
Order Mesogastropoda				
Family Viviparidae				
Filopaludina sp.		22		
Family Thairidae				
Melanoides sp.		44		
Class Bivalvia				
Order Veneroida				
Family Corbicullidae				
Corbicula sp.	132			
Total Density	242	704	22	66
Number of Species	2	5	1	1

Remark: Channel bottom composed of clay and gravel

Source: Field Survey by TEAM Consulting Engineering and Management Ltd., March 2016

Zooplankton

There were 8 species of zooplankton belonging to three phyla (Arthropoda, Protozoa, and Rotifera) as shown in **Table 4.2.2-1**. Centropyxis ecornis in Phylum Protozoa was the most abundant with the density of 13,500 cells/m^3, followed by Copepod larvae (Nauplius) with the density of 8,100 cells/m^3. The total density of zooplankton at this station was 37,800 cells/m^3.

According to Schannon-Weiner Diversity Index (1963), phytoplankton had the diversity index of 1.70 whereas that of zooplankton was 1.83, indicating that water quality was at medium level and fairly suitable for aquatic organisms to live.

Benthic Fauna

There were 6 species of benthos belonging to three phyla (Annelida, Arthropoda, and Mollusca). *Macrobrachium* sp. and *Bithynia* sp. are common with the density of 88 organisms/sq.m. The total density of benthos at this station was 308 organisms/sq.m. **(Table 4.2.2-2)**.

Station 3 (SW3): Discharge Point No. 2 of Pluak Daeng Industrial Park (Coordinate: 47P 0733386E 1432700N)

Phytoplankton

Phytoplankton found at this station consisted of 3 divisions (Cyanophyta, Chlorophyta, and Chromophyta), 4 classes (Cyanophycaea (blue-green algae), Chlorophycaea (green algae), Euglenophyceae, and Bacillariophycaea (diatom)), and 16 species **(Table 4.2.2-1)**. *Volvox tertius* was the most common species with the density of 41,650 cells/m^3, followed by *Pleodorina* sp. with the density of 29,400 cells/m^3. The total density of phytoplankton was 144,550 cells/m^3.

Zooplankton

There were 10 species of zooplankton belonging to three phyla (Arthropoda, Protozoa, and Rotifera) as shown in **Table 4.2.2-1**. Copepod larvae (Nauplius) were the most abundant with the density of 12,250 cells/m^3, followed by *Ascomorpha ecaudis* with the density of 4,900 cells/m^3. The total density of zooplankton at this station was 36,750 cells/m^3.

According to Schannon-Weiner Diversity Index (1963), phytoplankton had the diversity index of 2.17 whereas that of zooplankton was 2.08, indicating that water quality was at medium level and fairly suitable for aquatic organisms to live.

Benthic Fauna

No benthos was found due to high water volume (water depth at about 3.6 m) and torrents at the sampling station. General conditions at Station 3 (SW3) during the wet season are presented in **Photo 4.2.2-1**. Channel bottom at the sampling location is generally composed of gravel and slight clay **(Photo 4.2.2-2)**. Benthic animals living on channel bottom, or clinging to rock, reef, logs or even water plants were carried by rapidly flowing current during the flooding period. Therefore, no benthos was encountered at the time of survey.

PHOTO 4.2.2-1 : GENERAL CONDITIONS OF STATION SW3

PHOTO 4.2.2-2 : SEDIMENTS ON CHANNEL BOTTOM

Station 4 (SW4): about 500 M Downstream of Discharge Point No. 2 of Pluak Daeng Industrial Park (Coordinate: 47P 0733441E 1432280N)

Phytoplankton

Phytoplankton found at this station consisted of 3 divisions (Cyanophyta, Chlorophyta, and Chromophyta), 4 classes (Cyanophycaea (blue-green algae), Chlorophycaea (green algae), Euglenophyceae, and Bacillariophycaea (diatom)), and 15 species **(Table 4.2.2-1)**. *Volvox tertius* and *Oscillatoria* sp. were the most common species, each with the density of 14,750 cells/m^3, followed by *Trachelomonas volvocina* with the density of 11,800 cells/m^3. The total density of phytoplankton was 91,450 cells/m^3.

Zooplankton

There were 10 species of zooplankton belonging to three phyla (Arthropoda, Protozoa, and Rotifera) as shown in **Table 4.2.2-1**. Copepod larvae (Nauplius) were the most abundant with the density of 8,850 cells/m^3. The total density of zooplankton at this station was 41,300 cells/m^3.

According to Schannon-Weiner Diversity Index (1963), phytoplankton had the diversity index of 2.51 whereas that of zooplankton was 2.21, indicating that water quality was at medium level and fairly suitable for aquatic organisms to live.

Benthic Fauna

There were 3 species in Phylum Arthropoda, i.e. *Ablabesmyia, Macrobrachium,* and *Siamthelphusa,* each with the density of 22 organisms/sq.m. The total density of benthos at this station was 66 organisms/sq.m. **(Table 4.2.2-2)**

- **Survey Results in the Dry Season**

Station 1 (SW1): about 1 km Upstream of the Discharge Point No. 1 of Pluak Daeng Industrial Park (Coordinate: 47P 0731985E 1433179N)

Phytoplankton

Phytoplankton found at this station consisted of 3 divisions (Cyanophyta, Chlorophyta, and Chromophyta), 5 classes (Cyanophycaea (blue-green algae), Chlorophycaea (green algae), Euglenophyceae, Bacillariophyceae, and Dinophyceae), and 28 species **(Table 4.2.2-3)**. *Gonium pectorale* was the most common species with the density of 1,688,400 cells/m^3, followed by *Pandarina morum*, and *Closterium acerosum* with the density of 688,800 cells/m^3 and 243,600 cells/m^3 respectively. The total density of phytoplankton was 3,628,800 cells/m^3.

Zooplankton

There were 11 species of zooplankton belonging to three phyla (Arthropoda, Protozoa, and Rotifera) as shown in **Table 4.2.2-3**. *Coleps* sp. and *Diffugia lobostoma* were the most abundant each with the density of 25,200 cells/m^3, followed by *Tintinnidium* sp. and *Didinium nasutum* in Phylum Protozoa each with the density of 16,800 cells/m^3. The total density of zooplankton at this station was 142,800 cells/m^3.

According to Schannon-Weiner Diversity Index (1963), phytoplankton had the diversity index of 2.28 whereas that of zooplankton was 1.97, indicating that water quality was at medium level and fairly suitable for aquatic organisms to live.

Benthic Fauna

Two species in Phylum Annelida and Phylum Mollusca were found, i.e. *Corbicula* sp. and *Tubiflex* sp., with the density of 132 organisms/sq.m., and 110 organisms/sq.m, respectively. The total density of benthos at this station was 242 organisms/sq.m. **(Table 4.2.2-4).**

Station 2 (SW2): Discharge Point No. 1 of Pluak Daeng Industrial Park (Coordinate: 47P 0732907E 1433023N)

Phytoplankton

Phytoplankton found at this station consisted of 3 divisions (Cyanophyta, Chlorophyta, and Chromophyta), 5 classes (Cyanophycaea (blue-green algae), Chlorophycaea (green algae), Euglenophyceae, Bacillariophyceae, and Dinophyceae), and 42 species **(Table 4.2.2-3)**. *Lepocinclis ovum* was the most common species with the density of 28,495,000 cells/m^3, followed by green algae *Gonium pectoral* with the density of 10,286,000 cells/m^3, and diatom *Stephanodiscus hanzschii* with the density of 5,156,900 cells/m^3. The total density of phytoplankton was 54,196,100 cells/m^3.

Zooplankton

There were 11 species of zooplankton belonging to three phyla (Arthropoda, Protozoa, and Rotifera) as shown in **Table 4.2.2-3**. Unidentified Calanoids and *Tintinnidium* sp. in Phylum Protozoa was the most abundant each with the density of 62,550 cells/m^3, followed by Copepod larvae (Nauplius) with the density of 27,800 cells/m^3. The total density of zooplankton at this station was 215,450 cells/m^3.

According to Schannon-Weiner Diversity Index (1963), phytoplankton had the diversity index of 1.93 whereas that of zooplankton was 1.66, indicating that water quality was at medium level and fairly suitable for aquatic organisms to live.

Benthic Fauna

There were five species of benthos belonging to three phyla (Annelida, Arthropoda, and Mollusca). *Ablabesmyia* sp. was the most abundant with the density of 484 organisms/sq.m., followed by *Culicoides* sp. with the density of 88 organisms/sq.m. The total density of benthos at this station was 704 organisms/sq.m. **(Table 4.2.2-4).**

Station 3 (SW3): Discharge Point No. 2 of Pluak Daeng Industrial Park (Coordinate: 47P 0733386E 1432700N)

Phytoplankton

Phytoplankton found at this station consisted of 3 divisions (Cyanophyta, Chlorophyta, and Chromophyta), 4 classes (Cyanophycaea (blue-green algae), Chlorophycaea (green algae), Euglenophyceae, and Bacillariophycaea (diatom)), and 33 species **(Table 4.2.2-3)**. *Stephanodiscus hanzschii* (diatom) was the most common species with the density of 105,472,000 cells/m^3, followed by *Trachelomonas crebea* and *T.ovalis* with the density of 102,400,000 cells/m^3 and 32,640,000 cells/m^3. The total density of phytoplankton was 268,588,800 cells/m^3.

Zooplankton

There were 12 species of zooplankton belonging to three phyla (Arthropoda, Protozoa, and Rotifera) as shown in **Table 4.2.2-3**. *Arcella vulgaris* in Phylum Protozoa and *Polyrthra vulgaris* in Phylum Rotifera were the most abundant, each with the density of 38,400 cells/m^3, followed by *Tintinnidium* sp. with the density of 19,200 cells/m^3. The total density of zooplankton at this station was 179,200 cells/m^3.

According to Schannon-Weiner Diversity Index (1963), phytoplankton had the diversity index of 2.25 whereas that of zooplankton was 1.40, indicating that water quality was at medium level and fairly suitable for aquatic organisms to live.

Benthic Fauna

Ablabesmyia sp. in Phylum Arthropoda was found with the density of 22 organisms/sq.m. **(Table 4.2.2-4)**.

Station 4 (SW4): about 500 M Downstream of Discharge Point No. 2 of Pluak Daeng Industrial Park (Coordinate: 47P 0733441E 1432280N)

Phytoplankton

Phytoplankton found at this station consisted of 3 divisions (Cyanophyta, Chlorophyta, and Chromophyta), 5 classes (Cyanophycaea (blue-green algae), Chlorophycaea (green algae), Euglenophyceae, Bacillariophycaea, and Dinophyceae), and 31 species **(Table 4.2.2-3)**. *Stephanodiscus hanzschii* was the most common species with the density of 41,552,000 cells/m^3, followed by *T. ovalis* and *Trachelomonas crebea* with the density of 14,649,200 cells/m^3 and 11,448,000 cells/m^3 respectively. The total density of phytoplankton was 84,694,000 cells/m^3.

Zooplankton

There were 8 species of zooplankton belonging to three phyla (Arthropoda, Protozoa, and Rotifera) as shown in **Table 4.2.2-3**. *Tintinnidium* sp. in Phylum Protozoa was the most abundant with the density of 148,400 cells/m^3, followed by Copepod larvae (Nauplius) with the density of 74,200 cells/m^3. The total density of zooplankton at this station was 307,400 cells/m^3.

According to Schannon-Weiner Diversity Index (1963), phytoplankton had the diversity index of 1.53 whereas that of zooplankton was 1.60, indicating that water quality was at medium level and fairly suitable for aquatic organisms to live.

Benthic Fauna

Ablabesmyia sp. in Phylum Arthropoda was found with the density of 66 organisms/sq.m. **(Table 4.2.2-4)**.

- **Summary of the Existing Environmental Conditions and Living Organisms around Monitoring Stations in Huai Phu Sai**

Station 1 (SW1): about 1 km Upstream of the Discharge Point No. 1 of Pluak Daeng Industrial Park: During the rainy season, the area is inundated and water flows rapidly. In the dry season, the brook is dry and shallow. The bottom is composed of gravel and clay. Along both sides of the channel are covered with vegetation, including giant thorny bamboo, paragrass, cassod tree, Thao Jing Jo (Merremia umbellata (L.) Hallier f.). The brook passes community and farmland as illustrated in **Photo 4.2.2-3**.

Three divisions of phytoplankton: Cyanophyta, Chlorophyta, and Chromophyta, were found. *Eudorinaelegans* and *Gonium pectoral* were dominant species in the wet and the dry seasons, respectively. Three phyla of zooplankton: Arthropoda, Protozoa, and Rotifera, were common at this station. Unidentified Cyclopoids and *Arcella vulgaris* in Phylum Protozoa were abundant in the wet season whereas *Coleps* sp. and *Diffugialobostoma* were abundant in the dry season. Shrimps, marsh clams, and Tubliflex worms were benthic fauna mostly found in the dry season.

Station 2 (SW2): Discharge Point No. 1 of Pluak Daeng Industrial Park: The water quality sampling and monitoring station is at Wang Tan Mon weir where water lever is uplifted and water flows rapidly. Water levels in the dry and the wet seasons are not much different. Channel bottom is generally composed of clay. The water body passes farmland, e.g. oil palm and coconut tree plantations. Aquatic weeds are found along both sides, e.g. sea bean, paragrass, common grass (*Sorghum propinquum*), Krathin Yak (*Acacia mangium* Willd.), Indian Head Ginger, Morning Glory, Ivy Gourd, and Water Minosa as presented in **Photo 4.2.2-4**.

Three divisions of phytoplankton: Cyanophyta, Chlorophyta, and Chromophyta, were found. *Volvox tertius* and *Lepocinclis ovum* were abundant in the wet and the dry seasons respectively. Three phyla of zooplankton: Arthropoda, Protozoa, and Rotifera, were common at this station. *Centropyxis ecornis* was dominant in the rainy season whereas unidentified Calanoids and *Tintinnidium* sp. were abundant in the dry season. Shrimps (*Macrobrachium* sp.) and *Bithynia* sp. were the mostly found benthos in the wet season whereas *Ablabesmyia* sp in the dry season.

Wet Season

Dry Season

PHOTO 4.2.2-3 : ENVIRONMENTAL CONDITIONS AT STATION 1 IN THE WET AND THE DRY SEASONS

Upstream of Wang Tan Mon Weir
(Wet Season)

Downstream of Wang Tan Mon Weir
(Wet Season)

Upstream of Wang Tan Mon Weir
(Dry Season)

Downstream of Wang Tan Mon Weir
(Dry Season)

PHOTO 4.2.2-4: ENVIRONMENTAL CONDITIONS AT STATION 2 IN THE WET AND THE DRY SEASONS

Station 3 (SW3): Discharge Point No. 2 of PluakDaeng Industrial Park: The water quality sampling and monitoring station is located in a narrow channel. Water is about 3-4 m depths in the wet season and 0.6 m in the dry season. The channel bottom is composed of gravel and clay. The water body passes farmland and is covered with aquatic weeds along both sides, including giant thorny bamboo, sea bean, common grass (*Sorghum propinquum*), and Khagra reed as presented in **Photo 4.2.2-5**.

Wet Season

Dry Season

FIGURE 4.2.2-5 : ENVIRONMENTAL CONDITIONS AT STATION 3 IN THE WET AND THE DRY SEASONS

Three divisions of phytoplankton: Cyanophyta, Chlorophyta, and Chromophyta, were found. *Volvox tertius* and *Stephanodiscus hanzschii* were abundant in the wet and the dry seasons, respectively. Three phyla of zooplankton: Arthropoda, Protozoa, and Rotifera, were common at this station. Copepod (Nauplius) was abundant in the wet season and *Arcella vulgaris* and *Polyrthra vulgaris* were dominant in the dry season. The mostly found benthos in the dry season was *Ablabesmyia* sp.

Station 4 (SW4): about 500 M Downstream of Discharge Point No. 2 of PluakDaeng Industrial Park: The water quality sampling and monitoring station is located around Wang Ta Mon-Prum Pram Bridge, in front of Pluak Daeng Industrial Park. The channel is quite shallow and water depth is about 0.8-1.0 m. Water levels in the dry and the wet seasons are not much different. Water flows quite rapidly in the wet season. The channel bottom is generally composed of clay and sand. Along both sides of the channel are covered with water weeds, including common grass (*Sorghum propinquum*), giant sensitive tree, sea bean, Morning Glory, Banyan, and Bareet Grass (*Leersia hexandra Sw*) as presented in **Photo 4.2.2-6**.

Wet Season

Dry Season

FIGURE 4.2.2-6 : ENVIRONMENTAL CONDITIONS AT STATION 4 IN THE WET AND THE DRY SEASONS

Three divisions of phytoplankton: Cyanophyta, Chlorophyta, and Chromophyta, were found. *Volvox tertius* and *Stephanodiscus hanzschii* were abundant in the wet and the dry seasons respectively. Three divisions of phytoplankton: Cyanophyta, Chlorophyta, and Chromophyta, were found. *Volvox tertius* and *Stephanodiscus hanzschii* were abundant in the wet and the dry seasons respectively. *Tintinnidium* sp. was abundant in the dry season. *Ablabesmyia* sp, shrimps (*Macrobrachium* sp.) and freshwater crabs (*Siamthelphusa) were* the mostly found benthos in the wet season whereas *Ablabesmyia* sp in the dry season.

4.3 HUMAN USE VALUES

4.3.1 Land Use

(1) Introduction

The study of the existing land use was conducted within the radius of 5 km extending from the project area with the objectives to collect and analyze the data on land use characteristics and classification in the vicinity of the project area. Regulations and laws regarding town planning and land use requirements in the future were also gathered in order to study the trend of community expansion and land use around the project area, and to suggest suitable measures for prevention and mitigation of the project impacts on land use.

(2) Methodology

Data collection and field survey were conducted as follows.

- The latest aerial photographs from Google Earth version 7.1.5.1557 were collected, including photographic maps at 1:50,000 scale of the Royal Thai Survey Department, Sheets Nos. 5234 IV, IV and 5235 II, III, year 2005.

- Relevant documents were gathered including land use laws and requirements from the comprehensive plans of the Department of Public Works and Town & Country Planning (DPT), and the Rayong Provincial Office of Public Works and Town & Country Planning.
- Field survey to check and update the land use pattern

(3) Study Results

(a) Collection of Secondary Data

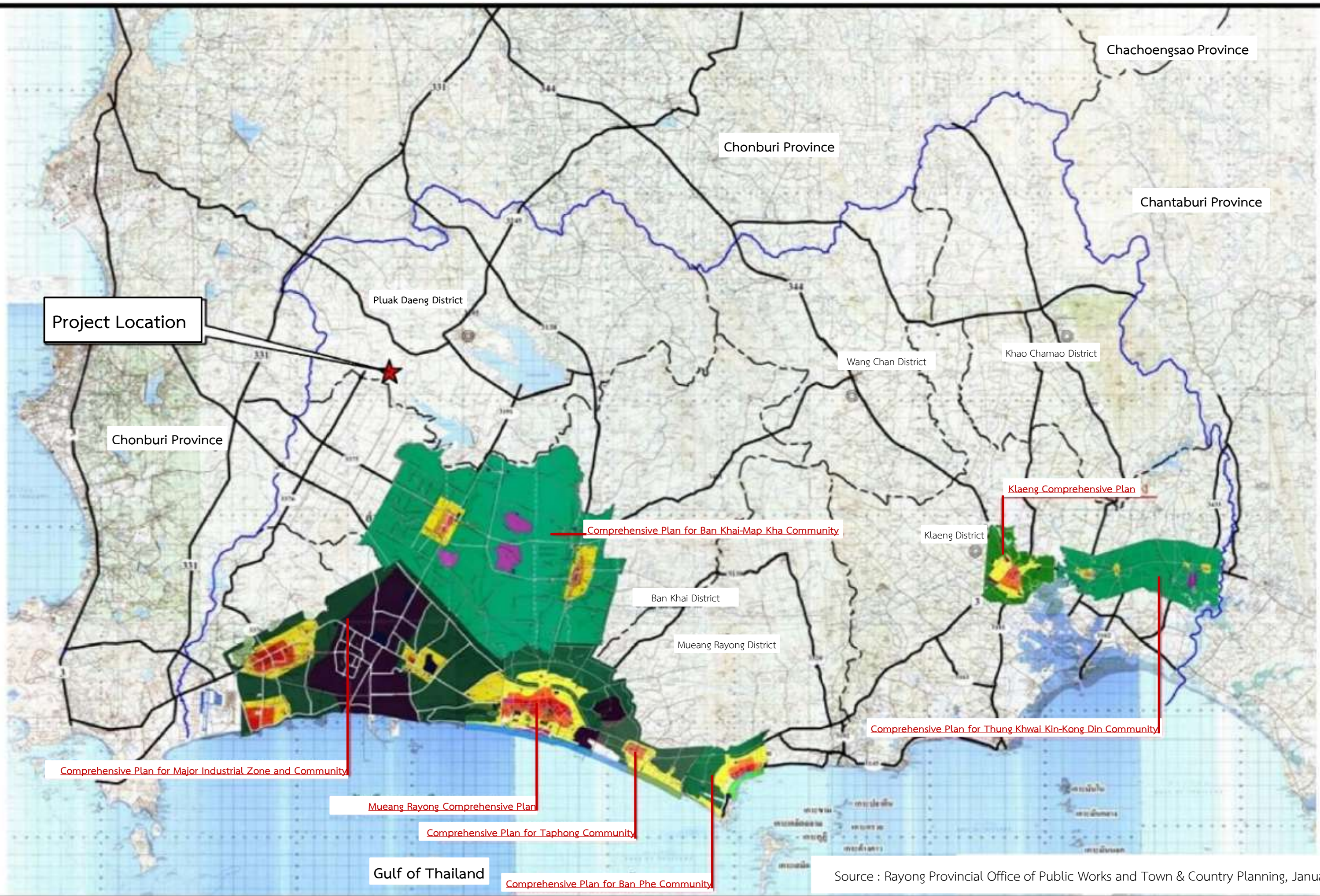
The 5-km radius study area encompasses partial areas of Pluak Daeng and Nikhom Phatthana districts in Rayong province. The project area is located in Map Yang Phon sub-district, Pluak Daeng district, Rayong province. Land use requirements are presented below.

- **Comprehensive Plans:** DPT and the Rayong Provincial Office of Public Works and Town & Country Planning have mutually prepared related 11 comprehensive plans as the development framework (data as of January 2016) as presented in **Figure 4.3.1-1** and **Table 4.3.1-1**.

The project delivered the letter to the Rayong Provincial Office of Public Works and Town & Country Planning, inquiring about the compliance between the project implementation and Pluak Daeng Comprehensive Plan. The Provincial Office sent the letter on the consideration result, informing that the project area is not included in the area designated in the Ministerial Regulation on Enforcement of the Rayong Provincial Comprehensive Plan. Currently, the Pluak Daeng District Office of Public Works and Town & Country Planning is in the process of improving the Pluak Daeng Comprehensive Plan in compliance with the requirements of the Provincial Office, pending submission of the Draft Ministerial Regulation to the Minister of Interior for signing. Considering land use and provisions stipulated in the draft comprehensive plan, the project area falls into the zone of non-polluting industries and warehouses (white color with violet diagonals) as presented in **Appendix 4J**.

Moreover, the Order of the Head of the National Council for Peace and Order No. 4/2559 promulgated on 20^{th} January 2016, by virtue of Section 44 of the Constitution of the Kingdom of Thailand (Interim) B.E. 2557 (**Appendix 4K**), has exempted the ministerial regulations on enforcement of city and town plans being effective as of 20^{th} January 2016 or coming into effect within one year from the promulgation date for the following business operation.

Fuel depot business as prescribed in the laws on fuel control and factory business No.88 (designated in the ministerial regulation in 1992), the Power Development Plan 2015-2036 (PDP 2015) approved by the Cabinet on 30^{th} June 2015, the Alternative Energy Development Plan 2015-2036, the Oil Plan 2015-2036, and the Gas Plan 2015-2036 approved by the Cabinet on 27^{th} October 2015.



Source : Rayong Provincial Office of Public Works and Town & Country Planning, January 2016

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FIGURE 4.3.1-1: EXISTING COMPREHENSIVE PLANS IN RAYONG PROVINCE AS PUBLISHED IN THE GOVERNMENT GAZETTE

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TABLE 4.3.1-1
COMPREHENSIVE PLANS FOR RAYONG PROVINCE

Type/Name of Comprehensive Plan	Published in the Government Gazette		Legal Process
	Promulgation Date	End of Enforcement	
1. Rayong Provincial Comprehensive Plan	New Plan		10. Submission to the Cabinet for Acceptance in Principle
2. Mueang Rayong Comprehensive Plan	Under Improvement		4. Public Consultation
3. Comprehensive Plan for Ban Phe Community (extension for another 5 years)	07 Oct 2011	10 Oct 2016	18. Published in the Government Gazette
4. Comprehensive Plan for Major Industrial Zone and Map Ta Phut Community	Under Improvement		5. Meeting of the Board of Town Planning (for Consideration of the Draft Comprehensive Plan)
5. Klaeng Comprehensive Plan	Under Improvement		14. DPT's preparation of the draft ministerial regulations reviewed by the Office of the Council of State
6. Comprehensive Plan for Taphong Community	Under Improvement		8. Preparation of Documents for Submission to the Ministry of Interior
7. Comprehensive Plan for Samnak Thon Community	New Plan		3. Meeting for Consideration of the Draft Plan
8. Pluak Daeng Comprehensive Plan	New Plan		5. Meeting of the Board of Town Planning (for Consideration of the Draft Comprehensive Plan)
9. Comprehensive Plan for Ban Khai-Map Kha Community	24 Jul 2012	23 Jul 2017	18. Published in the Government Gazette
10. Comprehensive Plan for Thung Khwai Kin-Kong Din Community	30 May 2012	29 May 2016	18. Published in the Government Gazette
11. Comprehensive Plan for Pak Nam Prasae Community	New Plan		3. Meeting for Consideration of the Draft Plan

Source: Website of the Department of Public Works and Town & Country Planning (http://eservices.dpt.go.th), data as of 28th January 2016

- **Draft Ministerial Regulation on Designation of Pluak Daeng, Ban Khai and Nikhom Phatthana Districts, Rayong Province as the Environmental Protection Zone:** The Project checked the compliance of land use in the project area with the Draft Ministerial Regulation on Designation of Pluak Daeng, Ban Khai and Nikhom Phatthana Districts, Rayong Province as the Environmental Protection Zone. According to the Office of Natural Resources and Environmental Policy and Planning (ONEP)'s letter No. Thor.Sor. 1010.3/12685 **(Appendix 4L)**, **Pluak Daeng Power Plant is located in Zone 6 which means other areas as stated in Clause 2 and is outside Zones 1-4 under the Draft Ministerial Regulation**. The Draft Ministerial Regulation prescribing Pluak Daeng, Ban Khai and Nikhom Phatthana Districts, Rayong Province as the Environmental Protection Zone was approved in the National Environment Board's Meeting No.4/2559 dated 21th September 2016. ONEP is in the process of submitting the Draft Ministerial Regulation to the Cabinet for approval in principle. After the Cabinet's approval, the Draft Ministerial Regulation will be submitted to the Office of the Council of State for review prior to promulgation in the Government Gazette to become effective.

(b) Field Survey

Survey of land use was conducted in October 2015 within the radius of 5 km extending from the project area which is located in Map Yang Phon sub-district, Pluak Daeng district, Rayong province. The study area covers 67,406 rai in Pluak Daeng, Map Yang Phon, and Mae Nam Khu sub-districts in Pluak Daeng district, and Phana Nikhom sub-district in Nikhom Phatthana district, Rayong province. There are three major categories of land use in the study area: agricultural area of 35,912.50 rai, urban and built-up area of 20,587.50 rai, and other area of 10,906.25 rai as illustrated in **Figure 4.3.1-2** and **Table 4.3.1-2**.

Agricultural Area covers the largest proportion of land use with a total area of 35,912.50 rai, or 53.29% of the total study area, consisting of:

- Field crops of 23,412.50 rai for cassava and pineapple cultivation, occupying the largest proportion of the total agricultural area.
- Para rubber plantations cover 10,668.75 rai-the second largest proportion of the total agricultural area.
- Orchards of 468.75 rai, comprising small plantations of coconut palms and cashew trees.
- Perennial plants of 468.75 rai, comprising small plantations of eucalyptus and fast growing plant.
- Oil palms of 775 rai near surface water bodies, e.g. Khlong Hin Yoi, Huai Chalit, Huai Phu Sai, etc.
- Chicken farms of 118.75 rai.

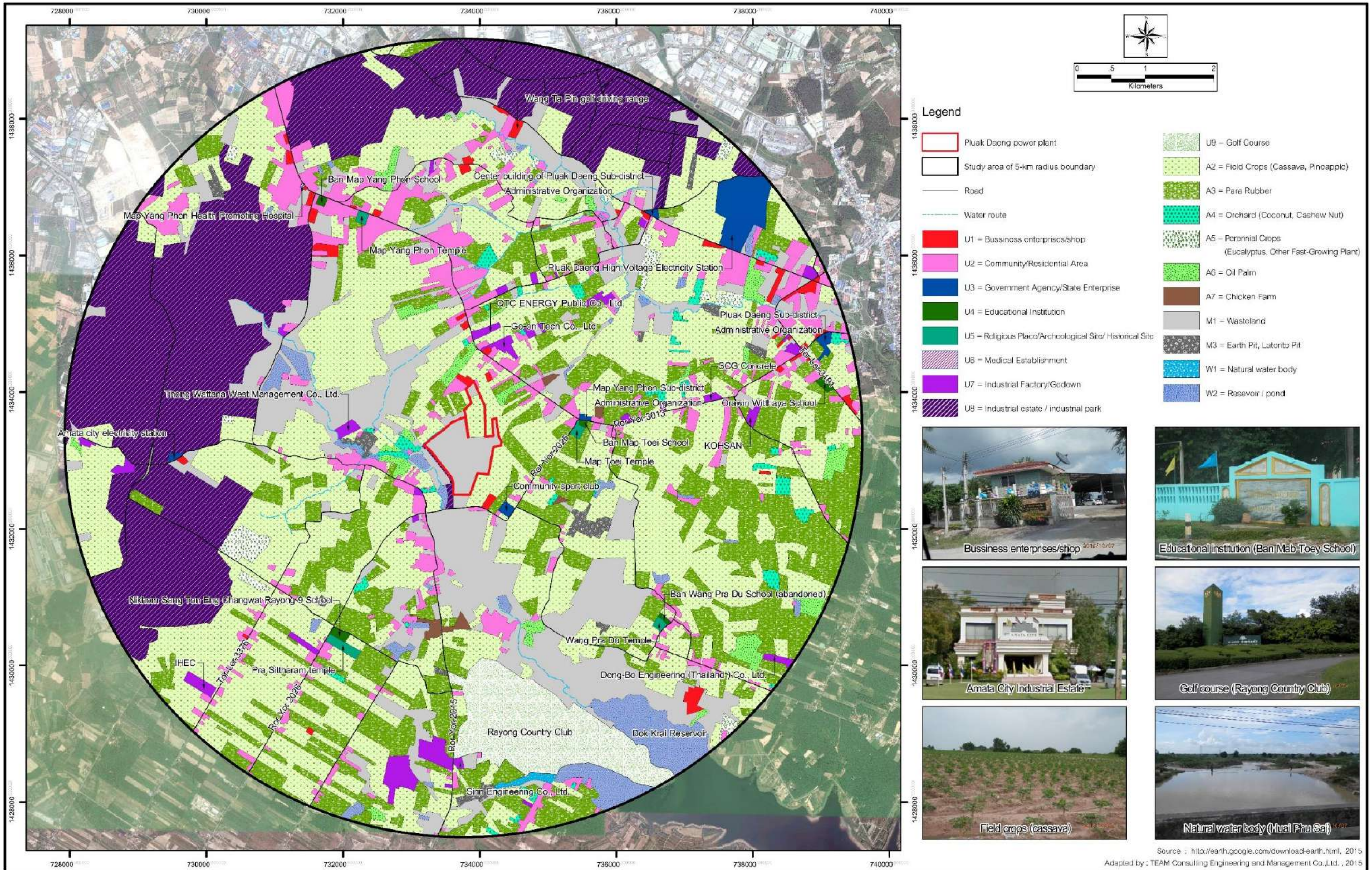

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FIGURE 4.3.1-2: EXISTING LAND USE WITHIN THE 5-KM RADIUS STUDY AREA

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TABLE 4.3.1-2
LAND USE IN THE 5-KM RADIUS STUDY AREA

Land Use Type	Symbol	Area		
		sq.m.	rai	Percentage
Agricultural Area	A			
Field Crops (Cassava/Pineapple)	A2	37.46	23,412.50	34.73
Para Rubber	A3	17.07	10,668.75	15.83
Orchard (Coconut Palm/Cashew Tree)	A4	0.75	468.75	0.70
Perennial Plant (Eucalyptus, other fast-growing plants	A5	0.75	468.75	0.70
Oil Palm	A6	1.24	775.00	1.51
Chicken Farm	A7	0.19	118.75	0.18
Total Agricultural Area		**57.46**	**35,912.50**	**53.29**
Urban and Built-up Area	U			
Commercial Area	U1	0.65	406.25	0.60
Residential Area	U2	7.20	4,500.00	6.68
Government Office/State Enterprise	U3	0.78	487.50	0.72
Educational Institution	U4	0.11	68.75	0.10
Religious Place/Archaeological Site and Historical Site	U5	0.15	93.75	0.14
Hospital	U6	0.02	12.50	0.02
Industrial Plant/Warehouse	U7	1.18	737.50	1.09
Industrial Estate	U8	19.86	12,412.50	18.41
Golf Course	U9	2.99	1,868.75	2.77
Total Urban and Built-up Area		**32.94**	**20,587.50**	**30.53**
Other Area				
Wasteland	M1	13.98	8,737.50	12.96
Soil Pit/Laterite Pit	M3	0.56	350.00	0.52
Natural Water Body	W1	0.09	56.25	0.08
Reservoir/Pond	W2	2.82	1,762.50	2.62
Total Other Area		**17.45**	**10,906.25**	**16.18**
Grand Total		**107.85**	**67,406.25**	**100.00**

Source: TEAM Consulting Engineering and Management Ltd., 2016

Urban and Built-up Area encompasses 20,587.50 rai of land or 30.53% of the total study area, consisting of:

- Commercial area of 406.25 rai around the crossing points of the Rural Highway No. Ror.Yor. 3013 and the National Highway No. 3191.
- Residential area of 4,500 rai in total: The expansion of residential zone depends on the development of the area. The residential area is mainly composed of new housing estates along the major transportation routes, e.g. the Rural Highway No. Ror.Yor. 3013 and the National Highway No. 3191, or near industrial area.

- Government offices/state enterprises cover a total area of 487.50 rai. All government offices/state enterprises, such as sub-district administrative office, are not large, except for the Pluak Daeng High Voltage Sub-station in the northeast of the project area.
- Educational institutions covering a total area of 68.75 rai: There are 5 schools: Ban Map Yang Phon School, Ban Map Toei School, Orawin Witthaya School, Nikhomsangtoneng 9 School, and Ban Wang Pradoo School (currently abandoned).
- Religious places/archaeological sites and historical sites cover a total area of 93.75 rai. There are 4 religious places, i.e. Map Yang Phon Temple, Map Toei Temple, Wang Pradu Temple, and Prasittharam Temple.
- Ban Map Yang Phon Sub-district Health Promoting Hospital is the only one medical establishment located on an area of 12.5 rai.
- Industrial plants/warehouses cover the total area of 737.50 rai. Most of them are small-sized factories or warehouses.
- Industrial estates/industrial parks encompass 12,412.50 rai of land. There are 6 industrial estates in the study area: Amata City Industrial Estate (Rayong), Eastern Seaboard Industrial Estate (Rayong), Siam Eastern Industrial Park, GK. Land Industrial Park, Pluak Daeng Industrial Park where the project is located, and Pluak Daeng Industrial Park (Expansion Phase).
- Golf course: Rayong Country Club covers 1,868.75 rai of land.

Other Area extends over a total land of 10,906.25 rai, or 16.18% of the total study area, consisting of:

- Wasteland: 8,737.50 rai.
- Soil pit/laterite pit: 350 rai.
- Natural water bodies covering a total area of 56.25 rai, e.g. Khlong Hin Loi, Khlong Chak Oi, Khlong Lek, Huai Phu Sai, Huai Wang Krarok, and Huai Chalit.
- Reservoir/pond (1,762.50 rai): There is Dok Krai reservoir in the study area.

4.3.2 Transportation

(1) Introduction

The project activities especially during the construction period, e.g. transportation of construction materials, tools and equipment and workers to the project area will affect the traffic conditions in the project area and its environs. Therefore, it is necessary to study and collect data on the existing transport conditions around the project area in order to assess the impacts on transportation due to the project development, and to further determine the impact prevention and mitigation measures during the construction and operation periods.

(2) Methodology

- Study and collection of secondary data on transportation networks from the Rayong Rural Road Office under the Bureau of Rural Roads 3 (Chon Buri), photographic maps at 1:50,000 scale of the Royal Thai Survey Department (2005), traffic volumes on the roads near the project area from the Traffic Volumes on Highways Report during 2011-2015 of the Bureau of Highway Safety, Department of Highways, Ministry of Transport.
- Field survey to study and gather data on the routes for transportation during the construction and operation periods by conducting traffic counts during workdays and weekend on the Rural Highways Nos. Ror.Yor. 2026 and Ror.Yor. 3013 which will be used for entering and exiting the project area.

(3) Study Results

(3.1) Collection of Secondary Data

(a) Transportation Network

The important routes for land transportation in the study area are illustrated in **Figure 4.3.2-1** and details of each route are described below.

- **National Highway No. 331 (Phanom Sarakham-Sattahip)**: It is the strategic route linking to the National Highway No. 3. This road begins from the National Highway No. 304 in Phanom Sarakham district, Chachoengsao province to end in Sattahip district, Chon Buri province. In 2007, another route of the Highway No. 331 was constructed with a length of about 17 km to connect to the National Highway No. 7 (Bangkok-Chon Buri). The 4-lane DBST road (bi-directional) is the main route for transporting cargoes from Laem Chabang Port. The road surface is damaged with potholes and cracks as trucks normally run on this road.
- **National Highway No. 36 (Krathing Lai-Pluak Ket)**: It is the Pattaya–Rayong bypass road, starting from the National Highway No. 3 (Sukhumvit Road) at the Pattaya (Pong) interchange in Bang Lamung district, Chon Buri province to end at the Highway No. 3 in Ban Pluak Ket, Choeng Noen sub-district, Mueang Rayong district, Rayong province. The 4-lane asphaltic concrete road (bi-directional) is 57 km long the main route for transporting cargoes from Laem Chabang Port. The road surface is generally in good condition.
- **Rural Highway No. Ror.Yor. 2026 (Intersection at Highway No. 36–Ban Wang Tan Mon)**: The road links between the Highway No. 36 and Phana Nikhom and Map Yang Phon sub-districts. It will be used as the transportation route during the construction period. The 15-km long undivided roadway consists of two lanes with DBST surface. The road surface is generally in good condition.

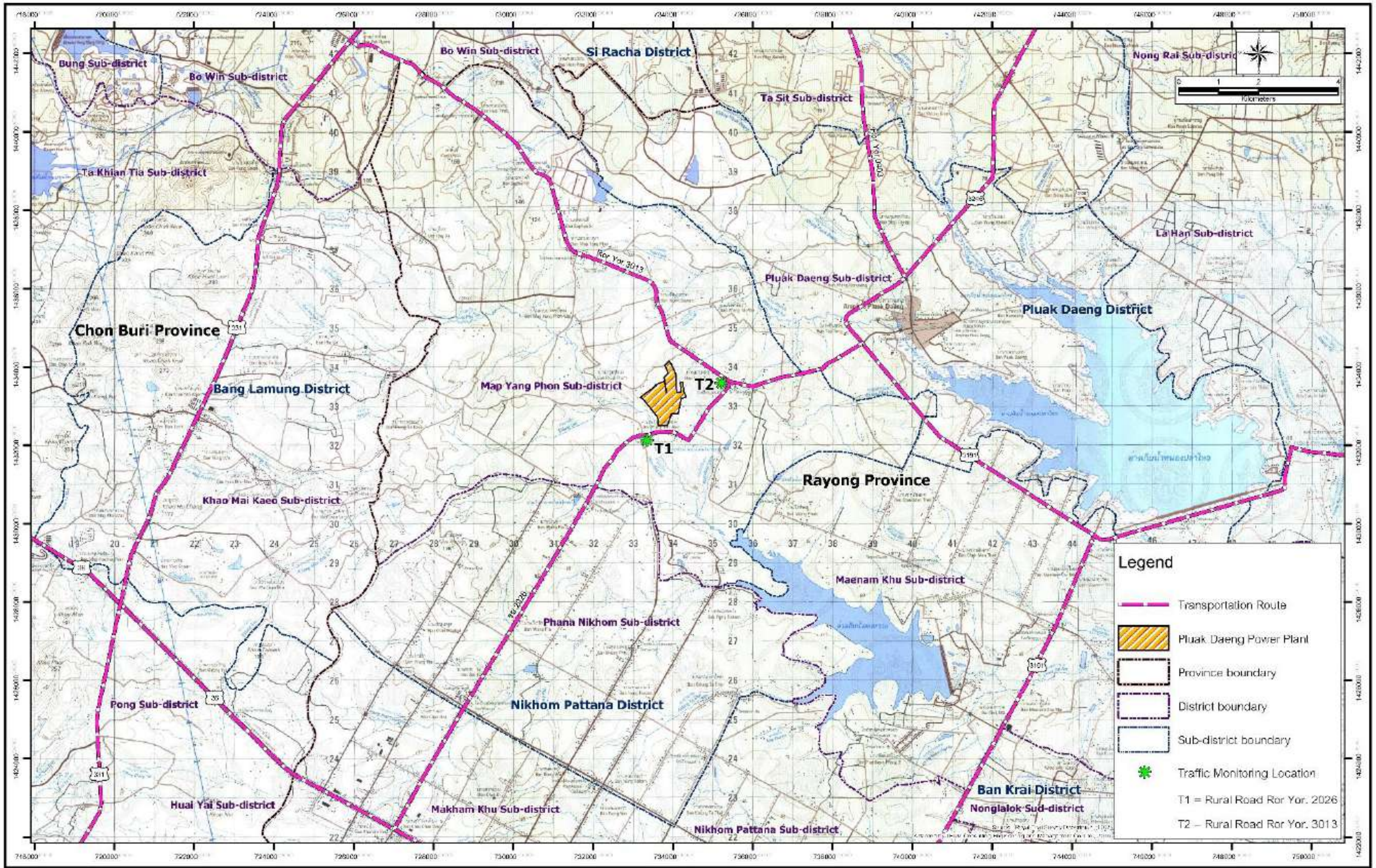

FIGURE 4.3.2-1 : TRANSPORTATION NETWORK IN THE STUDY AREA

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- **Rural Highway No. Ror.Yor. 3013 (Intersection at Highway No. 331–Intersection at Highway No. 3191)**: It links the Highway No. 331 to Pluak Daeng district and other industrial estates, e.g. Eastern Seaboard Industrial Estate (Rayong) and Amata City Industrial Estate. The 17.4-km long undivided roadway has two lanes with DBST surface. The road surface is generally in good condition.

(b) Traffic Volume

The traffic study was conducted on the major roads and the routes used for construction activities, transportation of construction materials and workers to the construction site, as well as travel of employees and transportation of chemicals during the operation period. Secondary data were gathered from the Traffic Volumes on Highways Report during 2011-2015 of the Bureau of Highway Safety, Department of Highways, Ministry of Transport. For the National Highway No. 331, the traffic count station which is closest to the project area is at KM 68+900. (During 2011-2012, the data from the traffic count station at KM 76+000 were used for the National Highway No. 331.) For the National Highway No. 36, the traffic count station which is closest to the project area is at KM 2+000. These traffic count data **(Table 4.3.2-1)** were considered to assess the probable impacts and can be summarized below.

- **Traffic Volume on the National Highway No. 331 (KM 68+900):** Light truck took the highest proportion of all vehicle types on this highway, followed by heavy truck, and passenger car, respectively. The highest traffic volume was in 2015 at 22,050 vehicles/day.
- **Traffic Volume on the National Highway No. 36 (KM 2+000):** Passenger car took the highest proportion of all vehicle types on this highway, followed by heavy truck and light truck, respectively. The highest traffic volume was in 2015 at 35,377 vehicles/day.

(3.2) Field Survey

Traffic counts were conducted during weekday and weekend: Sunday 13th and Monday 14th March 2016 during 06.01-18.00 hrs., at two stations, i.e. Rural Highway No. Ror.Yor. 2026 (Intersection at Highway No. 36–Ban Wang Tan Mon, at KM 12+230), and Rural Highway No. Ror.Yor. 3013 (Intersection at Highway No. 331–Intersection at Highway No. 3191, at KM 14+250). These two rural highways were anticipated to be affected by the project development **(Figure 4.3.2-1)**. The traffic count volumes at the two stations are presented in **Table 4.3.2-2** and **Table 4.3.2-3,** respectively and summarized below.

TABLE 4.3.2-1

TRAFFIC VOLUME ON HIGHWAYS IN THE PROJECT AREA DURING 2011-2015

No.	Highway No.	Traffic Count Station	Year	Traffic Volume by Vehicle Type (vehicle/day)								Total (vehicle/day)
				Passenger Car	Minibus	Bus	Light Truck	Medium Truck	Heavy Truck	Bicycle and Tricycle	Motorcycle and Motor Tricycle	
1	**331**	**KM 68+900**	2011[1/]	3,753	13	128	7,482	1,429	3,244	2	604	16,655
		(Nong Prue-Noen Mok)	2012[1/]	3,903	43	159	7,436	1,320	3,469	0	638	16,968
			2013	5,006	545	532	5,381	1,848	6,159	0	2,424	21,895
			2014	4,956	564	488	5,394	1,830	5,703	0	2,396	21,331
			2015	5,221	695	592	5,504	1,878	5,673	0	2,487	22,050
			Mean	**4,568**	**372**	**380**	**6,239**	**1,661**	**4,850**	**0**	**1,710**	**19,780**
2	**36**	**KM 2+000**	2011	12,361	178	418	2,134	550	3,401	21	2,047	21,110
		(Krathing Lai-Makham Khu)	2012	14,142	574	1,082	4,207	990	4,396	32	3,754	29,177
			2013	14,764	539	1,178	4,686	1,091	4,072	32	3,680	30,042
			2014	14,994	355	1,116	5,169	1,158	5,468	11	3,503	31,774
			2015	16,182	309	1,306	5,966	1,456	6,479	11	3,668	35,377
			Mean	**14,489**	**391**	**1,020**	**4,432**	**1,049**	**4,763**	**21**	**3,330**	**29,496**

Remark: 1/ Traffic count data on the Highway No. 331 during 2011-2012 were based on the traffic count data at KM 76+000 which is the closest station to the project area.

Source: Traffic Volumes on Highways Report during 2011-2015 (Department of Highways, Ministry of Transport), 2016

TABLE 4.3.2-2
TRAFFIC COUNT VOLUME ON RURAL HIGHWAY NO. ROR.YOR. 2026
DURING 13th-14th MARCH 2016

Vehicle Type	Rural Highway No. Ror.Yor. 2026, KM 12+230					
	Sunday 13th March 2016			Monday 14th March 2016		
	In bound	Out bound	Total	In bound	Out bound	Total
Bicycle	0	2	2	0	0	0
Motorcycle	698	796	1,494	710	756	1,466
4-wheeled Car (Passenger Car)	677	647	1,324	872	878	1,750
4-wheeled Truck/Pickup	871	800	1,671	941	816	1,757
6-wheeled Truck	60	63	123	187	164	351
10-wheeled Truck	103	82	185	152	201	353
Trailer/Semi-Trailer	68	73	141	97	145	242
4-wheeled Minibus/Van	86	129	215	237	232	469
Medium Bus	0	0	0	0	0	0
Bus (Tour Bus/Coach Bus)	3	6	9	23	9	32
Others (Tractor/Crane Truck/Motorcycle with Sidecar)	35	35	70	37	25	62
Total	**2,601**	**2,633**	**5,234**	**3,256**	**3,226**	**6,482**

Source: Field survey by TEAM Consulting Engineering and Management Ltd during 13-14 March 2016

TABLE 4.3.2-3
TRAFFIC COUNT VOLUME ON RURAL HIGHWAY NO. ROR.YOR. 3013
DURING 13th-14th MARCH 2016

Vehicle Type	Rural Highway No. Ror.Yor. 3013, KM 14+250					
	Sunday 13th March 2016			Monday 14th March 2016		
	In bound	Out bound	Total	In bound	Out bound	Total
Bicycle	1	0	1	1	0	1
Motorcycle	958	1,127	2,085	883	752	1,635
4-wheeled Car (Passenger Car)	2,174	2,459	4,633	1,700	2,290	3,990
4-wheeled Truck/Pickup	218	173	391	262	163	425
6-wheeled Truck	139	117	256	139	84	223
10-wheeled Truck	49	92	141	80	119	199
Trailer/Semi-Trailer	0	54	54	38	56	94
4-wheeled Minibus/Van	691	230	921	757	380	1,137
Medium Bus	0	0	0	1	0	1
Bus (Tour Bus/Coach Bus)	28	12	40	47	25	72
Others (Tractor/Crane Truck/Motorcycle with Sidecar)	0	6	6	0	1	1
Total	**4,258**	**4,270**	**8,528**	**3,908**	**3,870**	**7,778**

Source : Field survey by TEAM Consulting Engineering and Management Ltd during 13th-14th March 2016

- **Traffic volume on Rural Highway No. Ror.Yor. 2026, KM 12+230**: As for the traffic volume on Sunday 13th March 2016, four-wheeled truck/pickup took the highest proportion of all vehicle types, followed by motorcycle and 4-wheeled car (passenger car) respectively. The peak traffic volume was during 17.01-18.00 hrs. or 625 PCUs. On Monday 14th March 2016, four-wheeled truck/pickup occupied the largest proportion of all vehicle types, followed by 4-wheeled car and motorcycle, respectively. The peak traffic volume was during 07.01-08.00 hrs. or 1,086 PCUs. Details of traffic volume on this rural highway are described in **Appendix 4M**.
- **Traffic volume on Rural Highway No. Ror.Yor. 3013, KM 14+250**: As for the traffic volume on Sunday 13 rd March 2016, four-wheeled car (passenger car) took the highest proportion of all vehicle types, followed by motorcycle and 4-wheeled minibus/van, respectively. The peak traffic volume was during 16.01-17.00 hrs. or 875 PCUs. On Monday 14 th March 2016, four-wheeled car (passenger car) took the highest proportion of all vehicle types, followed by motorcycle and 4-wheeled minibus/van, respectively. The peak traffic volume was during 07.01-08.00 hrs. or 1,100 PCUs. Details of traffic volume on this rural highway are described in **Appendix 4M**.

(3.3) Existing Traffic Volume

The Consultant considered two routes for transportation during the project construction and operation periods. (1) The route starts from Laem Chabang Port, going along the Highway No. 331, making a U-turn under the interchange to head for Sattahip district, then running along the Highway No. 331 until Pak Ruam intersection, turning left to run along the Rural Highway No. Ror.Yor. 3013 until Wat Map Toei three-way intersection, turning right to run along the Rural Highway No. Ror.Yor. 2026, and reaching the project area. (2) The route starts from Laem Chabang Port, going along the National Highway No. 7, turning left at Pattaya (Pong) interchange, running along the National Highway No. 36, passing Khanam intersection for 1 km, turning left at the intersection to follow the Rural Highway No. Ror.Yor. 2026 to enter the project area. The existing traffic volumes are presented in the form of volume to capacity ratio (V/C ratio) as follows:

- There are totally 8 vehicle types and the Passenger Car Unit (PCU) of each vehicle type is converted to Passenger Car Equivalent (PCE) as shown in **Table 4.3.2-4**.
- V in the V/C ratio represents the traffic volume in PCU unit per hour. The obtained result is then compared to the standard set by the Traffic Engineering Division, and the highest ratio should not exceed 0.8 (80%).

The V/C ratio formula is as follows:

$$\text{V/C ratio} = \frac{\text{Additional Traffic Volume from the Project Development + Existing Traffic Volume}}{\text{Vehicle Carrying Capacity of each Highway}}$$

TABLE 4.3.2-4

PASSENGER CAR EQUIVALENT FACTOR FOR EACH VEHICLE TYPE

Vehicle Type	Passenger Car Equivalents Factor (PCE)
Passenger Car and Taxi	1.00
Minibus	1.25
Bus	2.00
Light Truck	1.50
Medium Truck	1.75
Heavy Truck	2.00
Motorcycle	0.33
Bicycle, Tricycle	0.20

Source: Phaophong Nijjanphansri, 1997, and Department of Highways, 2011

The vehicle carrying capacity of each highway is presented in **Table 4.3.2-5** based on the criteria of the Bureau of Highway Safety, Department of Highways. For example, the multi-lane road has the maximum carrying capacity of 2,000 PCUs/hr-lane.

The derived V/C ratios are then compared to the established standard values to assess the future traffic conditions as presented in **Table 4.3.2-6**.

TABLE 4.3.2-5

VEHICLE CARRYING CAPACITY OF EACH ROAD TYPE

Road Type	Vehicle Carrying Capacity (PCU/hr)
Multi-lane Road	2,000 (per 1 lane)
Bi-directional 2-lane Road	2,000 (Bi-directional)
Bi-directional 3-lane Road	4,000 (Bi-directional)

Source: Phaophong Nijjanphansri, 1997

TABLE 4.3.2-6

VOLUME/CAPACITY RATIO TO ASSESS THE FUTURE TRAFFIC CONDITIONS

Volume to Capacity Ratio (V/C ratio)	Future Traffic Conditions
0.89-1.00	Critical Traffic Condition
0.68-0.88	Heavy Traffic Condition
0.53-0.67	Slow Traffic Condition
0.37-0.52	Reasonably Free Flow
0.20-0.36	Free Flow

Source: Phaophong Nijjanphansri, 1997

According to the collected data on traffic volumes from the Traffic Volumes on Highways Report during 2011-2015 and from the field survey, the traffic conditions of these roads can be assessed from the derived V/C ratios as shown in **Table 4.3.2-7** and summarized below.

- **Traffic Volume on the National Highway No. 331:** The traffic volume in the latest year (2015) is 1,294 PCUs/hr. The V/C ratio is 0.16, indicating the free flow traffic condition.
- **Traffic Volume on the National Highway No. 36:** The traffic volume in the latest year (2015) is 1,869 PCUs/hr. The V/C ratio is 0.23, indicating the free flow traffic condition.
- **Traffic Volume on the Rural Highway No. Ror.Yor. 2026:** The traffic volume on Sunday 13th March 2016 is 457 PCUs/hr. The V/C ratio is 0.23, indicating the free flow traffic condition. The traffic volume on Monday 14th March 2016 is 611 PCUs/hr. The V/C ratio is 0.31, indicating the free flow traffic condition.
- **Traffic Volume on the Rural Highway No. Ror.Yor. 3013:** The traffic volume on Sunday 13th March 2016 is 665 PCUs/hr. The V/C ratio is 0.33, indicating the free flow traffic condition. The traffic volume on Monday 14th March 2016 is 643 PCUs/hr. The V/C ratio is 0.32, indicating the free flow traffic condition.

TABLE 4.3.2-7

EXISTING TRAFFIC CONDITIONS OF HIGHWAYS NEAR THE PROJECT AREA

Traffic Count Station	Year	Traffic Volume and Density					Traffic Conditions
		Traffic Volume			Carrying Capacity (vehicle/hr)	V/C Ratio	
		Vehicle/day	PCU/day	PCU/hr.			
National Highway No. 331[1/] Station at KM 68+900	2554	16,655	24,438	1,018	8,000	0.13	Free Flow
	2555	16,968	24,892	1,037		0.13	Free Flow
	2556	21,350	30,148	1,256		0.16	Free Flow
	2557	21,331	30,192	1,258		0.16	Free Flow
	2558	22,050	31,065	1,294		0.16	Free Flow
National Highway No. 36[1/] Station at KM 2+000	2554	21,110	25,084	1,045	8,000	0.13	Free Flow
	2555	29,177	35,147	1,464		0.18	Free Flow
	2556	30,042	36,144	1,505		0.19	Free Flow
	2557	31,774	39,562	1,648		0.21	Free Flow
	2558	35,377	44,861	1,869		0.23	Free Flow
Rural Highway No. Ror.Yor. 2026 Station at KM 12+300	2559[2/]	5,164	5,478	457	2,000	0.23	Free Flow
	2559[3/]	6,420	7,324	611		0.31	Free Flow
Rural Highway No. Ror.Yor. 3013 Station at KM 14+250	2559[2/]	8,522	7,977	665	2,000	0.33	Free Flow
	2559[3/]	7,777	7,711	643		0.32	Free Flow

Remark: Traffic count data on the Highway No. 331 during 2011-2012 were based on the traffic count data at KM 76+000 which is the closest station to the project area.

Source:
1/ Traffic Volumes on Highways Report during 2011-2015 (Department of Highways, Ministry of Transport), 2016
2/ Traffic count results from field survey conducted by TEAM Consulting Engineering and Management Co., Ltd. on Sunday 13th March 2016
3/ Traffic count results from field survey conducted by TEAM Consulting Engineering and Management Co., Ltd. on Monday 14th March 2016

4.3.3 Water Utilization

(1) Introdution

Water use study is a significant factor in the project development as water is utilized since the beginning of the process: from construction phase to operation phase. The objective is to study the existing water utilization for consumption and agriculture of the communities around the project area. The obtained data will serve as baseline data for analysis or prediction of the project development impacts on the water use of local people in the study area. Impact prevention and mitigation measures will be recommended together with impact monitoring measures.

(2) Methodology

Water use data were collected from documents or reports relating to the study area, namely Provincial Waterworks Authority (www.pwa.co.th), Regional Irrigation Office 9 (www.rid9.com), and Eastern Water Resources Development and Management Plc (www.eastwater.com), etc.

(3) Study results

(a) Water Resources

The data from Regional Irrigation Office 9 show that there are 5 reservoirs in Rayong province, with a total combined storage capacity of 540.75 million cubic meters. They are Nong Pla Lai reservoir (163.75 million cubic meters), Pra Sae reservoir (248.00 million cubic meters), Dok Krai reservoir (71.40 million cubic meters), Khlong Ra-ok reservoir (17.50 million cubic meters), and Khlong Yai reservoir (40.10 million cubic meters).

(b) Water Sources for Consumption

The data from Provincial Waterworks Authority (PWA), Rayong Province, show that 3 PWA offices are situated in the study area, i.e. PWA Rayong Branch, PWA Ban Chang Branch, and PWA Pak Nam Pra Sae Branch. The combined water production capacity is totally 110,664 m^3/day. The total water sales volume in September 2015 is 3,239,917 m^3 and the total number of customers is 117,878 (Provincial Waterworks Authority, 2015), as presented in **Table 4.3.3-1**.

(c) Agricultural Water Sources

Water resources development has been carried out in Rayong province to supply agricultural water. There are 5 irrigation projects, namely Rayong Flood Control Project, Ban Khai weir, Nong Pla Lai reservoir, Khlong Ra-ok reservoir, and Pra Sae Salinity Prevention Project, as shown in **Table 4.3.3-2.**

TABLE 4.3.3-1

WATER PRODUCTION AND UTILIZATION OF PROVINCIAL WATERWORKS AUTHORITY, RAYONG PROVINCE

Provincial Waterworks Authority Offices	Service Zones	Service Area (sq.km)	Water Sources	Production Capacity (m^3/day)	Water Production Volume, September 2015 (m^3)	Water Sales Volume, September 2015 (m^3)	Customers (No.)
Provincial Waterworks Authority, Rayong Branch Office	Map Ta Phut sub-district municipality, Ban Phe and Hat Mae Phim sub-district municipality, Choeng Noen sub-district administrative organization (SAO), Nam Khok SAO, Thap Ma SAO, Noen Phra SAO, Taphong SAO, Ban Khai SAO, Bang But SAO, and 4 villages outside the service zones, Rayong city municipality, Mueang district, Ban Khai sub-district municipality, Ban Khai district	203.030	Bueng Samnak Yai, Rayong River, irrigation canals	69,227	2,070,165	2,059,144	75,771
Provincial Waterworks Authority, Ban Chang Branch Office	Ban Chang sub-district municipality, Bang Chang district; Samnak Thon sub-district municipality, Ban Chang district, Ban Noen Kraprok, Ban La, Ban Phayun, Huai Pong sub-district, and Mueang Mai Map Ta Phut housing community, Ban Chang district	38.800	Khlong Bang Phai reservoir, East Water	35,083	1,416,902	1,052,482	35,882
Provincial Waterworks Authority, Pak Nam Pra Sae Branch Office	Pak Nam Krasae sub-district municipality, Thung Khwai Kin sub-district, Thang Kwian sub-district, Kong Din sub-district, Na Yai-am sub-district, Klaeng sub-district municipality, Thung Khwai Kin sub-district municipality, Pak Nam Pra Sae sub-district municipality, Klaeng district, Khlong Pun SAO, Thung Khwai Kin SAO, Kong Din SAO, and Na Yai-am SAO	102.026	Khlong Phlo	6,354	190,600	128,291	6,225

Source: www.pwa.co.th, search conducted on 27th April 2016

TABLE 4.3.3-2
LARGE IRRIGATION PROJECTS IN RAYONG

Project Name	Location		Storage Capacity (mcm)	Irrigation Areas (rai)
	Sub-district	District		
Nong Pla Lai reservoir	Lahan	Pluak Daeng	163.75	30,000
Dok Krai reservoir	Mae Nam Khu	Pluak Daeng	71.40	1,200
Khlong Ra-ok reservoir	Thung Khwai Kin	Klaeng	17.50	7,500
Khlong Yai reservoir	Lahan	Pluak Daeng	40.10	20,000
Pra Sae reservoir	Chum Saeng	Wang Chan	248.00	137,500
Total	**-**	**-**	**540.75**	**176,700**

Source: www.rid9.com/menu_basin.asp and http://cc.bsru.ac.th/downloads/ry_solar/index.php?option=com_content&view=article&id=870:2010-09-23-02-17-15&catid=130, search conducted on 2nd November 2016

(d) Industrial Water Sources

Eastern Water Resources Development and Management Plc or East Water was founded on 12 September 1992 in accordance with the Cabinet resolution. East Water's objectives are to be responsible for integrated raw water management via large water transmission pipeline systems for industrial sector and consumption; and support the plan for Eastern Seaboard Area development into the main industrial zone of the country. East Water has been listed on the Stock Exchange of Thailand, raising funds from the capital market to develop its service system in order to meet customers' water demand. Its major shareholders are Provincial Waterworks Authority (PWA), Industrial Estate Authority of Thailand (I-EA-T), financial institutions-both domestic and international, The Electricity Generating Public Company Limited, and general public.

East Water has invested in the construction of 394.5-km water transmission pipeline network to link to major water resources in the eastern region, i.e. Nong Pla Lai, Dok Krai, Khlong Yai, and Pra Sae reservoirs in Rayong province; Nong Kho and Bang Phra reservoirs in Chon Buri province; and Bang Pakong River in Chachoengsao province. This is aimed to create the country's only water grid that is most modern and comprehensive and capable of supplying raw water for water production to meet the water requirements of communities' consumption, tourism businesses, and industries. Its service areas include Chon Buri, Rayong, and Chachoengsao provinces (Source: http://www.eastwater.com according to a search conducted on 12th July 2016). In addition, the industrial sector's water demand has been on the increase.

- **East Water's Raw Water Sources**

East Water's water availability is based on water allocation by Regional Irrigation Office 9, Royal Irrigation Department, which is the main agency in charge of water management. East Water's existing water sources are Dok Krai, Nong Pla Lai, Nong Kho and Pra Sae reservoirs; Bang Pakong River; and private water sources, with the available water volume of 340 million m^3, as detailed in **Table 4.3.3-3.**

TABLE 4.3.3-3
EAST WATER'S WATER SOURCES

Water Sources	Province	Storage Capacity (mcm)	Water Availability (mcm/year)
1. Dok Krai reservoir	Rayong	71	116
2. Nong Pla Lai reservoir	Rayong	164	120
3. Nong Kho reservoir	Chon Buri	21	17
4. Pra Sae reservoir	Rayong	248	40
5. Bang Pakong River	Chachoengsao	-	27
6. Private water sources	Chon Buri	10	20
Total			**340**

Remarks: Water availability of Dok Krai reservoir is greater than its storage capacity. This means that inflow volume during the year is greater than the storage capacity and East Water can pump out more water than the reservoir storage capacity.

Source: Eastern Water Resources Development and Management Plc, 2016

- **Water Demand from Water Grid**

The water demand of customers in Rayong, Chon Buri and Chachoengsao provinces is expected to rise continuously owing to the expanding industrial sector in the eastern region, relocation of production bases from the central region to the eastern region as a result of the 2011 floods, and construction of new power plants with additional capacity of 5,000 MW. The water demand is forecast to increase from 303.67 million m^3 in 2016 to 364.52 and 459.00 million m^3 in the next 5-10 years, as shown in **Table 4.3.3-4**. The forecast water demand of Pluak Daeng-Bowin service area **(Table 4.3.3-4)** has already included the water requirements of Pluak Daeng Power Plant Project. The project's water use is planned to commence in 2020. However, to ensure adequate water availability for water demands in the future, East Water has adopted a 20-year water resources development plan.

TABLE 4.3.3-4
FORECAST WATER DEMAND OF RAYONG, CHON BURI AND CHACHOENGSAO PROVINCES

Service Area	Water Demand (mcm/year)					
	2016	2017	2020	2023	2026	2029
1. Rayong	181.83	189.49	214.84	235.99	235.14	243.94
2. Pluak Daeng-Bowin	26.56	32.06	54.92	97.10	110.48	113.07
3. Chon Buri	77.99	76.28	78.39	82.13	88.09	98.10
4. Chachoengsao	17.28	15.70	16.36	17.02	18.24	18.97
Total	**303.66**	**313.53**	**364.51**	**432.24**	**451.95**	**474.08**

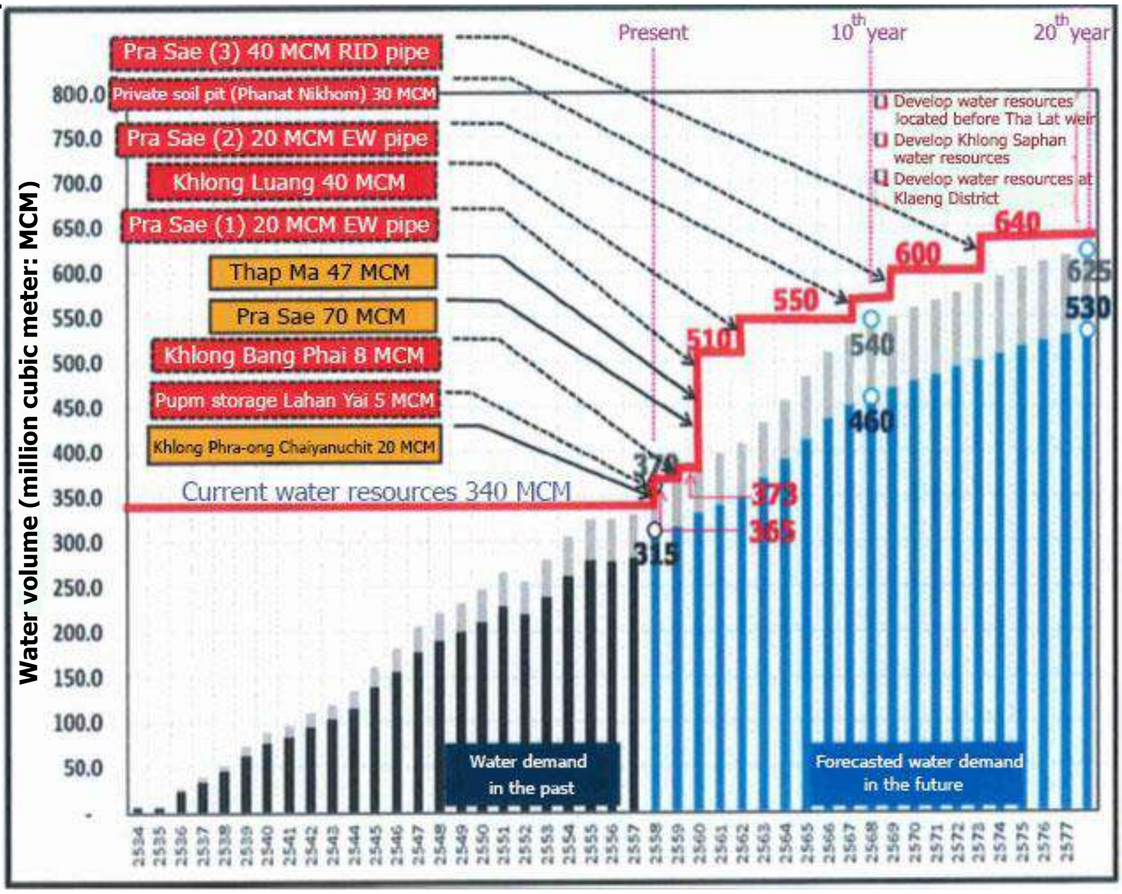
Source: Review of First Quarter 2016 Sales Volume of Eastern Water Resources Development and Management Plc, 2016

- **East Water's Water Resources Plan**

The existing water sources can meet the demand up to 2017. To ensure sufficient water availability for future water requirements, East Water has put in place a 20-year water resources development plan (as depicted in **Figure 4.3.3-1**). About 20 million m^3 of water will be diverted from Khlong Phra-ong Chao Chaiyanuchit while 5 million m^3 will be pumped by Lahan Yai pump station. Additionally, water will be pumped and diverted from Khlong Phai, Thap Ma reservoir, Pra Sae reservoir, Khlong Luang, and private ponds in Phanat Nikhom district. The total water diversion volume will be approximately 275 million m^3. Moreover, there are water resources development plans for the upstream reach of Tha Lat weir; Khlong Saphan; and water resources in Klaeng district. East Water is now implementing its 20-year water resources development plan as follows:

– Installation of Pra Sae Reservoir–Nong Pla Lai Reservoir transmission pipeline for diverting about 70 million m^3 of water per year from Pra Sae Reservoir to Nong Pla Lai Reservoir in order to solve water shortages, both short term and long term, in Rayong and Chon Buri provinces. The pipeline installation works have been about 94% completed (East Water's data as of 15th July 2016);

– Development of Thap Ma raw water reservoir to increase water availability for Rayong province by not less than 47 million m^3 per year. Pump stations will be constructed on the Rayong River and Khlong Thap Ma to draw raw water to Thap Ma raw water reservoir and water will be further pumped into East Water's water transmission system. The construction works of pump stations have been 77% completed (East Water's data as of 15th July 2016);



Source : Eastern Water Resources Development and Management Plc, 2016

FIGURE 4.3.3-1 : EAST WATER'S WATER RESOURCES DEVELOPMENT PLAN

– Installation of the 2nd Nong Pla Lai-Nong Kho water transmission pipeline system, about 20 km long, to increase water transmission capacities to Bo Win-Pluak Daeng area by about 60 million m^3 of water per year. Water will be pumped to be stored in Nong Pla Lai reservoir and then fed into East Water's water transmission pipeline system. Moreover, temporary pump station will be built. The works have been about 95% completed (East Water's data as of 15th July 2016).

- **Water Transmission from Water Sources to East Water's Customers**

The existing water transmission network of East Water is 394.5 km in total length, as illustrated in **Figure 4.3.3-2**, linking to the eastern region's important water sources. It is planned that the project will be supplied by Nong Pla Lai-Nong Kho raw water transmission system which mainly receives water from Nong Pla Lai and Pra Sae reservoirs. The preliminary raw water pipeline alignment of the project is depicted in **Figure 4.3.3-3.**

FIGURE 4.3.3-2 : EAST WATER'S WATER GRID IN THE EASTERN REGION

Source: Eastern Water Resources Development and Management Plc, 2016

FIGURE 4.3.3-3 : RAW WATER PIPELINE ALIGNMENT TO THE PROJECT AREA

- **East Water's Raw Water Characteristics**

The raw water characteristics of Nong Pla Lai reservoir analysed by East Water are presented in **Table 4.3.3-5**.

TABLE 4.3.3-5
RAW WATER CHARACTERISTICS OF NONG PLA LAI RESERVOIR
DURING JANUARY-JUNE 2016

Parameter	Unit	Minimum-Maximum	Standard*
pH	-	7.9-9.0	5.0-9.0
DO	mg/l	5.8-7.1	≥4.0
BOD	mg/l	1.8-3.8	≤2.0
COD	mg/l	12.0-21.8	-
Turbidity	NTU	5.8-14.0	-
Conductivity	us/cm	199-276	-
Colour	Pt-Co	10-15	-Natural
Calcium	mg/l as $CaCO_3$	30.8-46.1	-
Magnesium	mg/l as $CaCO_3$	9.6-25.5	-
Chloride	mg/l	17.6-34.1	-

TABLE 4.3.3-5
RAW WATER CHARACTERISTICS OF NONG PLA LAI RESERVOIR
DURING JANUARY-JUNE 2016 (Cont'd)

Parameter	Unit	Minimum-Maximum	Standard*
Total Iron	mg/l	0.006-0.082	-
Manganese	mg/l	0.038-0.186	≤1.0
Nitrate Nitrogen	mg/l	0.00-0.11	≤5.0
Sulfate	mg/l	21.1-31.6	-
Silica	mg/l	8.95-9.83	-
Total Suspended Solid	mg/l	4.4-7.4	-
Dissolved Solids	mg/l	109-178	-
Total Alkalinity	mg/l	62.6-68.6	-
Grease & Oil	mg/l	0.1-0.7	-
Total Phosphate	mg/l	0.04-0.10	-
Phosphate	mg/l	ND-0.05	-
Total Kjeldahl Nitrogen	mg/l	1.6-3.9	-
Ammonia Nitrogen	mg/l	0.00-0.06	≤0.5
Copper	mg/l	0.000-0.022	≤0.1
Zinc	mg/l	0	≤1.0
Fluoride	mg/l	0.20-0.74	-
Detergent	mg/l	0.00-0.01	-
Carbonate Hardness	mg/l as $CaCO_3$	34.0-66.5	-
Non Carbonate Hardness	mg/l as $CaCO_3$	0.0-22.6	-
Salinity	g/kg	0.1	-
TOC	mg/l	4.32-5.17	-
Arsenic	mg/l	0.0029-0.0037	≤0.01
Barium	mg/l	0.041-0.058	-
Cadmium	mg/l	0	≤0.005
Chromium (6+)	mg/l	0	≤0.05
Lead	mg/l	0	≤0.05
Mercury	mg/l	0.0001-0.0020	≤0.002
Nickel	mg/l	0	≤0.1
Selenium	mg/l	0	-
Silver	mg/l	0	-
Sodium	mg/l	15.0-18.3	-
Cyanide	mg/l	0	≤0.005
Phenol	mg/l	0.000-0.013	≤0.005
Fecal Coliform	MPN/100ml	<1.8-490	≤4,000

Remarks: *Surface Water Quality Standards, Class 3: Water resources receiving effluents from some activities that can be used for (1) consumption which must pass through an ordinary water treatment process before use, and (2) agriculture

Source: Eastern Water Resources Development and Management Plc, 2016

4.3.4 Electricity Use

(1) Introduction

Electricity is the major factor in project development. The study of existing power consumption of communities in the study area is to provide baseline data for analysis or forecast of the project development impacts on the electricity usage of people living in the study area. In addition, measures will be recommended for prevention and mitigation as well as monitoring of impacts on the electricity usage of local communities in the project vicinity.

(2) Methodology

The existing power consumption in the study area was studied by collecting power consumption data from relevant documents or reports, e.g. Provincial Electricity Authority (PEA), Energy Regulatory Commission (ERC), National Statistical Office (NSO), etc.

(3) Study results

(a) Electricity Usage

The power demand of Rayong province during 2011-2015 reveals an increasing trend of both electricity users and power consumption. In 2015, there were 352,269 customers and the power consumption was 9,510,211,103 kilowatt-hours. During 2011-2015, the electricity usage has averagely increased by 3.14% per year **(Table 4.3.4-1)**.

TABLE 4.3.4-1

POWER CONSUMPTION OF RAYONG PROVINCE DURING 2011-2015

Customer Type	2011	2012	2013	2014	2015
Users (No.)	283,067	296,348	314,626	334,112	352,269
Power Sales and Usage (kilowatt-hours)	7,805,325,106	8,524,603,785	8,758,195,178	9,101,211,037	9,510,211,103
Percentage of power demand (increase/decrease (-))	-4.65	9.22	2.72	3.92	4.49
- Residential	613,370,446	673,354,481	705,811,901	744,188,478	799,501,116
- Small business	186,173,592	202,543,304	225,547,031	242,609,760	258,894,034
- Medium business	780,992,047	805,115,476	822,039,523	873,900,945	889,659,931
- Large business	5,980,989,349	6,552,254,707	6,816,268,960	6,996,190,130	7,273,591,057
- Others	243,799,672	291,335,817	188,527,763	244,321,724	288,564,965

Remarks: Small business means businesses, industries, government agencies, and offices with the highest average 15-minute power demand of less than 30 kW

Medium business means businesses, industries, government agencies, and offices with the highest average 15-minute power demand of 30-999 kW

Large business means businesses, industries, government agencies, and offices with the highest average 15-minute power demand of over 1,000 kW

Others means specific businesses, e.g. hotels, guesthouses, etc.; non-profit organizations; water pumping for agricultural purposes; temporary power users

Source: http://service.nso.go.th/nso/web/statseries/statseries18.html, search conducted on 27th April 2016

The project area is located inside Pluak Daeng Industrial Park which has a total power demand of 17 MW (50 KVA per one-rai area). The project's electricity supply will be provided by PEA Pluak Daeng Branch. PEA will construct a 115/22 kV substation on a 7-rai land to supply the electric power in the Industrial Park.

(b) Power Supply Sufficiency

The Electricity Generating Authority of Thailand (EGAT) will manage the country's power supply by electricity generation as well as purchase of electricity from independent power producers. The Energy Regulatory Commission's database system (www.erc.or.th/ERCSPP/default.aspx?x=0&muid=23&prid=41, search conducted on 17th July 2016) shows that there are 41 power plants in Rayong province which sell electricity to EGAT and PEA. The combined installed capacity is totally 9,068.783 MW and the contracted power sale volume is 7,195.100 MW. Of the total 41 power plants, there are 3 IPPs, 35 SPPs and 3 VSPPs. Therefore, Rayong province is close to power generation sources. Furthermore, there are high voltage substations in the study area, e.g. Pluak Daeng 500 kV high voltage substation, etc. Electricity will be received from the transmission line, which is connected to the national power grid, and then distributed to the Industrial Park including local people in the area; consequently, power supply will be adequate to serve the demand.

4.3.5 Drainage and Flood Control

(1) Introduction

The study of existing drainage and flood control in the study area is aimed to provide baseline data for environmental impact assessment, and establishment of impact prevention and mitigation measures as well as monitoring measures.

(2) Methodology

Secondary data were collected from Draft Flood Impact Study Report for Pluak Daeng Power Plant Project, Pluak Daeng district, Rayong province, as presented in **Appendix 3Q**, to be used as baseline data for environmental impact assessment.

(3) Study results

The average ground elevation of Pluak Daeng power plant site is about 80 m MSL. The power plant is situated in Khlong Yai river basin, with 30-meter difference in elevation-from northwest towards Dok Krai reservoir downstream of the project area-between the power plant site and the point of inflow into Dok Krai reservoir. As a result, flood probability is very low and floods will only occur in the riverside areas. Inundated areas in the past are mainly located downstream of the reservoir which is quite far from the project area.

On the Huai Phu Sai stream reach near the project site, there is a weir located in front of Pluak Daeng Industrial Park, diverting water for use in the upstream communities and agricultural land. Huai Phu Sai stream will flow over this weir before flowing into Dok Krai reservoir which is about 4 kilometres downstream of the weir. During the flooding season, overflows from the weir will submerge the floodplains along the stream's banks, but not over large areas.

4.3.6 Waste Management

(1) Introduction

Waste management study in the study area is to provide baseline data for environmental impact assessment, and establishment of impact prevention and mitigation measures as well as monitoring measures.

(2) Methodology

Waste management data in the study area were collected, e.g. solid waste volume, waste collection data from relevant agencies, etc., to be used as baseline data for environmental impact assessment and preparation of prevention and mitigation measures for probable impacts.

(3) Study results

(a) Solid Waste Management of Rayong Province

Local agencies in the study area signed a memorandum of understanding (MOU) with regard to Integrated Waste Management Project, namely Map Yang Phon Sub-district Administrative Organization (SAO), Phana Nikhom SAO, Mae Nam Khu SAO, and Pluak Daeng SAO. All local governments of Rayong province have entered into the waste management agreement. Rayong Provincial Administrative Organization (PAO) is the responsible agency and carrying out waste management operations in the integrated waste management center, Rayong province, which is located in Mu 3, Nam Khok sub-district, Mueang Rayong district, Rayong. Its objectives are to ensure proper solid waste disposal according to technical principles, and to support local governments for efficient solid waste disposal in line with the Solid Waste Management Roadmap. The goals of the Roadmap are to accelerate the solving of improper solid waste disposal problems and accumulated waste volume as per the approval of the National Council for Peace and Order (NCPO). The local agencies in the study area also signed the MOU concerning solid waste disposal at the integrated waste management center. The solid waste management of the local agencies in the study area is presented in **Table 4.3.6-1**.

TABLE 4.3.6-1

SUMMARY OF SOLID WASTE MANAGEMENT RELATING TO LOCAL GOVERNMENTS IN THE STUDY AREA

Responsible Agency	Solid Waste Disposal Site	Area (rai)	Waste Collection Truck Type/Quantity (No.)	Solid Waste Disposal System	Waste Management Status
Map Yang Phon SAO	Integrated Waste Management Center in Mu 3, Nam Khok sub-district, Mueang Rayong district, Rayong province	429-3-10	6 Rear loader compaction trucks	Sub-district administrative organizations in the study area had signed a memorandum of understanding (MOU) dated 1 April 2015 regarding Integrated Waste Management Project. There will be solid water transfer stations, transporting solid waste from the sub-district administrative organizations to the Center which has waste separation and landfill systems as well as waste to energy system.	Solid waste volume: About 28 tons/day Waste disposal contractor is engaged for solid waste collection from all locations where waste containers are placed. Solid waste will be delivered to solid waste disposal system of the Integrated Waste Management Center
Phana Nikhom SAO			1 Rear loader compaction truck, with capacity of 14 m^3		Solid waste volume: About 5 tons/day Solid waste will be delivered to solid waste disposal system of the Integrated Waste Management Center
Mae Nam Khu SAO			2 Rear loader compaction trucks, with capacity of 12 m^3 each 1 Container hauling truck with capacity of 4 m^3		Solid waste volume: About 7 tons/month There is a plan for joint waste management with the people by promoting waste separation at source to reduce solid waste volume Solid waste will be delivered to solid waste disposal system of the Integrated Waste Management Center
Pluak Daeng SAO			3 Rear loader compaction trucks, with capacity of 10 m^3 each 1 Container hauling truck with capacity of 4 m^3 1 garbage truck of a private firm, with capacity of 4 m^3		Solid waste volume: 35-38 tons/day Solid waste collection is, at present, quite adequate to meet the needs. Solid waste will be delivered to solid waste disposal system of the Integrated Waste Management Center

Source: Map Yang Phon SAO, Phana Nikhom SAO, Mae Nam Khu SAO and Pluak Daeng SAO, 2016

(b) Solid Waste Management of Pluak Daeng Industrial Park

According to the EIA Report for Pluak Daeng Industrial Park Project, Expansion Phase 1 (February, 2016), the total solid waste volume is projected to be 3,306 kilogrammes/day, comprising 3,226 kilogrammes/day of solid waste from industrial areas, and 80 kilogrammes/day of solid waste from commercial/residential/office areas. All the solid waste will be collected and delivered for disposal at Map Yang Phon SAO or an external agency permitted by Map Yang Phon SAO. Besides, hazardous waste volume is estimated to be around 165.30 kilogrammes/day, and the Industrial Park will arrange with an external agency permitted by the Department of Industrial Works for proper hazardous waste collection and disposal.

4.3.7 Fire Suppression System

(1) Introduction

Fire prevention and suppression system in the study area was studied to provide baseline data for assessment of project development impacts, and establishment of environmental impact prevention and mitigation measures as well as monitoring measures.

(2) Methodology

Fire prevention and suppression data of Pluak Daeng Industrial Park were collected together with data of local governments in the study area.

(3) Study results

(a) Firefighting Service Capabilities of External Agencies

In case of a fire in the project area which cannot be controlled by the staff of the project and Pluak Daeng Industrial Park, the Industrial Park will coordinate with Map Yang Phon Sub-district Administrative Organization (SAO), Pluak Daeng district, Rayong province, which is the responsible local agency, as well as other nearby agencies such as Pluak Daeng SAO, Mae Nam Khu SAO and Phana Nikhom SAO, etc. The fire prevention and suppression readiness is summarized as follows:

- **Map Yang Phon Sub-district Administrative Organization**

Map Yang Phon Sub-district Administrative Organization is about 4 km from the project area, with a journey time of 4 minutes. It has 1 fire truck, with capacity of 12,000 litres, 1 platform truck, and 200 dry chemical fire extinguishers, with 10-lb capacity. Its manpower includes 13 disaster mitigation officers and 190 civil defence volunteers.

- **Pluak Daeng Sub-district Administrative Organization**

Pluak Daeng Sub-district Administrative Organization is about 9 km from the project area, with a journey time of 9 minutes. Its firefighting equipment includes 1 multi-purpose fire truck, with capacity of 12,000 litres; 1 fire truck with fire nozzles, with capacity of 5,000 litres; 1 platform truck; 1 multi-purpose rescue car; and 1 patrol car. Its personnel include 2 disaster prevention and mitigation officers, 1 permanent employee, 2 task-specific workers, 3 general workers and 195 civil defence volunteers.

- **Mae Nam Khu Sub-district Administrative Organization**

Mae Nam Khu Sub-district Administrative Organization is about 14 km from the project area, with a journey time of 14 minutes. Its firefighting system includes 2 multi-purpose water trucks, 4 firefighters, and 103 civil defence volunteers.

- **Phana Nikhom Sub-district Administrative Organization**

Phana Nikhom Sub-district Administrative Organization is about 12 km from the project area, with a journey time of 12 minutes. Its personnel include 4 disaster mitigation officers, equipped with 1 water truck, with capacity of 12,000 litres. In case of inability to contain the fire, cooperation can be sought from Makham Khu sub-district municipality, Nikhom Phatthana Sub-district Administrative Organization, Map Kha sub-district municipality, and Map Kha Phatthana sub-district municipality.

(b) Pluak Daeng Industrial Park

Pluak Daeng Industrial Park has specified and provided appropriate fire-fighting equipment in adequate quantities which will be regularly inspected. Locations of equipment installation are as follows:

- **Inside the Factory Buildings**

Firefighting equipment inside the factory buildings must be provided in compliance with the building control laws or other applicable laws. The fire suppression equipment for initial response is listed herein.

– Portable fire extinguishers suitable for fuel types, with a capacity of not less than 4.5 kilogrammes, which will be installed inside buildings according to the standards of the Engineering Institute of Thailand (EIT);

– Fire alarm system is of conventional type and/or automatic type. In case of fire breakout, fire alarm equipment will send a signal to the fire control panel, showing the illuminated location of a fire-at which device and working area. The control panel will then activate alarm bells so that people can evacuate to safe places. The fire alarm system consists of the following devices.

➢ Initiating devices, i.e. heat detector and ionization smoke detector.

➢ Control panel.

➢ Audible notification appliances, namely bells, horns, and strobe lights.

- **Outside the Factory Buildings**

For the areas outside the factory buildings in the Industrial Park, fire water piping system will be provided in combination with water supply piping system with a minimum diameter of 100 mm. Two-way fire hydrants, 2.5-4 inches in diameter, will be installed at 150-m intervals to enable external fire trucks and emergency cars to pump water for firefighting operations. The Industrial Park has manifestly prepared adequate fire prevention and suppression system capable of fire suppression in case of a fire in accordance with the standards of the Engineering Institute of Thailand (EIT).

Pluak Daeng Industrial Park has classified abnormal and emergency situations according to the power and duties consistent with those prescribed in the Public Disaster Prevention and Mitigation Act, B.E. 2550. Three classes of emergency have been defined, with details given in **Appendix 3AC.**

4.4 QUALITY OF LIFE

4.4.1 Socio-Economics

(1) Introduction

The development of Pluak Daeng Power Plant Project in Map Yang Phon sub-district, Pluak Daeng district, Rayong province aims to support the increased demand of electricity and to stabilize an electric energy. The power plant is located in Pluak Daeng Industrial Park. However, the project development may affect the resources, nature, environment and socio-economics of people in the project vicinities. The study of socio-economics in communities in the project vicinities aims at surveying the current socio-economics of communities to be affected, compiling the opinions on the project development and establishing the environmental impact prevention and mitigation measures for socio-economics analysis that are in line with communities in the project vicinities

(2) Methodology

The methodology for socio-economics study of Pluak Daeng Power Project is given below.

(2.1) Collection of secondary data

The socio-economics data were collected from relevant documents and reports. It covered the province, districts and sub-districts within 5 km radius from the project boundary, such as the summary report of Rayong province, B.E. 2558, the summary reports of Pluak Daeng and Nikhom Pattana districts under the 3-year development plan (the sub-district administrative organization economic and social development plan, B.E.

2558), the official website of the province, the official website of sub-district, the statistical report of number of population and households in the provincial, district and sub-district levels of by Department of Local Administration Organization, Ministry of Interior, satellite images, etc.

(2.2) Collection of primary data

(a.) Operation area

The socio-economics operation area covers 5 km radius from the project boundary. The operation area consists of 1 province, 2 districts and 4 sub-districts: Map Yang Phon sub-district, Pluak Daeng sub-district, Mae Nam Khu sub-district, Pluak Daeng district and Phana Nikhom sub-district, Nikhom Pattana district, Rayong province. For clarity, the study area is divided into 2 sections, i.e. (1) community within 0-3 km radius from the project boundary, or the area adjacent to the project and (2) community within 3-5 km radius from the project boundary, or the area far from the project. In addition, concerns and opinions on the project development are shown (**Table 4.4.1-1** and **Figure 4.4.1-1**).

TABLE 4.4.1-1
SOCIO-ECONOMICS OPERATION AREA

Province	Districts	Sub-Districts	Village	Radius from Project Boundary	
				0-3 km	3-5 km
Rayong	Pluak Daeng	Map Yang Phon	Village no. 1 Ban Map Toei	✓	-
			Village no. 2 Ban Noen Sawan	✓	✓
			Village no. 3 Ban Map Yang Phon	✓	✓
			Village no. 5 Ban Wang Tan Mon	✓	✓
			Village no. 6 Ban Map Yang Mai	✓	✓
			Village no. 7 Ban Sak Oi	✓	✓
		Pluak Daeng	Village no. 4 Ban Wang Ta Phin	-	✓
			Village no. 6 Ban Thap Tong	✓	✓
		Mae Nam Khu	Village no. 4 Ban Sak Manthet	-	✓
			Village no. 7 Ban Wang Pradu	✓	✓
	Nikhom Pattana	Phana Nikhom	Village no. 4 Ban Khao Maphut	✓	✓
			Village no. 5 Ban Khlong Phlu	✓	✓
			Village no. 6 Ban Nong Rakam	-	✓
			Village no. 7 Ban Wang Pla	✓	✓
			Village no. 8 Ban Soi 13	✓	✓
1 province	2 districts	4 sub-districts	15 villages	12 villages	14 villages

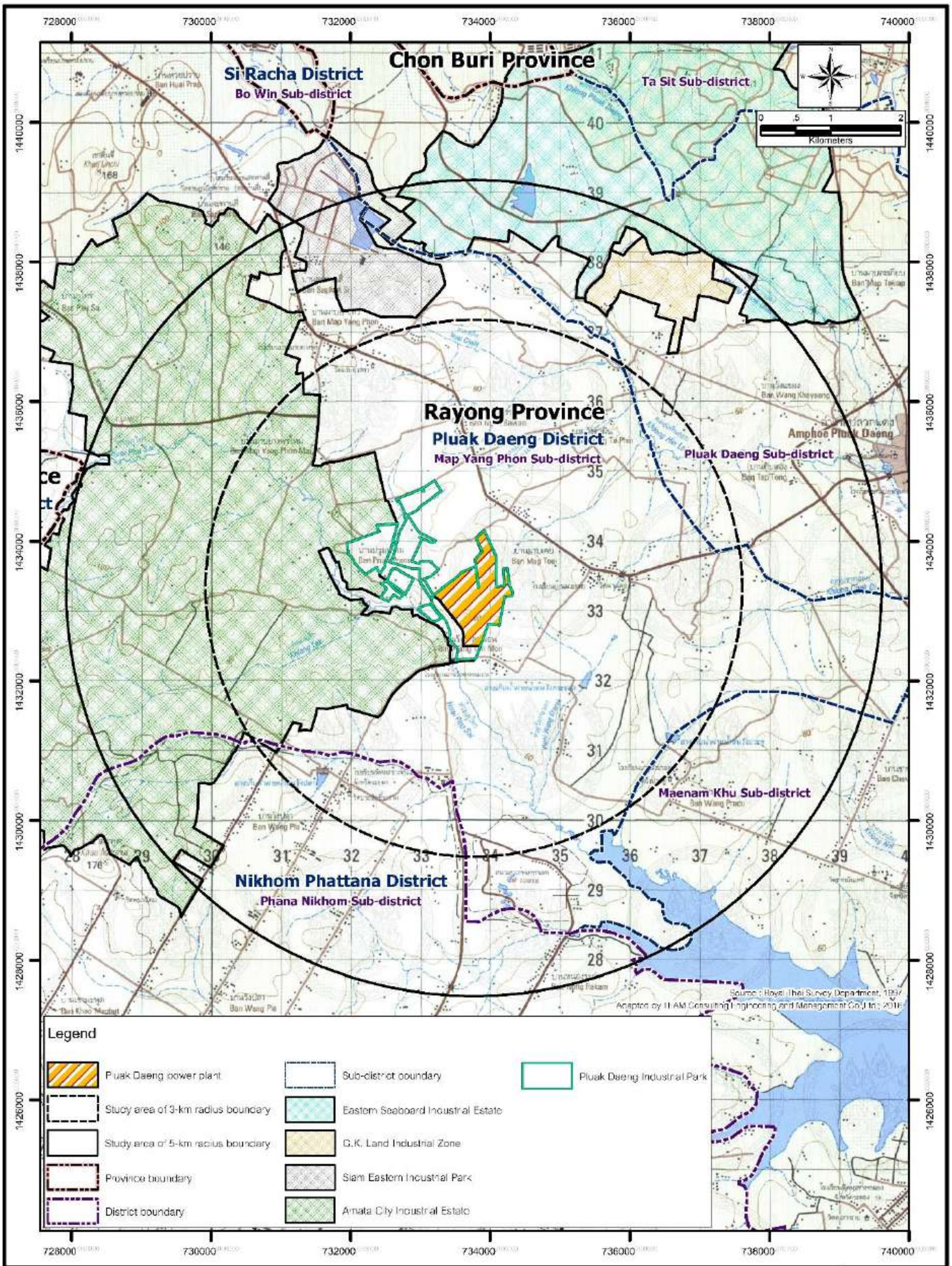


FIGURE 4.4.1-1 : SOCIO-ECONOMICS STUDY AREA

10P2809/Damrongsak.B/15-08-60/P2809-001 (เพิ่มรัศมี 3 กิโลเมตร - English).mxd

(b.) Surveyed target groups

The Consultant determined 5 surveyed target groups below on socio-economics.

- Involved government agencies.
- Representatives of the sensitive receptors in the study area, i.e. the one of a religious place and that of an educational institute.
- Community leaders in the study area.
- Households in the study area.

Water user association in Huai Phu Sai.

Sample size determination and sampling method are provided below.

(b.1) Representatives of involved government agencies

A purposive sampling was made for involved government agencies. One representative of each government agency in a provincial, district and local administration organization levels was interviewed.

(b.2) Representatives of sensitive receptors in the study area

A purposive sampling was made by interviewing representatives of sensitive receptors in the study area, i.e. representatives of educational institutes and religious places within 5 km radius from the project boundary.

(b.3) Community leaders

A purposive sampling was made for community leaders. A community leader means the person who is appointed by a government agency to supervise and communicate the ideas of local people. Community leaders include a sub-district headman, a village headman, an assistant sub-district headman, an assistant village headman, the Village Committee, the Community Chairman, the Vice Community Chairman and the Community Committee, etc. The sample shall consist of 3 samples per government agencies/villages at minimum.

(b.4) Households

The target households were within 5 km radius from the study area, which covers 4 sub-districts: Map Yang Phon sub-district, Pluak Daeng sub-district, Mae Nam Khu sub-district, Pluak Daeng district and Phana Nikhom sub-district, Nikhom Pattana district, Rayong province. All sub-districts are under the Sub-district Administrative Organization (SAO), namely Map Yang Phon Sub-district Administrative Organization, Pluak Daeng Sub-district Administrative Organization, Mae Nam Khu Sub-district Administrative Organization and Phana Nikhom Sub-district Administrative Organization.

According to satellite images, there were 6,925 houses/buildings in the study area on January, 2016. To find a suitable sample size for socio-economics survey, the Consultant applied Taro Yamane's simple formula at a 95% confidence level.

$$n = \frac{N}{(1 + Ne^2)}$$

where n = sample size

N = total household

e = 95% confidence level or 0.05% tolerance

Substitution

$$n = \frac{6,925}{\left(1 + 6,925 \times (0.05)^2\right)}$$

$$= 379 \text{ samples}$$

According to the calculation of a suitable sample size, 379 samples needed to be surveyed to consider potential impacts from the project operation. The Consultant divided the study area into 2 sections: (1) the one within 0-3 km radius from the project boundary, or the adjacent area. Out of a total sample, 60% were collected as the area will be affected rather than farther communities, (2) the one within 3-5 km radius from the project boundary, or the far area. Out of a total sample, 40% were collected. To enable an opportunity of selection for all sample in the project vicinities, the sample was distributed covering 4 sub-districts. Details are shown in **Table 4.4.1-2**.

A systematic random sampling was made for the survey on socio-economics of households in the study area. A random interval survey was made, so the sample had an equal opportunity to be selected without prejudice. Head of household or the representive felt free to express the ideas or share the data throughout the interviewing time. The interview was conducted under the supervision, recommendations and coordination of experienced staff provided by the consultant.

(b.5) Water use association in Huai Phu Sai

Water use association in Huai Phu Sai mean those who make use of Huai Phu Sai for utilization-consumption. Water use association in Huai Phu Sai shall own houses/buildings 100 m away from Huai Phu Sai at maximum. According to satellite images, there were 7 households/buildings, 100 m away at maximum from Huai Phu Sai on both sides on January, 2016. As a result, a purposive sampling was made.

Considering the project location shown in **Figure 4.4.1-1**, Dok Krai reservoir was located 5 km outside the project boundary. Moreover, the chairman of Dok Krai Fishery Resource Management Group stated that its members came from various sub-districts/districts of Rayong province, so it was difficult to meet Dok Krai Fishery Resource Management members. However, the meetings were organized 2 times for idea sharing with these group of people before the commencement of study and during the study and environmental impact assessment report preparation (Details are included in Chapter 4: Public Participation).

TABLE 4.4.1-2

NUMBER OF SAMPLE HOUSEHOLDS FOR SOCIO-ECONOMICS SURVEY BY VILLAGE/COMMUNITY

Province	District	Sub-District	Village	Number of Households within 0-3 km Radius				Number of Households within 3-5 km Radius			
				Number (household)[1/]	Number of Sample at 95% Confidence Level (set)[2/]	Target Collection	Collected Target	Number (household)[1/]	Number of Sample at 95% Confidence Level set)[3/]	Target Collection	Collected Target
Rayong	Pluak Daeng	Map Yang Phon	Village no. 1 Ban Map Toei	460	38.02	39	48	-	-	-	-
			Village no.2 Ban Noen Sawan	1,228	101.51	102	113	12	0.52	1	5
			Village no.3 Ban Map Yang Phon	505	41.74	42	15	591	25.55	26	34
			Village no.5 Ban Wang Tan Mon	529	43.73	44	53	31	1.34	2	3
			Village no.6 Ban Map Yang Mai	361	29.84	30	3	584	25.25	26	52
			Village no.7 Ban Sak Oi	86	7.11	8	-	124	5.36	6	16
		Pluak Daeng	Village no.4 Ban Wang Ta Phin	-	-	-	-	729	31.51	32	22
			Village no.6 Ban Thap Tong	44	3.64	4	9	645	27.88	28	29
		Mae Nam Khu	Village no.4 Ban Sak Manthet	-	-	-	-	17	0.73	1	17
			Village no.7 Ban Wang Pradu	44	3.64	4	7	233	10.07	11	10
	Nikhom Pattana	Phana Nikhom	Village no.4 Ban Khao Maphut	1	0.08	1	-	32	1.38	2	6
			Village no.5 Ban Khlong Phlu	42	3.47	4	-	150	6.48	7	14
			Village no.6 Ban Nong Rakam	-	-	-	-	155	6.70	7	7
			Village no.7 Ban Wang Pla	94	7.77	8	11	91	3.93	4	10
			Village no.8 Ban Soi 13	24	1.98	2	5	113	4.88	5	12
Total				**3,418**	**227.4**	**288**	**264**	**3,507**	**151.6**	**158**	**237**
Total (0-5 km)											
- **Target collection**				**446 samples**							
- **Surveyed sample**				**501 samples**							

Remarks:
1/ Number of households from satellite images within 0-5 km radius from the study area. (3,418 households within 0-3 km radius from the study area and 3,507 households within 3-5 km radius from the study area)
2/ Number of sample at 95% confidence level: 60% of the sample were within 0-3 km radius from the study area, or 60% of sample number derived from the substitution according to Taro Yamane's Formula
3/ Number of sample at 95% confidence level: 40% of the sample were within 3-5 km radius from the study area, or 40 % of sample number derived from the substitution according to Taro Yamane's Formula

(c) Socio-economics survey tools

The primary data on socio-economics of Pluak Daeng Power Plant Project were collected from the field survey through the 3 interview formats/questionnaire appropriate for the target groups.

- **Interview formats for community leaders/government agencies/sensitive receptors in the study area (Appendix 4N):** The questionnaire structure consists of:
  - General information of the interviewee, such as position, duration of this position, age, educational level, etc.
  - Socio-economics data of the community, namely community history/background, religion, occupation, social and economic status and the relationship level of community people.
  - Satisfaction on the overall living conditions at present, such as environmental problems, infrastructure service, public service, and public utilities service, problems of livelihood in communities, opinions on community development in the future.
  - Information about the agency, such as roles and responsibilities, duration of existence, number of staff/employees
  - Acknowledgement of information, concerns, and forecast of impacts due to the project development
  - Involvement in environmental impact monitoring
  - Public relations campaign and recommendations on the project development
- **Household survey tools (Appendix 4N):** The interview format/questionnaire structure is as follows:
  - General information of the interviewee, such as gender, age, household status of the interviewee, educational level, religion, domicile, resettlement, etc.
  - Household socio-economics, such as number of household members, income-expense, occupational problems, etc.
  - Health data/use of chemical substance, such as use of chemical substance for agricultural purpose, illness of household members, smoking, drinking, use of public facilities in the community, satisfaction and adequacy of hospitals, etc.
  - Satisfaction on the overall livelihood at present, such as public health services, conditions of drinking water-water sources, environmental sanitation (waste and wastewater disposal), public utilities, malnutrition, satisfaction on villages/communities, etc.
  - Acknowledgement of information, concerns, and forecast of impacts due to the project development
  - Involvement in environmental impact monitoring

- Public relations campaign and recommendations on the project development

- **Questionnaire for water use association in Huai Phu Sai (Appendix 4N):** The interview format/questionnaire structure consists of:
  - Use of water in Huai Phu Sai, such as exploitation of Huai Phu Sai, etc.
    - In case of agricultural purpose: water use interval, water sufficiency, water quality, agricultural.
    - In case of fishery purpose: types and quantities of catched aquatic animals, fishing tools.
    - Use of water in Huai Phu Sai for aquatic animal production: types, size of area, cost and duration of aquatic animal production.
    - Use of water in Huai Phu Sai for consumption, sufficiency and water quality.
    - Use of water in Huai Phu Sai for consumption, sufficiency and water quality, water use problems.
  - Concerns and recommendations on the project development.

(d) Data analysis

Two types of data were analyzed: primary data derived from enquiry/ interview using a questionnaire as data collection tool and secondary data derived from the study and compilation of textbooks and documents related to the project location. Primary data derived from the survey/ interview of community leaders, head of households in the study area and users of water in Huai Phu Sai were statistically analyzed through SPSS (Statistical Package for Social Science) and Microsoft Excel to save the data. The data were presented in descriptive statistics, i.e. frequency, percentage, etc. Secondary data and primary data were derived from the interview of officers in the involved government agencies and representatives of sensitive receptors in the study area. The data were presented in descriptive statistics.

(3) Study results

(3.1) Compilation of secondary data

(a.) Rayong province

Topographic conditions and territory: Rayong province is a coastal plain due to sedimentation in Rayong Basin with hills and mountains and low and high undulation. Two mountain ridges passe over the province: Khao Chamao ridge in the east, 1,035 m high from the sea level and the mountain ridge in the middle of the province passing over Mueang Rayong to the north until it reaches the provincial boundary. Short rivers originated from Chanthaburi mountain range and Banthat mountain range flow past this province and the Gulf of Thailand. Major rivers include Bang Pakong River, Chantaburi River, Rayong River, etc. The coastline comprises a beautiful beach and small and large islands which are important tourism resources of the country.

Rayong is located in the east of Thailand, with the area of 3,552 sq.km. or 2,220,000 rai. The territory of Rayong province is as follows:

North: adjacent to Nong Yai district, Bo Thong district, Si Racha district, Chon Buri province

South: adjacent to the Gulf of Thailand, with the length of 100 km

East: adjacent to Na Yai Am district and Kaeng Hang Maew district, Chantaburi province

West: adjacent to Sattahip district and Bang Lamung district, Chonburi province

Administrative division: According to Rayong province development plan (B.E. 2557-2560), Rayong is divided into 8 districts, i.e. Muaeng Rayong, Klaeng, Ban Khai, Pluak Daeng, Ban Chang, Wang Chan, Khao Chamao and Nikhom Pattana, 54 sub-districts, 439 villages and 181 communities. The local administration consists of one provincial administrative organization, one city municipality, two town municipalities, 27 sub-district municipalities and 37 sub-district administrative organizations (Details are shown in **Table 4.4.1-3**).

Population structure: According to Department of Provincial Administration, Ministry of Interior, on December 2015, there were 688,999 people in a house registration: 339,333 males, 349,666 females and 423,943 households. Taking into account the population and number of households during 2011-2015, the population change rate of Rayong province were likely to increase every year. Details are shown in **Table 4.4.1-4**.

TABLE 4.4.1-3

SIZE OF AREA, NUMBER OF SUB-DISTRICTS, VILLAGES, LOCAL ADMINISTRATION ORGANIZATION AND COMMUNITIES BY DISTRICT

Districts	Area (km^2)	Administrative Divisions					
		City Municipality	Town Municipality	Sub-district Municipality	Sub-district Administrative Organization	Sub-Districts	Villages
Muaeng Rayong	514.547	1	1	6	7	11	84
Ban Chang	238.372	-	1	3	1	3	20
Klaeng	788.463	-	-	8	9	15	147
Wang Chan	395.249	-	-	1	4	4	29
Ban Khai	489.075	-	-	3	5	7	66
Pluak Daeng	618.341	-	-	2	6	6	34
Khao Chamao	269.950	-	-	1	3	4	29
Nikhom Pattana	238.000	-	-	3	2	4	30
Total	**3,551.997**	**1**	**2**	**27**	**37**	**54**	**439**

Source: Rayong Development Plan, B.E. 2557-2560, Strategy Group, Rayong Province

TABLE 4.4.1-4
NUMBER OF POPULATION FROM HOUSE REGISTRATION AND POPULATION CHANGE RATE OF RAYONG PROVINCE, B.E.2554-2558 (AD 2011-2015)

Districts	Number of Population (Year)				
	2011	2012	2013	2014	2015
Mueang Rayong	92,415	93,601	94,980	96,624	97,653
Change rate (%)	-	1.28	1.47	1.73	1.06
Ban Chang	8,581	8,739	8,956	9,186	9,568
Change Rate (%)	-	1.84	2.48	2.57	4.16
Klaeng	66,298	66,830	66,988	67,083	67,247
Change Rate (%)	-	0.80	0.24	0.14	0.24
Wang Chan	21,708	21,924	22,025	22,041	22,194
Change Rate (%)	-	0.10	0.46	0.07	0.69
Ban Khai	59,274	60,010	60,745	61,377	62,013
Change Rate (%)	-	-1.24	1.22	1.04	1.04
Pluak Daeng	41,417	43,298	45,379	48,401	51,728
Change Rate (%)	-	4.54	4.81	6.66	6.87
Khao Chamao	23,344	23,496	23,775	23,816	23,880
Change Rate (%)	-	0.65	1.19	0.17	0.27
Nikhom Pattana	14,291	14,979	15,372	15,830	16,608
Change Rate (%)	-	4.81	2.62	2.98	4.91
Total	**637,736**	**649,275**	**661,220**	**674,393**	**688,999**
Change Rate (%)	**-**	**1.81**	**1.84**	**1.99**	**2.17**

Source: http://stat.bora.dopa.go.th/stat/statnew/statTDD/ Retrival on June 2016

Economic conditions

Rayong Province-Gross Provincial Product, at an annual price: The Gross Provincial Product of Rayong province in 2013 amounted to 905,664 million baht, which was mainly the result of industrial products. That is 22,600 million baht from the agriculture sector, which is likely to decrease every year and 883,004 million baht from the non-agriculture sector, which is likely to increase every year. The GDP per capita of Rayong province is 1,038,293 baht/person/year, which is ranked 1st of the country. Details are given in **Table4.4.1-5**.

Rayong's economy depends chiefly on the following sectors.

1. **Agriculture, livestocks and fisheries**

- Agriculture/cultivation: Topographic conditions and climate of Rayong province are suitable for agriculture. Major economic crops in Rayong province are as follows:

  - Rubber tree: This major economic crop is mainly grown in the province compared with other major economic crops as it does not need various nutrients. Also, topographic conditions of the province are suitable for cultivation.

TABLE 4.4.1-5
PROVINCIAL PRODUCTS AND POPULATION INCOME OF RAYONG PROVINCE, B.E. 2553-2557 (AD 2010-2014) BY FIELD

Manufacturing Fields	Values (million baht)				
	2010	2011	2012	2013	2014[P]
Agriculture sector	**27,363**	**33,705**	**25,199**	**22,115**	**20,962**
Agricultural, hunting and forestry	23,942	29,691	20,698	18,040	16,892
Fishery	3,421	4,014	4,501	4,075	4,070
Non-agriculture sector	**688,762**	**730,853**	**816,736**	**867,343**	**853,585**
Mine and quarry	241,906	274,982	344,663	353,021	349,770
Industry	311,187	286,181	299,090	335,906	314,381
Electricity, gas and water supply	40,634	57,254	47,452	46,297	52,570
Construction	6,294	5,440	4,663	6,741	5,800
Wholesaling, retailing and repair Automotive	50,067	52,231	49,087	53,167	53,316
Personal care products and household objects	1,747	1,974	2,377	2,685	2,644
Hotel and restaurant	15,261	16,156	16,171	15,495	16,277
Transportation, warehouse and communication	4,682	5,417	6,694	7,727	9,622
Financial intermediaries	5,550	19,093	32,637	32,931	34,385
Real estate service, rental and service	5,736	6,068	7,074	6,743	7,226
Government administration and national defense and compulsory social security	3,222	3,271	3,406	3,570	3,888
Education	1,692	1,758	2,073	1,845	2,286
Health and social services	640	827	1,022	1,032	1,133
Community, social and personal services	146	202	235	183	288
Gross provincial product	716,125	764,558	841,935	889,458	874,547
GPP per capita (baht)	873,241	918,744	997,343	1,039,356	1,008,615
Population (1,000 people)	820	832	844	856	867

Remark: [P] Estimated value

Source: http://www.nesdb.go.th/main.php?filename=gross_regional retrival on July 26th, 2016

- Tapioca: It is one of major economic crops mostly grown in Klaeng district, Wang Chan district and Mueang district, respectively.
- Pineapple: The cultivation of this fruit in Rayong province is ranked 2nd in the country second to Prachuap Khiri Khan, or about 20% of the national yield. Typically, pineapple will be sold to factories to be processed as a canned pineapple or pineapple juice.
- Durian: This kind of fruit has long been grown by farmers in Rayong province as the area is suitable for durian growing. Durian is grown in Klaeng district, Mueang Rayong district, Khao Chamao district, Wang Chan district, Ban Khai district and Nikhom Pattana district, respectively.
- Rambutant: The cultivation of rambutant in Rayong province is ranked 6th in the country.
- Mangosteen: There is only one type of mangosteen or “THE QUEEN OF FRUIT” which is not mutated. Mangosteen is grown during May-September and harvested during May-July.

• Livestocks: The overall commercial animal production in Rayong province has increased, especially chicken and duck. This is due to the high return of the yields loan promotion from the government agencies, such as the village funds and grants. The number of livestock operators of each district is different.

• Fisheries: The coastline of Rayong province is about 100 km long. Therefore, saltwater fishing is an important occupation, followed by inland fisheries and brackish water fisheries. There are about 1,500,000 rai for saltwater fishing and about 63,080 rai for inland fisheries. There are 2,603 fishing boats, 6 fisheries associations, 36 groups of fish farmers, 2 fisheries cooperatives and 45 fishing ports.

2. Industry

Rayong province plays an important rule in the eastern seaboard development project. Furthermore, it is determined as the new development center, the educational standard and technological research center. The east coast is determined as the gateway in the Northeast of Thailand for the export of products to overases without passing Bangkok. The government has prepared the comprehensive infrastructure. Map Ta Phut sub-district, Mueang district, Rayong province is designated as the industrial estate location, or the new industrial town in the area of 10,000 rai of which 8,000 rai is reserved for industrial land. There is one deep sea port for the vessels having the capacity of 20,000 tons and 2 ports for liquid material transportation for the vessels having the capacity of 8,000 tons. Rayong province is the location of main industries like a gas separation plant, petrochemical industry, and chemical fertilizer industry. As a result, Rayong province has a high potential for industrial investment. Furthermore, it is categorized by the Board of Investment of Thailand (BOI) to be in Zone 3 of the industrial promotion zone, which is more advantageous than Bangkok Metropolitan Region, resulting in a fast-growing industrial development in the province.

There are 23 industrial estates and private industrial estates, industrial operation zone, industrial community and industrial park in the area of approx. 80,000 rai **(Table 4.4.1-6)**. There are several industrial types in Rayong province, such as automotive manufacturing, electronic parts, agricultural processing industry, electricity generation, production of chemical substances, etc. with the value of about one thirds of the expenditure budgets of Thailand.

There are 1,966 factories in Rayong province. The largest number of business premises is the agriculture industry, metal product industry and transportation industry. Most of them are upstream industries, using high technology for manufacturing with high investment. Mainly, these business premises have 1-25 employees (25,323 business premises). Others employ more than 200 employees (278 business premises). Mueang Rayong district has the highest investment of 773,422,108,740.12 baht. Most of the labours (58,560 persons) and business premises (476 places) are in Pluak Daeng district (**Table 4.4.1-7 and Table 4.4.1-8**).

3. Tourism and services

Rayong is a coastal province with various tourist destinations, i.e. beach, sea, mountains, waterfall, fruit orchards and fresh sea food. The beach is 120 km long. Koh Samet is highly popular among tourist. Tourists are able to visit Rayong which is about 179 km from Bangkok by water, on land or by air.

Labour situation in Rayong

The labour situation report of Rayong province during January-December, 2015 reveals the following information.

Population and labour force: There were 882,002 people in Rayong province. Among these population, 723,515 people were 15 years old and over. The total labour force was 542,746 person: 537,936 employed persons and 4,810 unemployed persons. Person not in labour force: There were 180,769 persons who were not in labour force and there were 158,487 persons under 15 years of age.

TABLE 4.4.1-6

SUMMARY OF TYPES OF INDUSTRY AND SIZES OF AREA OF INDUSTRY, RAYONG PROVINCE

Types of Industry	Sizes of Area (rai)
Eight Industrial Estates	
1. Map Ta Phut Industrial Estate	10,000
2. Eastern Industrial Estate	2,430
3. Pha Daeng Industrial Estate	516
4. Eastern Seaboard Industrial Estate	6,588
5. Amata City Industrial Estate (Rayong) Branch	4,700
6. Asia Industrial Estate	2,522
7. Hemaraj Eastern Seaboard Industrial Estate	6,588
8. RIL Industrial Estate	1,592
Five Industrial Zones	
1. Siam Eastern Industrial Park	1,341
2. TPI Industrial Park	4,335
3. G.K. Land Industrial Park	882
4. Rayong Industrial Land Co., Ltd.	3,500
5. Rojana Industrial Park	2,100
Five Industrial Communities	
1. Nakharin Industrial Park	1,497
2. SSP Property	1,246
3. Tuntex Industrial Park Co., Ltd.	1,497
4. I.P.P. Industrial Park	390
5. Rojana Industrial Park	2,200
Two Industrial Parks	
1. Rayong Industrial Park	1,500
2. Charoen Pokphand Group Industrial Park	54
Three Industrial Estates which are under establishment	
1. Lakchai Muang Yang Industrial Estate	1,766
2. Rayong Industrial Estate (Ban Khai)	2,101
3. Hemaraj Eastern Industrial Estate (Map Ta Phut), Extension	400

Source: Rayong's Strategic Planning, B.E. 2557-2560, Strategy Group, Rayong Province

TABLE 4.4.1-7

NUMBER OF INDUSTRIAL OPERATION PREMISES, INVESTMENT AMOUNT, NUMBER OF LABOURS BY DISTRICT

Districts	Industrial Plants	Investment Amount (baht)	Labours (person)
Mueang Rayong	623	773,422,108,740.12	44,755
Ban Chang	74	15,189,249,621.30	2,527
Klaeng	281	17,616,227,479.67	13,517
Wang Chan	26	799,460,000.00	737
Ban Khai	238	116,860,757,750.05	15,933
Pluak Daeng	476	309,469,102,161.38	58,560
Khao Chamao	6	262,450,000.00	656
Nikhom Pattana	242	49,461,589,124.85	24,264
Total	**1,966**	**1,283,080,944,877.37**	**160,949**

Source: Rayong Provincial Industry Office, December 2014

TABLE 4.4.1-8

INDUSTRIAL OPERATION PREMISES BY TYPE OF INDUSTRY

Sizes of Industrial Operation Premises/Economic Activities	Industrial Operation Premises	Staff		Employees	
		Number	Percent	Number	Percent
Total	**26,658**	**252,956**	**100.0**	**220,519**	**100.0**
Sizes of industrial operation premises					
1-25 persons	25,323	56,996	22.5	25,315	11.5
16-25 persons	386	7,590	3.0	7,207	3.3
26-30 persons	98	2,807	1.1	2,788	1.3
31-50 persons	210	8,539	3.4	8,368	3.8
51-200 persons	363	38,417	15.2	38,242	17.3
More than 200 persons	278	138,607	54.8	13,899	62.9
Economic activities					
Wholesaling and retailing, automotive and motorcycle repair	2,410	7,577	3.0	4,720	2.1
Wholesaling	839	5,996	2.4	4,919	2.2
Retailing	9,362	21,598	8.5	9,729	4.4
Lodging place, food and beverage service	4,627	18,332	7.2	11,688	5.3
Information, computer and communication	213	457	0.2	208	0.1
Real estate activity	1,639	3,191	1.3	1,406	0.6
Professional development, science and technical activities	302	2,313	0.9	1,933	0.9

TABLE 4.4.1-8

INDUSTRIAL OPERATION PREMISES BY TYPE OF INDUSTRY (CONT'D)

Sizes of Industrial Operation Premises/Economic Activities	Industrial Operation Premises	Staff		Employees	
		Number	Percent	Number	Percent
Rental, tourism and service	484	6,155	2.4	5,666	2.6
Art, entertainment and recreational activities	226	1,013	0.4	692	0.3
Other services	3,637	5,352	2.1	1,373	0.6
Manufacturing	2,290	165,203	65.3	162,853	73.8
Wastewater and waste management and treatment	10	290	0.1	290	0.1
Construction	414	9,578	3.8	9,257	4.2
Land transportation and warehouse	202	4,980	2.0	4,864	2.2
Private hospital	3	921	0.4	921	0.4

Source: Rayong Provincial Industry Office, December 2014

Employment: There were 537,936 employed persons: 300,822 males (55.43% of labour force) and 237,114 females (43.69% of labour force). The overall employment rate of this quarter was 99.11%, slightly increased from the previous quarter.

Unemployment: There were 4,810 unemployed persons, or 0.89%: 2,522 unemployed males (0.46% of labour force) and 2,288 unemployed females (0.42% of labour force). The unemployment rate was not high compared with a total labour force. It was an economic indicator of continuous employment in Rayong province **(Table 4.4.1-9)**.

TABLE 4.4.1-9

POPULATION IN RAYONG PROVINCE BY GENDER AND LABOUR FORCE STATUS

Labour Force Status	Male	Female	Total
Total Population	**446,856**	**435,146**	**882,002**
Population 15 years and over	365,216	358,299	723,515
- Total labour force	303,344	239,402	542,746
- Employed	300,822	237,114	537,936
- Unemployed	2,522	2,288	4,810
- Person not in labour force	61,872	118,897	180,769
- Housekeeping	3,065	62,353	65,418
- Studying	22,632	23,814	46,446
- Others	36,175	32,730	68,905
Population under 15 years	81,640	76,847	158,487
Employment rate per labour force	55.43	43.69	99.11
Unemployment rate	0.47	0.42	0.89

Source: Labour Situation Report in Rayong Province, 2015, Rayong Provincial Statistical Office

Foreign labour: All 87,410 foreign labours were categorized as follows: 5,785 persons for the investment promotion (BOI), 3,819 persons for VISA NON B, 1,258 persons who work at height, 5,237 persons as a result of MOU, 9,791 persons for marine fishery, 39,904 persons for general activity, 2,911 persons for marine fishery and aquatic animal processing, and 18,705 persons (Foreign labours illegally enter the Kingdom, i.e. Laotian, Burmese and Canmbodian according to the Cabinet's resolution on March 3, 2015).

Social aspect:

In the past, local people in Rayong province lived by the seas and rivers. These people were fishermen and farmers. Later, the emergence of factories in the industrial estate and outside the industrial estate has attracted a large number of labours from other provinces. This province has been gradually changed from agricultural to industrial society.

Education:

Currently, there are 275 educational institutes in Rayong province: 224 schools for basic education, 37 vocational/private schools, 10 schools under the supervision of Provincial Office for Local administration and the other 4 schools **(Table 4.4.1-10)**.

TABLE 4.4.1-10

NUMBER OF SCHOOLS BY SUPERVISORY AGENCY BY DISTRICT

Districts	Total	Supervisory Agencies			
		Office of Basic Education Commission	Office of the Private Education Commission	Provincial Office for Local Administration	Others
Mueang Rayong	275	224	37	10	4
Ban Chang	78	49	18	9	2
Klaeng	26	15	10	-	1
Wang Chan	69	65	4	-	-
Ban Khai	16	16	-	-	-
Pluak Daeng	21	19	2	-	-
Khao Chamao	16	16	-	-	-
Nikhom Pattana	13	13	-	-	-

Source: Rayong Provincial Statistical Office, December 2014

Religion:

Local people adhere to religion and culture. Most of them were Buddhist (about 95%), followed by Islam (4%) and Christianity (1%), respectively. There were 268 temples, 36 houses of prist, 4 churches and 6 mosques **(Table 4.4.1-11)**.

TABLE 4.4.1-11
NUMBER OF TEMPLES, HOUSES OF PRIEST, CHURCHES, MOSQUES, MONKS AND NOVICES BY DISTRICT

Districts	Number of Temples	Number of Houses of Priest	Number of Churches	Number of Mosques	Number of Monks	Number of Novices
Total	**268**	**36**	**4**	**9**	**3,425**	**441**
Mueang Rayong	58	4	2	6	983	205
Ban Change	15	-	2	-	160	113
Klaeng	75	10	-	1	880	48
Wang Chan	19	6	-	1	208	7
Ban Khai	42	2	-	1	561	36
Pluak Daeng	23	4	-	-	225	11
Khao Chamao	19	8	-	-	190	11
Nikhom Pattana	17	2	-	-	218	10

Source: Rayong Office of Buddhism 2015

Public health:

Public health is divided into 2 parts: medical treatment and health promotion and disease prevention. There were 9 public hospitals, 3 private hospitals, 95 Tambon Health Promoting Hospitals and 222 clinics **(Table 4.4.1-12)**.

TABLE 4.4.1-12
NUMBER OF HOSPITALS BY DISTRICT

Districts	Public Hospitals	Private Hospitals	Tambon Health Promoting Hospitals	All Types of Clinic
Total	**9**	**3**	**95**	**222**
Mueang Rayong	2	3	20	124
Ban Change	1	-	9	22
Klaeng	1	-	23	28
Wang Chan	1	-	7	2
Ban Khai	1	-	15	8
Pluak Daeng	1	-	10	25
Khao Chamao	1	-	6	-
Nikhom Pattana	1	-	5	13

Source: Rayong Provincial Statistical Office, December 2014

Infrastructure:

Electricity Authority

Rayong Provincial Electricity Authority is responsible for power supply for 8 districts (statistical data in 2014). There were 5 district electricity authorities, namely:

- Rayong Provincial Electricity Authority is responsible for power supply for Mueang Rayong district and Ban Khai district.
- Pluak Daeng Provincial Electricity Authority is responsible for power supply for Pluak Daeng district.
- Ban Chang Provincial Electricity Authority is responsible for power supply for Ban Chang.
- Klaeng Provincial Electricity Authority is responsible for power supply for Klaeng district, Wang Chan district and Khao Chamao district.
- Map Ta Phut Provincial Electricity Authority is responsible for power supply for Map Ta Phut sub-district, Mueang Rayong district and Nikhom Pattana district.

There were 324,913 electricity consumers. Most of them lived in Mueang Rayong district (149,375 persons). The electric power of 6,657.35 million kilowatts-hour was supplied to business premises and industries, especially in Pluak Daeng district where business premises and industries consumed the electric power of 3,781.72 million kilowatts-hour as shown in **Table 4.4.1-13.**

TABLE 4.4.1-13

ELECTRICITY CONSUMERS AND POWER SUPPLY BY DISTRICT

Districts	Number of Electricity Consumers (person)	Power Supply (million kilowatts/hour)				
		Total	Residence	Business Premises and Industries	Government Compounds and Public Places	Others
Total	**324,913**	**7,589.39**	**841.21**	**6,657.35**	**34.45**	**62.40**
Mueang Rayong	149,375	1,291.30	435.14	842.40	8.24	13.52
Ban Chang	28,311	215.57	70.98	133.58	4.17	4.84
Klaeng	52,585	671.51	145.40	511.08	4.38	10.65
Wang Chan	8,580	46.86	22.79	13.45	0.72	9.90
Ban Khai	24,900	922.41	50.58	862.13	9.70	-
Pluak Daeng	37,758	3,879.03	69.71	3,781.72	6.70	20.91
Khao Chamao	6,108	14.09	12.88	0.65	0.15	0.42
Nikhom Phattana	17,296	548.63	33.73	512.34	0.41	2.16

Source: Rayong Provincial Electricity Authority, December 2014

Waterworks Authority

There were 6 waterworks authorities in Rayong province: 4 provincial waterworks authorities, namely Rayong Provincial Waterworks Authority, Pak Nam Prasae Provincial Waterworks Authority, Ban Chang Provincial Waterworks Authority and Nikhom Pattana Provincial Waterworks Authority and 2 Municipality Waterworks Authorities, namely Mueang Klaeng municipal district and Pluak Daeng municipal district. There were 103,733 water supply consumers in total. Details are given in **Table 4.4.1-14**.

TABLE 4.4.1-14
STATISTICS OF WATER SUPPLY BY DISTRICT

Districts	Supplied Volume of Water					
	Production Capacity (cu.m)	Produced Water (cu.m)	Supplied Water (cu.m)	Public Benefit and Leakage (cu.m)	Consumed Water in System (cu.m)	Number of Water Supply Users (person)
Total	**32,414,500**	**38,186,711**	**27,504,249**	**7,735,225**	**12,770,734**	**103,733**
Mueang Rayong	876,000	440,444	16,825,737	4,418,790	54,860	75,773
Ban Chang	31,536,000	22,157,493	520,039	-	-	2,183
Klaeng	1,100	8,058,211	6,184,886	1,693,325	7,878,211	19,307
Wang Chan	400	2,736,000	920,694	1,440	163,200	6,001
Ban Khai	-	-	-	-	-	-
Pluak Daeng	-	-	-	-	-	-
Khao Chamao	-	-	-	-	-	-
Nikhom Pattana	1,000	4,794,563	3,052,893	1,621,670	4,674,563	469

Source: Rayong Provincial Waterworks Authority, December 2014

Land Transportation:

Land transportation is the most important system of Rayong province, especially in the industrial zone as it connects sea freight and rail transport. Roads are constructed to connect the province and districts, sub-districts and villages, making it more convenient to travel and transport of goods. Major roads leading to Rayong province include:

- **National Highway No. 3 (Sukhumvit Road):** The national highway starts from Bangkok. It passes Bang Phu-Bang Pakong-Bang Saen-Si Racha-Pattaya-Jomtien Beach-Sattahip-Ban Chang and ends at Mueang Rayong district, Rayong province for the distance of 220 km. The transportation of goods and raw materials from other regions to Rayong province is available through this national highway. Currently, traffic congestion occurs and the road surface is partially damaged.

- **National Highway No. 34 (Bang Na-Trat Road):** There are a lot of road users on this national highway. The national highway starts from Chalerm Maha Nakhon Expressway, Bang Na-Bang Phli-Bang Bo in Samut Prakan province and it connects the National Highway No. 3 at Km 70, Bang Pakong district, Chachoengsao province.
- **National Highway No. 36 (Bypass 36):** The national highway starts from Km 140 in Bang Lamung district, Chon Buri province to Rayong province for the distance of 70 km. This 4-lane road has a total distance of 210 km.
- **National Highway No. 344 (Ban Bueng-Klaeng):** The national highway starts from Chon Buri. It passes Ban Bueng-Nong Hai-Wang Chan and ends at Klaeng district for the distance of 100 km. This route is suitable for those who want to travel to Klaeng district, Chantaburi province or Trat province.
- **National Highway No. 7 (motorway):** The national highway starts at Pattanakan road, Prawet district in Bangkok and ends at Chon Buri for the distance of 75 km. Then take the National Highway No. 36 for the distance of 100 km to reach Mueang Rayong district, Rayong province for the distance of 175 km.

Natural resources and environment

Minerals are important natural resources in Rayong province. The mostly found minerals include sans-sized white and clear quartz, industrial minerals, granit for construction, gneiss for construction, limestone for construction, industrial minerals. Other economic minerals include kaolin minerals, feldspar, quartz and gold. Furthermore, rare minerals have accumulated along the coastline and in the sea, i.e. tin, Rhomasite, zircon, xenotime, leucoxene, ilmenite, rutile, columbite, and tantalite.

Forest resources: According to the National Reserved Forest Act and the National Forest Park Royal Decree, land in Rayong province is categorized as follows: 8 national reserved forests in the area of 821.99 sq.km, or 513,743 rai; 2 national parks, i.e Khao Laem Ya-Mu Ko Samet National Park in the area of 81,875 rai an Khao Chamao-Khao Wong National Park in the area of 42,400 rai in the area of 198.84 sq.km, or 124,275 rai; 1 wildlife sanctuary, i.e. Khao Ang Rue Nai Wildlife Sanctuary in the area of 32,875 rai and 2 nature parks, i.e. Phe Arboretum and Nong Sanom Arboretum. Nowadays, the forest land covers the area of 313.21 sq.km., or 195,760 rai (9% of the province's area). Tropical dry evergreen forests are usually found. In addition, mangrove, mixed deciduous forest and grove wood are found.

Water sources and irrigation

Rivers: There are 2 major rivers in rayong province, namely:

- The Rayong River, or Khlong Yai. The river is about 50 km long. It is originated from Kong Song mountain range and Phanom Sart mountain. The river flows into canals and converges in Khlong Yai. Then it flows into the sea in Pak Nam sub-district, Mueang Rayong district, Rayong province.

- The Pra Sae River: The river is originated from Khao Yai, Khao Ang Rue Nai, Khao Hin Rong and Khao Ang Kraden. The river flows along the waterway and canals, such as Khlong Pra Sae, Khlong Pling, Khlong Bo Thong, Huai Hin Khom, Khlong Jawet, Khlong Ta Kloi, Khlong Chumsaeng, Khlong Phai Nue-Tai, Khlong Tawat, Khlong Pang Wai, Khlong Jaka, Khlong Chai, Khlong Waen, Khlong Phlo, Khlong Ta Si Kaew and Khlong Nong Plong. The river converges and it is called the Pra Sae River, which is about 120 km long. It flows into the sea at Ban Pak Nam in Pak Nam Pra Sae sub-district, Klaeng district, Rayong province.

Canals: There area about 170 canals in Rayong province. Water is available for use the whole year. Major canals include:

- Khlong Dok Krai: The canal is about 45 km long. It is originated from Khao Sak Kloi in Bang Lamung district, Chon Buri province and flows into Khlong Nong Pla Lai before converges into Khlong Yai.
- Khlong Nong Pla Lai: The canal is about 42 km long. It is originated from Nam Jone mountain range, Khao chompu and Khao Rue Tok in Chon Buri. Water flows along the waterway and canals such as Khlong Rawing, Khlong Kram, Khlong Pluak Daeng, Rayong province. The canal converges and it is called Khlong Nong Pla Lai. The canal flows into Khlong Yai at Ban Huo Tung, Nong Bua sub-district, Ban Khai district, Rayong province.
- Khlong Phlo: The canal is about 38 km long. It is originated from Kho Chamun, Khao Cha Aim and Khao Plai Khong Phlo. Water flows into the Pra Sae River at Ban Tha Kra Chai, Klaeng district, Rayong province.
- Khlong Thap Ma: The canal is about 12 km long. It is originated from various mountain ranges, such as Khao Jom Hae, Khao Ket, Khao Krabok. Water flows along the waterway and canals such as Khlong Sak Yai, Khlong Nong La, Khlong Chang Tai. The canal converges and it is called Khlong Thap Ma. Then it flows into the Rayong River at Ban Koh Loi, Mueang district, Rayong province.
- Khlong Ra Oak: The canal is about 10 km long. It is originated from Khao Chamao. Water flows along canals, such as Khlong Khao Jut, Khlong Sa Thon and Khlong Nam Pen. The canal converges and it is called Khlong Ra Oak. The canal flows into Khong Phlo at Ban Nuen Suk Samran, Klaeng district, Rayong province.

Groundwater sources

Groundwater sources with moderate to good quality are available in Mueang Rayong district, Klaeng district and Wang Chan district.

Irrigation

Water source development have been made for agricultural purpose, utilization, consumption and industry. In 2008, there were 5 large and moderate scale projects with the water holding capacity of 542.65 million cu.m. The irrigation projects were advantageous for the irrigation area of 201,700 rai **(Table 4.4.1-15)**. Irrigation is categorized into 3 main groups based in its objectives as follows:

- Irrigation project for industry: Two irrigation industry projects include Nong Pla Lai Reservoir Project and Dok Krai Reservoir Project.
- Saltwater and inundation prevention and water storage irrigation project: Six saltwater and inundation prevention and water storage irrigation projects consist of Inundation Prevention Project in Rayong Province (Ban Khai), Dok Krai Reservoir Project, Nong Pla Lai Reservoir Project, Khlong Kra Oak Reservoir Project and Saltwater Prevention for the Pra Sae River Project.
- Irrigation project for agriculture in Rayong province: Five Irrigation projects for agriculture include Inundation Prevention Project in Rayong Province (Ban Khai), Nong Pla Lai Reservoir Project, Khlong Kra Oak Reservoir Project and Saltwater Prevention for the Pra Sae River Project.

TABLE 4.4.1-15

LARGE-SCALE IRRIGATION PROJECTS IN RAYONG

Project Names	Locations		Storage Volume (Mm^3)	Irrigation Areas (rai)
	Sub-Districts	Districts		
Nong Pla Lai Reservoir	Lahan	Pluak Daeng	163.75	30,000
Dok Krai Reservoir	Mae Nam Khu	Pluak Daeng	71.40	1,200
Khlong Ra Oak Reservoir	Thung Kwai Kin	Klaeng	17.50	7,500
Khlong Yai Reservoir	Lahan	Pluak Daeng	40.00	20,000
Pra Sae Reservoir	Chum Saeng	Wang Chan	248.00	137,500
Total	-	-	**540.65**	**176,700**

Source: www.rid9.com/menu_basin.asp Retrieval on April 27th, 2016

According to the categorization of water sources by district, there are 72 water sources in Klaeng district, 62 water sources in Nikhom Pattana and 53 water sources in Wang Chan district. Most of the water sources are ponds, swamp, marsh. There are 2 large reservoirs in Rayong: Pra Sae Reservoir in Wang Chan district and Dok Krai Reservoir in Pluak Daeng district. Details are provided in **Table 4.4.1-16**.

TABLE 4.4.1-16

WATER SOURCES BY DISTRICT

District	2013										2014									
	Type of water source									Total	Type of water source									Total
	Reservoir			Concrete Weir	Dike	Swamp	Canal	Groundwater Well	Shallow Well		Reservoir			Concrete Weir	Dike	Swamp	Canal	Groundwater Well	Shallow Well	
	Large Size	Medium Size	Small Size								Large Size	Medium Size	Small Size							
Mueang Rayong	-	-	3	4	-	12	13	-	-	32	-	-	3	4	-	12	13	-	-	32
Ban Chang	-	-	1	3	-	2	1	-	-	7	-	-	1	3	-	2	1	-	-	7
Klaeng	-	1	-	13	3	42	13	-	-	72	-	1	-	13	3	42	13	-	-	72
Wang Chan	1	-	3	13	-	30	6	-	-	53	1	-	3	13	-	30	6	-	-	53
Ban Khai	-	-	1	4	-	18	15	-	-	38	-	-	1	4	-	18	15	-	-	38
Pluak Daeng	1	2	-	6	-	8	4	-	-	21	1	2	-	7	-	8	4	-	-	22
Khao Chamao	-	-	2	2	-	-	-	-	-	4	-	-	2	2	-	-	-	-	-	4
Nikhom Phattana	-	-	-	10	-	43	9	-	-	62	-	-	-	10	-	43	9	-	-	62
Total	**2**	**3**	**10**	**55**	**3**	**155**	**61**	**-**	**-**	**289**	**2**	**3**	**10**	**56**	**3**	**155**	**61**	**-**	**-**	**290**

Source: Rayong Irrigation Projects, 2014, Rayong's Strategic Planning, 2014-2017

(b.) Pluak Daeng and Nikhom Pattana districts in Rayong province

(b.1) Pluak Daeng district, Rayong Province

Size of area, territory and administrative division: Pluak Daeng district encompasses the area of 343,582 rai. Regarding an administrative division, Pluak Daeng districts has 6 sub-districts and 34 villages. The territory of Pluak Daeng district is adjacent to the following administrative divisions.

North: adjacent to Si Racha and Nong Yai districts, Chon Buri province
East: adjacent to Wang Chan and Ban Khai districts, Rayong province
South: adjacent to Ban Khai and Nikhom Pattana districts, Rayong province
West: adjacent to Bang Lamung district, Chon Buri province

Most of the area is undulation, alternating with 3-15% steep mountainous terrains from the west to the east of the district. Waterways contain water for the whole year. Water flows and converges in Dok Krai Reservoir, Nong Pla Lai Reservoir and Khlong Yai Reservoir. These 3 large-scale reservoirs are major water resources in the eastern region.

Number of population and households: According to the the civil registration, there were 51,728 people: 26,190 males (50.63% of population) and 25,538 females (49.37% of population) and 66,272 households (Department of Local Administration, December 2015).

Economic conditions: The implementation of the government policy for industrial development promotion in the eastern seaboard due to the expansion of the industry sector without land use plan makes several areas in Pluak Daeng district become urban community and industrial areas in a short period of time, with forests scarcity. Involved government agencies, therefore, perform land allocation. Farmers have changed Som Set-Ra Woeng National Reserved Forest into agricultural land. Most of the people grow pineapple, rubber tree, and tapioca. Supplementary jobs include work for hire and selling.

(b.2) Nikhom Pattana district, Rayong province

Size of area, territory and administrative division: Nikhom Pattana district encompasses the area of 148,750 rai, or about 238 sq.km. Regarding an administrative division, Nikhom Pattana districts has 1 sub-district municipality, 4 sub-districts and 30 villages. The territory of Nikhom Pattana district is adjacent to the following administrative divisions.

North: adjacent to Pluak Daeng district, Rayong province
East: adjacent to Ban Khai district, Rayong province
South: adjacent to Mueang Rayong district and Ban Chang district, Rayong province
West: adjacent to Bang Lamung district, Chon Buri province

Number of population and households: According to the the civil registration, there were 16,608 people: 8,206 males (49.41% of population) and 8,402 females (50.59% of population) and 10,901 households (Department of Local Administration, December 2015).

(c.) Map Yang Phon sub-district, Pluak Daeng sub-district, Mae Nam Khu sub-district in Pluak Daeng district and Nikhom Pattana sub-district in Nikhom Pattana district, Rayong province

(c.1) Map Yang Phon sub-district

Size of area and territory: Map Yang Phon sub-district encompasses 81.072 sq.km, or 50,670 rai. The territory of the sub-district is adjacent to the following administrative divisions.

North: adjacent to Pluak Daeng sub-district, Pluak Daeng district, Rayong province

West: adjacent to Phana Nikhom district, Nikhom Pattana district, Rayong province

East: adjacent to Mae Nam Khu sub-district, Pluak Daeng district, Rayong province

South: adjacent to Bo Win sub-district, Si Racha province and Khao Mai Kaew sub-district, Bang Lamung district, Chon Buri province.

Administrative division, number of population and households: Map Yang Phon sub-district is administered by Map Yang Phon Sub-district Administrative Organization. It is divided into 7 villages. According to the the civil registration, there were 14,381 people: 7,455 males (51.84% of population) and 6,926 females (48.16% of population) and 31,287 households (Department of Local Administration, December 2015).

Economic conditions: The overall economy of Map Yang Phon Sub-district Administrative Organization depends on 2 sectors.

- Agriculture sector: Farming is a traditional occupation of local people. Most of the plants grown nowadays include pineapple, tapioca, rubber tree, and jackfruit, followed by work for hire, both in the agriculture sector and the industry sector.
- Industry sector: There are 2 industrial estates in Map Yang Phon Sub-district Administrative Organization: Amata City Industrial Estate in the area of 3,059 rai and Siam Eastern industrial park in the area of 527 rai. There are 121 factories below.

Village no. 1 Ban Map Toei

- Metal roofing manufacturer 1

Village no. 2 Ban Nuen Sawan

- Adhesive tape and aluminum sheet factory 1
- Transformer manufacturing factory 1
- Leather bag manufacturer 1

- Water filtration agent sorting and packing factory 1

Village no. 3 Ban Map Yang Phon

- Automotive and automotive parts factories 10
- Plastic and polymer factories 4
- Steel and metal construction materials factories 5
- Electric generator factories 1
- Electric sowing machine manufacturers 3
- Electronics factories 2
- Supporting industries and others 7

Village no. 4 Ban Huai Prap

- Automotive and automotive parts factories 8
- Plastic and polymer factories 11
- Consumable goods factories 2
- Steel and metal construction materials factories 3
- Electronics factories 6
- Supporting industries and others 21

Village no. 6 Ban Map Yang Phon Mai

- Automotive and automotive parts factories 14
- Plastic and polymer factories 2
- Consumable goods factories 2
- Steel and metal construction materials factories 1
- Electronics factories 2
- Supporting industries and others 12

Social conditions

- Education: There are 4 elementary schools under Map Yang Phon Sub-district Administrative Organization.

Elementary schools: 4 schools include:

- Ban Map Toei School, Village no. 1 Ban Map Toei
- Ban Saphan Si School, Village no. 3 Ban Map Yang Phon
- Ban Huai Prap School, Village no. 4 Ban Huai Prap
- Ban Map Yang Phon School, Village no. 6 Ban Map Yang Phon Mai

Child Development Center: 1

- Child Development Center under Map Yang Phon Sub-district Administrative Organization, Village no. 1 Ban Map Toei

Public library: 1

Village reading places: 7 (7 villages)

- Religion and culture: There are 4 religious places under Map Yang Phon Sub-district Administrative Organization.

- Wat Map Toei, Village no. 1 Ban Map Toei
- Wat Rat Asadaram, Village no. 3 Ban Map Yang Phon
- Wat map Yang Phon, Village no. 1 Ban Map Yang Phon Mai
- One joss house

Traditions and culture of the sub-district:

- Ngan Bun Klang Ban in October-January
- Songkran Festival and National Elderly Day in April
- Pineapple Days in April
- Candle Festival in July
- Tak Bat Devo and Chak Phra Festivals in October
- Loy Krathong Festival in November

- **Public health:** There are 2 tambon health promoting hospitals under Map Yang Phon Sub-district Administrative Organization.
  - Ban Map Yang Phon Tambon Health Promoting Hospital
  - Ban Huai Prap Tambon Health Promoting Hospital

Infrastructure:

- Transportation: Transportation routes in Map Yang Phon sub-districts are as follows: 35 lateritic roads, 75 asphalt roads and 21 re-inforced concrete roads.
- **Telecommunication:** There are 3 post offices (private) and 20 public telephone booths in Map Yang Phon sub-districts.
- **Electricity:** Power supplies is provided for 7 villages for 99.6% of households.
- **Water sources**: Water sources in Map Yang Phon sub-districts are as follows:

Natural water sources

- 17 Huai
- 6 canals

Artificial water sources

- 11 overflow weirs
- 66 shallow wells
- 13 deep wells
- 10 wells
- 12 rainwater tanks, For. 33
- 10 re-inforced concrete reservoirs
- 3 overflow roads

- **Water supply** in 4 places
  - Village water supply, Village no. 2
  - Village water supply, Village no. 4
  - Village water supply, Village no. 1 and Village no. 5
  - Village water supply, Village no. 6

(c.2) Pluak Daeng sub-district

Topographic conditions, size of area and territory: Pluak Daeng sub-district is undulating and mountainous, with permeable sandy loam soil. Pluak Daeng sub-district encompasses the area of 71.22 sq.km., or 44,508.75 rai. The territory of Pluak Daeng sub-district is as follows:

North: adjacent to Tasit sub-district, Pluak Daeng district, Rayong province and Bo win sub-district, Si Racha district, Chon Buri province

West: adjacent to Map Yang Phon sub-district, Pluak Daeng district, Rayong province

East: adjacent to Tasit sub-district and Lahan sub-district, Pluak Daeng district, Rayong province

South: adjacent to Lahan sub-district, Mae Nam Khu sub-district, and Map Yang Phon sub-district, Pluak Daeng district, Rayong province

Administrative division, Number of population and households: Pluak Daeng sub-district is divided into 2 parts, i.e. Pluak Daeng Sub-district Municipality and Pluak Daeng Sub-district Administrative Organization. Pluak Daeng Sub-district Administrative Organization has 6 villages: Village no. 1 Ban Pluak Daeng, Village no. 2 Ban Chak Malai, Village no. 3 Ban Ra Woeng, Village no. 4 Ban Wang Ta Phin, Village no. 5 Ban Wang Kha Yaeng and Village no. 6 Ban Thap Tong.

There are 12,150 people in a house registration: 6,241 males (51.37% of population), 5,909 females (48.63% of population) and 17,822 households. (Department of Local Administration, December 2015).

Economic conditions: Nong Pla Lai Reservoir is located almost in the middle of Pluak Daeng sub-district. The sub-district is divided into 2 sides: (1) Village no. 1 which is part of Pluak Daeng Sub-district Municipality. It is the center of all services since important government agencies, state enterprises and the private sector are located in this area. In addition to this, it is the residential and commercial area (2) Village no. 4 which is the location of Eastern Seaboard Industrial Estate and GK Land Industrial Park and residential and commercial area as well.

There are rapid expansion of commerce and services for Pluak Daeng Sub-district Administrative Organization, especially in Village no. 1, 4, 5 and 6 as they are adjacent to communities or industrial estates. However, the overall economy in the area of Pluak Daeng Sub-district Administrative Organization relies on agriculture. Most of the plants grown are pineapple, rubber tree, and tapioca. Some of them are mixed crops. Furthermore, local people do freshwater fisheries in Nong Pla Lai reservoir and animal production. Apart from agriculture, people work for hire in the agriculture sector, industry sector and service sector, which has rapidly increased.

Social conditions

1. **Education:** There is no school under Pluak Daeng Sub-district Administrative Organization. However, some educational institutes are located in this area.

- Ban Pluak Daeng School is open for kindergarten-Prathom Suksa 6.
- Orawin Wittaya School is open for kindergarten-Prathom Suksa 6.
- Pluak Daeng Pittayakhom School is open for Matthayom Suksa 1-6.
- Non-formal and informal education: There is one community learning center, i.e. Chalerm Phrakiat Community Learning Center, Pluak Daeng sub-district which is provided for uneducated persons-senior high school.
- Informal education: There are 4 village reading places.

2. **Religion and culture:** There are 3 religious places in Pluak Daeng Sub-district Administrative Organization.

- Wat Map Luk Chan, Village no. 2 Ban Chak Malai
- Ban Ra Woeng House of Priest, Village no. 3 Ban Ra Woeng
- Wang Kha Yaeng House of Priest, Village no. 5 Ban Wang Kha Yaeng

Important culture and traditions

- Pineapple Days (during April-May) are organized every year by the cooperation of Pluak Daeng district and 8 Local Administration Organizations.
- Ngan Bun Klang Ban (organized by community leaders)
- Loy Krathong Festival and covering Luang Pho Pho with gold leaf (organized by Pluak Daeng Sub-district Administrative Organization)
- Songkran Festival (organized by Ban Pluak Daeng Sub-district Municipality and the Village Committee)
- Traditional Buffalo Run and Food Festival (organized by Pluak Daeng Sub-district Municipality)
- Merit making on religious days and municipal ceremonial

- Sporting day of the SAO relations for anti-narcotics (organized by Pluak Daeng Sub-district Administrative Organization)
- Merit making for the opening ceremony of Nong Pla Lai Reservoir/fishing competition (Nong Pla Lai Fishing Game organized by Nong Pla Lai Reservoir conservative tourism group and the Village Committee of Village no. 1)

Infrastructure:

1. **Transportation**

Transportation routes

- Provincial Highway 3191 Pluak Daeng-Map Yang Phon
- Provincial Highway 3138 Ban Khai-Ban Bueng
- Provincial Highway 3245 Pluak Daeng-Nong Yai
- Asphalt road Ror. Yor. 3080 Ban Saphan Si-Ban Wang Ta Hin, 4.367 km
- Asphalt Road No. 2019 Pluak Daeng Hospital-Covergence to National Highway No. 3245, 3.441 km
- Re-inforced concrete road: Ban Chak Malai
- Re-inforced concrete road: Ban Chak Malai, 1.425 km
- Re-inforced concrete road: Ban Wang Kha Yaeng KM.+000 to 0+770
- Re-inforced concrete roads /Mai Phai 51, about 19.15 km
- 73 Asphalt Roads,77.73 km
- 54 lateritic roads, about 30.67 m
- 17 unpaved roads, about 7.38 m
- 10 bridges

Buses for 7 lines

- Pluak Daeng-Huo Kun Jae-Chon Buri (green bus)
- Pluak Daeng-Rayong (red bus)
- Pluak Daeng-Bo Win (minibus)
- Pluak Daeng-Si Racha (six-wheeled vehicle)
- KM. 12-Bang Na (van)
- Pluak Daeng-Watergate (van)
- Pluak Daeng- Watergate

2. **Electricity:** According to the data of Pluak Daeng Provincial Electricity Authority of Thailand, 2005-2012, there were the increase in electricity consumers/ electricity use. As shown in **Table 4.4.1-17**.

TABLE 4.4.1-17
NUMBER OF ELECTRICITY CONSUMERS AND CONSUMED ELECTRICITY ENERGY
DURING 2005-2012

Years	Number of Electricity Consumers (person)	Consumed Electricity Energy (kilowatt)
2005	14,507 persons	326,885,167.84 kilowatts
2006	16,595 persons	438,208,474.06 kilowatts
2007	18,748 persons	151,147,584.29 kilowatts
2008	20,913 persons	126,154,750.37 kilowatts
2009	22,293 persons	170,467,635.56 kilowatts
2010	23,860 persons	193,640,982.84 kilowatts
2011	26,320 persons	224,465,067.07 kilowatts
2012	28,176 persons	289,646,991.77 kilowatts

Source: Pluak Daeng Provincial Electricity Authority

3. Village water supply system: Under Pluak Daeng Sub-District Administrative Organization, village water supply system is provided in the following areas:

- One water supply system in Ban Chak Malai, Village no. 2
- Four water supply systems in Ban Ra Woeng, namely Ban Nang Sa-ing Permsin Group/ Ban Mrs. Lek Chang Daeng Group/Ban Mr. Lek Son Daeng Group and Ban Tit Lan Group (Soi Si Chai) , Village no. 3
- One water supply system in Ban Wang Ta Hin, Village no. 4
- One water supply system in Ban Wang Kha Yaeng, namely Ban Lung Home Si Chalee Group, Village no. 5
- Two water supply systems in Ban Thap Tong, namely Thap Tong and Khong Sawan, Village no. 6

In some areas, the water supply system is provided by Ban Pluak Daeng Municipality and the private sector in Pluak Daeng Sub-district Administrative Organization. Most of the people used water from ponds or wells for utilization and consumption. There were 10 transferred water sources: 5 from the Rural Development Acceleration Office, 2 from Department of Provincial Administration and 3 from Agricultural Land Reform Office.

1. Groundwater wells according to water source development project (5 projects)
2. A re-inforced concrete weir, Mor. Tor. 2527 type, Khlong Hin Loy, 2 m high, 12 m wide, with a holding capacity of 7,200 cu.m.
3. A re-inforced concrete weir, Mor. Tor. 2527 type, Khlong Pluak Daeng, 2 m high, 15 m wide , with a holding capacity of 9,000 cu.m.

4. Three groundwater wells according to the groundwater well digging project with the installation of a hand pump having the diameter of 6 inches

4. Water sources

- One reservoir, i.e. Nong Pla Lai Reservoir, with a holding capacity of 163.75 M cu.m
- One hundred sixteen deep wells
- Fourty eight shallow wells
- Seventeen groundwater wells
- Seven re-inforced overflow weirs

Five canals including:

- Khlong Pluak Daeng, 5 km
- Khlong Wang Ta Phin, 3 km
- Khlong Hin Loy, 4.50 km
- Khlong Ra Woeng, 3 km
- Khlong Wang Ka Yaeng, 3 km

5. Reservoir

There is one reservoir in Pluak Daeng sub-district, i.e. Nong Pla Lai Reservoir.

(c.3) Mae Nam Khu sub-district, Pluak Daeng district, Rayong province

Size of area and territory: Mae Nam Khu Sub-district Administrative Organization encompasses the area of 112.23 sq.km., or 70,197 rai. There are 7 villages with the following territory.

North: adjacent to Pluak Daeng sub-district Pluak Daeng district, Rayong province

West: adjacent to Nikhom Pattana sub-district, King Amphoe Nikhom Pattana and Nong Lalok sub-district, Ban Khai district, Rayong province

East: adjacent to Map Yang Phon sub-district, Pluak Daeng district, Rayong province

South: adjacent to Lahan sub-district, Pluak Daeng district, Rayong province

Number of population and households: Mae Nam Khu sub-district is under Mae Nam Khu Sub-district Administrative Organization. There were 9,541 people in a house registration: 4,720 males (49.47% of population) and 4,821 females (50.53% of population) and 5,760 households (Department of Provincial Administration, December 2015).

Economic conditions

Most of the people in Mae Nam Khu sub-district are farmers. They grow pineapple, tapioca, rubber tree, mushroom, do freshwater fisheries, animal production and work for hire in business premises/factories. There are 27 factories in Mae Nam Khu sub-district.

- At Village no. 1, there is one factory, namely Master Glove Industry Co., Ltd.
- At Village no. 3, there are 9 factories, i.e. S.D.G (S.D Global) Co., Ltd., Haeng Sung Electronics (Thailand) Co., Ltd., Dongjin Electronics Co., Ltd., Dae Khiang Text Co., Ltd., YK International Co., Ltd., KYVC Engineering Co., Ltd., Il Jin Electronics (Thailand) Co., Ltd., Villagen Sung Electronics (Thailand) Co., Ltd. and TK Intercon and Built Co., Ltd.
- At Village no. 4, there are 5 factories, i.e. Thai Steel Caspi co., Ltd., Eun Sung Industrial (Thailand) Co., Ltd., Sin Win Thai Co., Ltd., Mirae Plas Co., Ltd., and Duck sung Co., Ltd.
- At Village no. 5, there are 9 factories, i.e. Thai Unit Bearing Co., Ltd., Sangji Precision Co., Ltd., Thai Max Plastic Co., Ltd., Thai Wire Industry (Rayong) Co., Ltd., Thai Rubber Latex Group Co., Ltd., Siam TKM Co., Ltd., S Frame Co., Ltd., Eastern Water Resources Development and Management PLC (East Water) and World Flex Public Company Limited.
- At Village no. 6, there are 2 factories, i.e. Eastern Polypack Co., Ltd. and O.C.T Polymer Limited Partnership.
- At Village no. 7, there is one factory, namely Collingborne Import Export Co., Ltd.

Social Conditions

Education: Educational institutes in Mae Nam Khu sub-district are as follows:

- One Child Development Center
- Six elementary schools, namely
  - Ban Mae Nam Khu School
  - Ban Nong Ma Pling School
  - Self-help Land Settlement School 10, Rayong province
  - Self-help Land Settlement School 8, Rayong province
  - Self-help Land Settlement School, 13 Rayong province
  - Ban wang Pradu School
- One educational opportunity expansion school
- A community learning center

Religion:

- Six temples and houses of priest
  - Wat Mae Nam Khu, Village no. 1, Mae Nam Khu sub-district
  - Wat Nong Ma Pling, Village no. 2, Mae Nam Khu sub-district
  - Wat Sak Manthet, Village no. 4, Mae Nam Khu sub-district
  - Wat Sitthi Samakkee, Village no. 5, Mae Nam Khu sub-district
  - Wat Dok Krai, Village no. 6, Mae Nam Khu sub-district
  - Wat Wang Pradu, Village no. 7, Mae Nam Khu sub-district
- One joss house
  - In Soi behind the new Mae Nam Khu market, Village no. 5 next to the Child Development Center
- Culture and tradition
  - Pouring scented water onto the elderly on Songkran Day
  - Tradition of giving food offerings to a Buddhist monk on the first day of the Buddhist Lent and the end of the Buddhist Lent
  - Ngan Bun Klang Thung, Ban Mae Nam Khu Kao
  - Loy Kratong Festival
  - Merit making on religious days

Public health: Infirmaries in Mae Nam Khu sub-district are as follows:

- Two Tambon health promoting hospitals: Ban Mae Nam Khu Tambon Health Promoting Hospital, Village no. 5, Mae Nam Khu sub-district and Ban Dok Krai Tambon Health Promoting Hospital, Village no. 6, Mae Nam Khu sub-district
- One modern drugstore
- Two private hospitals

Infrastructure:

- Transportation routes
  - Provincial Highway 3191 or Map Kha-Pluak Daeng: This route starts from Nikhom Pattana district and passes Village no. 6, Village no. 5, and Village no. 3 of Mae Nam Khu sub-district and Pluak Daeng district. It is an entire 4-lane asphalt pavement.
  - Mae Nam Khu-Wat Rai: This route starts from an intersection in front of Wat Sitthi Samakkee. Provincial Highway 3191, Village no. 5 directs to the east, passes Village no. 1 and Village no. 2 of Mae Nam Khu sub-district and Nong Lalok sub-district, Ban Khai district. It is an entire 2-lane asphalt pavement.
  - Provincial Highway 22 or Wang Pradu-Map Toei: This route starts from from an intersection in front of Wat Sitthi Samakkee. Provincial Highway 3191, Village no. 5 directs to the the west, passes Village no. 3, Village no. 4 and Village no. 7 and Map Yang Phon sub-district, Pluak Daeng district. It is a 2-lane asphalt pavement and

re-inforced concrete. An access to Map Yang Phon sub-district is a lateristic road. Villages comprise re-inforced concrete, asphaltic concrete and lateristic roads. Preferred vehicles are pickup trucks and mortocycles.

➢ As for the travel to Pluak Daeng district, use Provincial Highway 3191 for the distance of 12 km. Regarding the travel to Rayong province, use Provincial Highway 3191 and Sukhumvit Road for the distance of 40 km. Optionally, Pluak Daeng-Rayong bus line may be used.

- Telecommunication
  - ➢ One sub-post office
- Public utilities
  - ➢ Electricity for 7 villages

(c.4) Phana Nikhom sub-district, Nikhom Pattana district, Rayong province

Topographic conditions, size of area and territory: Typically, the area is undulating and mountainous, with permeable sandy loam soil and moderate fertility. This area is not too hot or too cold. Phana Nikhom sub-district encompasses the area of 53 sq.km., or 33,135 rai. According to an administrative division, this sub-district is composed of 8 villages with the following territory.

North: adjacent to Map yang Phon sub-district, Pluak Daeng district, Rayong province

West: adjacent to Ban Soi 14, Khao Mai Kaew sub-district, Bang Lamung district, Chon Buri province

East: adjacent to Nikhom Pattana sub-district (divided by Soi 6 Road). It ends at Ban Khlong Ta Tai.

South: adjacent to Makham Khu sub-district, Nikhom Pattana district, Rayong province (divided by the National highway No. 3375)

Administrative Division, number of population and households: Phana Nikhom sub-district is under Phana Nikhom Sub-district Administrative Organization. There were 7,391 people in a house registration: 3,632 males (49.14% of population) and 3,759 females (50.86% of population) and 4,154 households (Department of Provincial Administration, December 2015).

Economic conditions

People in Phana Nikhom sub-district are farmers rather than working for the industry sector. There were 5 factories in Mae Nam Khu sub-district. Mainly, Mae Nam Khu sub-district encompasses 31,342 rai of agriculture land. The commonly grown crops include pineapple, rubber tree, tapioca. In addition, people earn a living by freshwater fisheries, animal production, etc. as detailed in **Table 4.4.1-18**.

TABLE 4.4.1-18

SIZE OF AGRICULTURE LAND, NUMBER OF FARMER HOUSEHOLDS IN PHANA NIKHOM SUB-DISTRICT

Village	Name of Villages	Occupied Area (rai)	Agriculture Land (rai)	Farmer Households (household)
1	Ban Soi 12	2,500	2,300	78
2	Ban Soi 8	5,700	5,300	250
3	Ban Khlong Ta Thai	4,850	4,445	132
4	Ban Khao Maphut	5,625	5,445	139
5	Ban Khlong Phlu	4,600	4,350	180
6	Ban Nong Rakam	4,450	4,282	150
7	Ban Wang Pla	2,800	2,640	94
8	Ban Soi 13	2,600	2,550	70
8 villages in total		**33,125**	**31,342**	**1,093**

Source: A Three-Year Development Plan of Phana Nikhom Sub-district Administrative Organization, 2013-2017

Social Conditions

Education: Educational institutes in Phana Nikhom sub-district are as follows:

- Three Child Development Centers
- Four educational institutes
- Self-Help Land Settlement School 4, Rayong province
- Self-Help Land Settlement School 6, Rayong province
- Self-Help Land Settlement School 9, Rayong province
- Ban Nong Rakam School
- Self-Help Land Settlement School 4 , Rayong province for educational opportunity expansion to Matthayom Suksa 3
- One community learning center

Religion and culture: There are 5 temples in Phana Nikhom sub-district as follows:

- Wat Charoen Si Rat Village no. 1
- Wat Khlong Ta Thai Village no. 3
- Wat Phana Nikhom (Khao Khao Maphut) Village no. 4
- Wat Nong Rakam Village no. 6
- Wat Prasittharam (Lak Roi) Village no. 7

Culture and tradition:

- Pouring scented water onto the elderly on Songkran Day
- Tradition of giving food offerings to a Buddhist monk on the first day of the Buddhist Lent and the end of the Buddhist Lent

- Loy Kratong Festival
- Bun Khao Lam merit making at Ban Nong Rakam
- Merit making on religious days

Public health:

- One Tambon Health Promoting Hospital in Phana Nikhom sub-district
- Two modern drugstores
- Nikhom Pattana Hospital

Transportation:

The National Highway No.3375 or the provincial highway leads to Phana Nikhom sub-district. The Provincial Highway 13 is the transportation route to Nikhom Pattana district and Rayong province. This road starts from Yaek Soi until it reaches Nikhom Pattana district for the distance of 13 km. It is the entire 2- asphalt pavement lane. Additionally, road users can use the National Highway No. 36, which is about 35 km to Rayong province. Optionally, Nikhom-Rayong Kankheha bus line is provided.

Electricity and water supply:

- An electricity is supplied for 8 villages.
- Village water supply is provided for 7 villages.

Water sources:

Natural water sources

- Ten Water channels and Huai
- Twelve marshes and swamps

Man-made water sources consisting of:

- Eight weirs

(3.2) Field survey results

The Consultant conducted the field survey after the 1st public participation meeting during February to April, 2016. The field survey on socio-economic conditions was divided into 3 stages: Stage 1 during February 10th-17th, 2016; Stage 2 during February 23rd – March 3rd, 2016 and Stage 3 during April 7th -11th, 2016. A questionnaire/interview was applied for 605 interviewees **(Table 4.4.1-19)** with the following details.

- Group of 32 involved government agencies (provincial/district/sub-district levels): representative of Rayong Provincial Fisheries Office, representative of Rural Road Office, representative of Rayong Provincial Office for Natural resources and Environment, Pluak Daeng district chief officer, Nikhom Pattana district chief officer, Chief Executive of Map Yang Phon Sub-district Administrative Organization, Chief Executive of Pluak Daeng Sub-district Administrative Organization, Chief Executive of Mae Nam Khu Sub-district Administrative Organization, representative of Map Yang Phon Tambon Health Promoting Hospital and representative of Nikhom Pattana Hospital, etc.

- Group of sensitive receptors in the study area (religious places and educational institutes): 20 samples
- Group of community leaders: 45 samples
  - 12 community leaders within the radius of 0-3 km or the area in the project vicinities
  - 33 community leaders within the radius of 3-5 km or the area far from the project
- Group of households in the study area: 501 samples (Sample distribution is shown in **Figure 4.4.1-2**).
  - Households within the radius of 0-3 km or the area in the project vicinities: 264 samples
  - Households within the radius of 3-5 km or the area far from the project: 237 samples
- 7 water user association in Huai Phu Sai

TABLE 4.4.1-19

SUMMARY OF SURVEY ON SOCIO-ECONOMIC CONDITIONS

Target Groups	Survey Methods	Surveyed Number* (person)
a. Group of involved government agencies	Purposive sampling	32
b. Group of sensitive receptors in the study area (religious places and educational institutes)	Purposive sampling	20
c. Group of community leaders	Purposive sampling	45
- Community leaders within the radius of 0-3 km	Systematic random	12
- Community leaders within the radius of 3-5 km	Systematic random	33
d. Group of households - Households within the radius of 0-3 km	Systematic random	264
- Households within the radius of 3-5 km	Systematic random	237
e. Water user association in Huai Phu Sai	Purposive sampling	7
Total		**605**

Remark: * Survey through questionnaire/interview

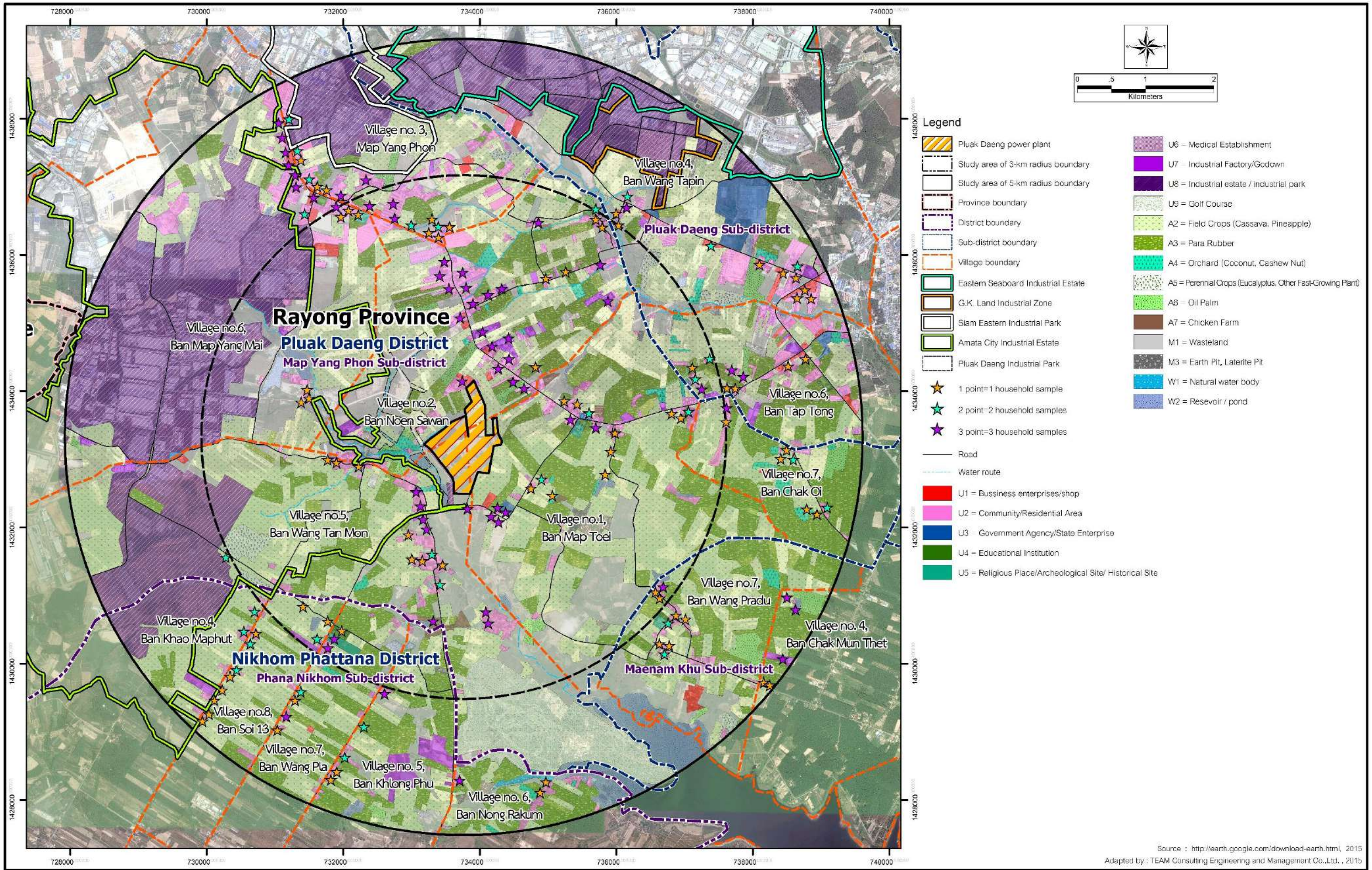


FIGURE 4.4.1-2 : LOCATIONS OF HOUSEHOLDS IN STUDY OF SOCIO-ECONOMIC CONDITIONS WITHIN RADIUS OF 5 KM FROM PROJECT BOUNDARY

10P2809/Damrongsak.B/15-08-60/P2809-022 (Land Use - เพิ่มขอบเขตนิคม - ตำแหน่งครัวเรือน - English).mxd

(a) Results of interview of representatives of involved government agencies

The Consultant made coordination to meet representatives of involved government agencies to provide the project information and enquired them about socio-economics, concerns, and opinions on the project development **(Photo 4.4.1-1)**. Details are given in **Table 4.4.1-20**. Summary was made from the interview of representatives of involved government agencies as shown in **Table 4.4.1-21**.

(b) Results of interview of representatives of sensitive receptors in the study area

The Consultant interviewed representatives of sensitive receptors in the study area, namely representatives of 20 religious places and educational institutes: 8 religious places and 12 educational institutes. Sensitive receptors covered the study area of 5 km from the project boundary under Administrative Division 4, the Sub-district Administrative Organization. Interview results are shown in **Table 4.4.1-22**.

(c) Results of interview of community leaders

The Consultant interviewed community leaders who were appointed from government agencies to supervise and act as a spokesperson for local people. Community leaders include sub-district headman, village headman, assistant sub-district headman, assistant village headman, the Village Committee, including community president, deputy community president and the Community Committee. The interview was conducted for 45 community leaders, covering 5 km radius from the project boundary. The project location is under Administrative Division 4, the Sub-district Administrative Organization. Community leaders from 15 villages (3 representatives from each village) were interviewed: 12 community leaders in the study area within the radius of 0-3 km and 33 community leaders in the study area within the radius of 3-5 km. Results of interview of community leaders are shown in **Appendix 4O** and summarized below.

(c.1) Interview of community leaders living within 0-3 km radius from the project boundary

- **General information of interviewees**

Most of the community leaders were males rather than females (8 and 4, respectively out of 12 interviewees). An average age of the interviewees was 46.8 years. Most of the interviewees were Buddhists (11 out of 12 interviewees). Most of them graduated from an elementary school, and lower secondary school (3 each out of 12 interviewees).

Groups of Government Agencies

Representative of Office of the Energy Regulatory Commission, Regional Office 8, Chon Buri province

Representative of Provincial Irrigation Office, Rayong Province

Representative of Rayong Provincial Fishery Office

Representative of Provincial Labour

Groups in Sensitive Receptors in the Study Area (Religious Places and Educational Institutes)

Wat Rat Atsadaram (Saphan Si)

Wat Phana Nikhom

Orawin Wittaya School

Self-Help Land Settlement School 9, Rayong Province

PHOTO 4.4.1-1 : INTERVIEW OF TARGET GROUP IN STUDY AREA

<table>
<tr><th colspan="2">Community Leaders</th></tr>
<tr><td>
Sub-District Headman, Map Yang Phon Sub-District</td><td>
Village Headman, Village no. 7 Mae Nam Khu Sub-District</td></tr>
<tr><td>
Village Headman, Village no. 5
Phana Nikhom Sub-District</td><td>
Village Headman, Village no. 1
Map Yang Phon Sub-District</td></tr>
<tr><th colspan="2">Groups of Households</th></tr>
<tr><td>
Representative of Household, Village no. 6
Map Yang Phon Sub-District</td><td>
Representative of Household, Village no. 6
Pluak Daeng Sub-District</td></tr>
<tr><td>
Representative of Household, Village no. 4
Mae Nam Khu Sub-District</td><td>
Representative of Household, Village no. 7
Phana Nikhom Sub-District</td></tr>
</table>

PHOTO 4.4.1-1 : INTERVIEW OF TARGET GROUPS IN STUDY AREA (CONT'D)

TABLE 4.4.1-20
REPRESENTATIVES OF GOVERNMENT AGENCIES FOR INTERVIEW

Group of Government Agencies	Interviewee	Date
Administration	- Nikhom Phatthana District Chief Officer	24th February 2016
	- Pluak Daeng District Chief Officer	2nd March 2016
	- Chief Executive of Pluak Daeng Sub-district Administrative Organization	2nd March 2016
	- Chief Administrator of Map Yang Phon Sub-district Administrative Organization	3rd March 2016
	- Chief Executive of Phana Nikhom Sub-district Administrative Organization	2nd March 2016
	- Secretary to the Chief Executive of Mae Nam Khu Sub-district Administrative Organization	26th February 2016
Natural Resources and Environment	- Environmental Technical Officer, Rayong Provincial Office of Natrual Resouces and Environment	24th February 2016
Industry/Energy	- Director of the Energy Regulatory Commission, Regional Office 8 (Chon Buri)	2nd March 2016
	- Engineer (Professional Level), Rayong Industrial Office	23rd February 2016
Agriculture	- Director of the Agricultural Occupation Promotion and Development Center, Rayong province (Horticulture), and team	24th February 2016
	- Head of Nikhom Phatthana District Agricultural Office	24th February 2016
	- General Administration Officer (Professional Level), Rayong Farm Crops Research Center	26th February 2016
	- Agricultural Extensionist (Professional Level), Pluak Daeng District Agricultural Office	2nd March 2016
	- Head of Rayong Provincial Fishery Office	3rd March 2016
Public Health	- Director of Map Yang Phon Sub-district Health Promoting Hospital	7th April 2016
	- Director of Mae Nam Khu Sub-district Health Promoting Hospital	7th April 2016
	- Director of Pluak Daeng Hospital	7th April 2016
	- Public Health Technical Officer, Pluak Daeng District Public Health Office	7th April 2016
	- Director of Ban Huai Prap Sub-district Health Promoting Hospital	8th April 2016
	- Head of Nikhom Phatthana District Public Health Office	8th April 2016
	- Public Health Technical Officer, Phana Nikhom Sub-district Health Promoting Hospital	8th April 2016
	- Public Health Technical Officer, Dok Krai Sub-district Health Promoting Hospital	8th April 2016
	- Director of Nikhom Phatthana Hospital	11th April 2016
Safety in Life and Property	- Deputy Superintendent (Suppression), Pluak Daeng Police Station	23rd February 2016
	- Staff Inspector, Nikhom Phatthana Police Station	2nd March 2016

TABLE 4.4.1-20
REPRESENTATIVES OF GOVERNMENT AGENCIES FOR INTERVIEW (CONT'D)

Group of Government Agencies	Interviewee	Date
Development	- Chief of Community Development Pluak Daeng District Office	26th February 2016
	- Chief of Community Development Phatthana Nikhom District Office	2nd March 2016
Labor and Protection	- Chief of Rayong Provincial Labour and Social Welfare Office	4th March 2016
Public Utilities	- Engineer (Class 5), Pluak Daeng District Electricity Office	23 rd February 2016
	- Manager of Nikhom Phatthana Electricity Office	25th February 2016
	- Head of Engineering Section, Rayong Provincial Irrigation Office	25th February 2016
	- Director of Rayong Rural Road Office	3rd March 2016

Source: Survey by TEAM Consulting Engineering and Management Ltd., 2016

TABLE 4.4.1-21
SUMMARY OF OPINIONS FROM INTERVIEW WITH RELATED GOVERNMENT AGENCIES

Group of Government Agencies	Summary of Opinions from Interview
Administration	Most representatives from the government agencies in administration group have expressed opinions as follows: - Importance should be given to local people's opinions and public relations to continually disseminate related information, e.g. project description, project impacts on communities, project benefits to communities, etc. - Project development should be carefully undertaken, especially in terms of safety/explosion due to machinery deterioration. Related environmental impact prevention and mitigation measures should be strictly adhered to. - Representatives of local people should be allowed take part in observing the measurement of environmental quality, e.g. air quality, water quality, noise, etc. in order to promote public participation and to enhance better understanding about the project implementation among local people. - The project should support local community's activites, development of public utilities, employment of local people, and development of people's quality of life. The support should be provided to local communities in a concrete manner in the long run. - Effluent from the project should be treated before discharging into public water bodies. There should be a treatment pond in the project area before conveying water to the central treatment pond of the Pluak Daeng Industrial Park. - The project should carefully prepare a water management plan to prevent the impacts on water for local people.

TABLE 4.4.1-21
SUMMARY OF OPINIONS FROM INTERVIEW WITH RELATED GOVERNMENT AGENCIES (CONT'D)

Group of Government Agencies	Summary of Opinions from Interview
Natural Resources and Environment	Representatives from the government agencies in natural resources and environment group have expressed their opinions as follows: - They have expressed concern about environmental impacts from the project development, e.g. air quality, water quality, noise, sufficiency of water in locality, social problems, and shortage of public health facilities. - The project should support/develop communities around the project area in terms of public health, setup of a power development fund, and quality of life of local people. - Environmental quality monitoring should be regularly conducted and related environmental impact prevention and mitigation measures should be strictly adhered to.
Industry/Energy	Representatives from the government agencies in industry/energy group have expressed their opinions as follows: - They have had concern about adequacy of water volume in locality since it may affect people, such as shortage of water for use, drought, etc. - If it is necessary to expand the natural gas pipeline of the power plant, consideration should be carefully made on the pipeline alignment which may affect local people. - The power development fund should be set up to allocate benefits to all local communities. - They have expressed concern about environmental impacts from the project development, e.g public utilities, social impacts, water quality, wastewater treatment prior to discharge into public water resources, air quality, noise, damaged/narrow roads, safety in life and property, narcotics problem, theft, quarrel, etc. - All steps of the project operation should cause the least impact on local people.
Agriculture	Most representatives from the government agencies in agriculture group have expressed their opinions as follows: - They have expressed concern about environmental impacts from the project development, e.g. air quality/dust, noise, sufficiency of water for local use, heavy metal contamination in water, and temperature of effluent discharged into public water bodies which may affect aquatic organisms. The project should strictly control and monitor environmental quality in accordance with the established measures. - They have agreed to the project development because the power plant is an important factor for economic development. - There should be the clearly defined criteria for budget allocation of the power development fund to ensure the maximum benefits of local people. - The project information should be continually and thoroughly disseminated to local people through public relations activities, for example, verbal communication, site visit, and health promotion activities. Also local people

TABLE 4.4.1-21

SUMMARY OF OPINIONS FROM INTERVIEW WITH RELATED GOVERNMENT AGENCIES (CONT'D)

Group of Government Agencies	Summary of Opinions from Interview
	should have opportunity to be the members of the monitoring community in order to create understanding/confidence about the project operation among local communities. - Study should be conducted on species of aquatic animals in Dok Krai reservoir and other water resources in locality for assessment of the project impact on aquatic animals and organisms. - Control or prevention of high temperature from the project operations should be performed to avoid the impact on agricultural produces in nearby areas.
Public Health	Most representatives from the government agencies in public health group have expressed their opinions as follows: - They have expressed concern about environmental impacts from the project development, e.g. air quality, dust, and higher temperature from the project development. The project should report the air quality measurement results to local people. - Public health services and medical personnel will not be sufficient for the increased number of patients due to the higher number of migrant workers, resulting in spread of communicable diseases/contagious diseases, and increase in transport/work accidents. The project should provide budget for public health services, e.g. purchase of medical equipment, employment of medical personnel to be sufficient for the number of patients, etc. - Transport accidents, high vehicle density, damaged roads, piles of construction equipment and materials on roads, noise from transportation of construction materials, and truck traffic - The project area currently has insufficient water and electricity supply. The project should support/improve the public utilities system to be more efficient to meet the demand for water/electricity. - The project should focus on employment of local workers as a way to promote the quality of life of local people. - The project should strictly follow the proposed rules and regulations and carefully prevent the probable impacts in all respects. - The project development is regarded as the way to enhance the country's economic conditions and energy security. - They have expressed concern about drainage of water into natural water resources, and contaminated water due to the project operation, especially the cooling process. - The power generating process may cause accidents, leakage, explosion, or fire. This causes anxiety to people living near the power plant. - The project details should be disseminated to create knowledge and understanding among local people so that they have confidence about the project operation. Material safety data sheet should be prepared. Emergency response plan should be clearly defined. The measures to relieve people's anxiety should be established and good relationship between the project and

TABLE 4.4.1-21

SUMMARY OF OPINIONS FROM INTERVIEW WITH RELATED GOVERNMENT AGENCIES (CONT'D)

Group of Government Agencies	Summary of Opinions from Interview
	local communities should be built. The project advantages and disadvantages should be informed. - The established measures should be strictly followed in all steps of the project operation. - Representatives of local government agencies should participate in the meetings to consider and express opinions about the project operation, and fairly allocate the budget from the power development fund to the communities around the power plant.
Safety in Life and Property	Representatives from the government agencies in the group of safety in life and property have expressed their opinions as follows: - They have expressed concern about the traffic problem due to the increased number of vehicles, transportation of construction materials and equipment, narrow roads, damaged road surface, and transport accidents. The project should have some staff at the entrance/exit of the project site to provide convenience to drivers. - Public consultation meetings should be organized in the study area to gather input from people living around the project area as they are directly affected by the project. - The environmental impacts that they have expressed concern about include air pollution, dust, noise, discharge of effluent from the project into the public water resources, sufficiency of water for usage in the project area and its surroundings, impact on agricultural produces, disposal of solid waste, and explosion/leakage. - As for social impact around the project area, migration of more workers will result in theft, narcotics problem, quarrel, and insufficient medical establishments and personnel to meet the increased number of patients. - The project development should be carefully undertaken to avoid impacts on nearby communities.
Development	Most representatives from the government agencies in the development group have expressed their opinions as follows: - At present, there are many non-registered population in the project area. Since these people do not appear in the house registration and therefore cannot be referred to in order to request for increase in transformers, water meters, and medical supplies in hospitals and sub-district health promoting hospitals. As a consequence, the public utilities and public health services are not sufficient to serve local people. - The environmental impacts that they have expressed concern about include air quality due to combustion, explosion/leakage, sufficiency of water for use in the project area and its vicinity, discharge of effluent from the project into public water resources, noise, traffic problem, transportation of construction materials and equipment, and disposal of solid waste. The project area should be carefully studied. The established measures should be followed.

TABLE 4.4.1-21

SUMMARY OF OPINIONS FROM INTERVIEW WITH RELATED GOVERNMENT AGENCIES (CONT'D)

Group of Government Agencies	Summary of Opinions from Interview
	- As for social impact around the project area, migration of more workers will result in theft, narcotics problem, and quarrel. - The budget from the power development fund should be fairly allocated to all communities. - Community development should be continually supported in all aspects. - The project should continually inform local communities of the EIA results and the project operations so that they can monitor the project operations. - Power plant visit should be held for the representatives of communities and related government offices to observe the project operations.
Labor and Protection	Representatives from the government agencies in the labor and protection group have expressed their opinions as follows: - The environmental impacts that they have expressed concern about include air pollution, noise, disposal of solid waste, wastewater treatment, high water temperature from the cooling process, sufficiency of water for use in the project area and its vicinity. The long-term environmental impact prevention plan should be prepared for the sustainable control of pollution and impacts. - As for social impact around the project area, the higher number of migrant workers will lead to theft, narcotics problem, quarrel, and change in the way of life/culture of local people. The higher number of non-registered population will result in the rising demand for public utilities. - As for employment of the project, more local people should be employed. If the project will employ foreign workers, they should be controlled not to trespass on local people's private property. - A secure fuel supply should be selected for power generating process. This project will use natural gas as the primary fuel. - The project information should be communicated by using the simple language to build correct understanding among people in local communities. The project information should be regularly informed to the public. - The budget from the power development fund should be thoroughly allocated to all local communities. Supports and assistance should be also provided to local communities.
Public Utilities	Most representatives from the government agencies in the public utilities group have expressed their opinions as follows: - The environmental impacts that they have expressed concern about include safety of the power generating system, explosion/leakage, traffic accident, road damage due to transportation of construction materials and equipment, etc. The project should strictly follow the established measures. - As for the traffic during the construction period, transportation of construction materials and equipment should be avoided during the rush hours/heavy traffic. Truck loads should be also strictly controlled. - Data on traffic survey in the study area should be also given to the Rayong Rural Road Office.

TABLE 4.4.1-21
SUMMARY OF OPINIONS FROM INTERVIEW WITH RELATED GOVERNMENT AGENCIES (CONT'D)

Group of Government Agencies	Summary of Opinions from Interview
	- The project should have the measures for controlling/overseeing migrant staff or workers who may cause social impacts to local communities, e.g. theft, narcotics problem, quarrel, etc. - Water required for power generating may affect water volume in local area which will not be sufficient for use in households and in agricultural sector. - Quality of water discharged from the project area into the public water resources may affect aquatic animals. This is because the discharged effluent will contain no mineral, causing change to water properties and quality. - As for the safety system to prevent explosion/leakage, separate safety systems should be used instead of the centralized safety system in order to prevent accidents and hazards in nearby areas. Emergency response drill should be regularly conducted. - Public relations activities should be organized, including dissemination of the project information, and power plant visit so that local people understand the safety system and the project operations. - Establishment of the power plant to generate electricity for use in the industrial estate will affect the revenue of the Provincial Electricity Authority. - They have expressed concern about the accidents with the trucks loaded with construction materials/equipment passing the power transmission lines as the trucks may bring down the power lines. The project should coordinate with the responsible provincial electricity office about the power lines before transportation. - In case of ground survey and drilling, the project should directly coordinate with the responsible provincial electricity office in advance. This is because drilling may affect the ground wires and electricity poles. Date and place of survey and drilling should be also informed in advance to the responsible provincial electricity officers so that they will provide convenience and damage will be minimized.

Source: Survey by TEAM Consulting Engineering and Management Ltd., 2016

TABLE 4.4.1-22
SUMMARY OF ISSUES FROM INTERVIEWS WITH REPRESENTATIVES OF SENSITIVE RECEPTORS

Agencies	Summary of Issues from Interviews
Religious places	Most representatives of religious places provided the following information to the project. - A work plan should be prepared and staff assigned to be responsible in the long term for community impacts, with personnel designated to receive complaints from communities so as to handle and solve problems in cooperation with communities. - Anxieties about environmental impacts cover water supply insufficiency in the area, impacts on agriculture/agricultural products, loud noise, air pollution/dust, possible impacts of the project's effluent discharge to public watercourses, and traffic accidents due to an increase in vehicular volume. - Anxieties about social impacts include life and property safety of local people owing to an increase in labour migration into the area which may have some impacts concerning thefts, drugs problems, and quarrels and fights. - Economic advantages of the project development are improvement of local people's income because of higher labour in-migration such as retail shops around the project area. Moreover, power plant project development is very vital and necessary because it will support industrial activities. - Workers should be controlled to comply with measures prescribed by law so that the project operations will have minimum impact on nearby communities. - Community relations activities should be organized to build good relationship between the project and communities, e.g. community development activities, promotion of local people's employment and income generation, anti-drug sports activities, road improvement, and improvement of electricity system and water supply system, etc.
Educational Institutions	Representatives of educational institutions provided the following information. - Anxieties about environmental impacts from the project development are air pollution/ dust, water pollution, effluent discharge to public waterways, safety/accidents, loud noise, solid waste disposal, and traffic problems. - Anxieties about social impacts include labour migration into the area which may lead to thefts, drugs problems, and quarrels and fights. It is suggested that legal workers should be selected to work in the project as this will reduce problems relating to illegal migrant labour and enable better labour control and management. - Economic advantages of the project development are improvement of local people's income because of higher labour in-migration such as retail shops around the project area. - Environmental impact prevention and mitigation measures should be established to be a guideline for mitigating probable community impacts that may arise from the project development and building local people's confidence in the safety system. The most important thing is strict compliance with the prescribed measures on a consistent basis. - The results of project operations should be regularly monitored to stringently control and prevent impacts.

TABLE 4.4.1-22

SUMMARY OF ISSUES FROM INTERVIEWS WITH REPRESENTATIVES OF SENSITIVE RECEPTORS (CONT'D)

Agencies	Summary of Issues from Interviews
Educational Institutions (Cont'd)	- If dust/air quality monitoring and measurements are undertaken, the local agencies should be informed of the results and a summary of the study results should be widely disseminated to local communities. - Water sufficiency (water reserve) should be managed along with water quality and good drainage system. This will ensure that local people will not be affected by water shortage and flood prevention will be achieved by improvement of the project area conditions. - Community relations activities should be organized to build good relationship between the project and communities, e.g. community development activities, educational promotion, development of quality of life, and a wide range of activities in diverse models with emphasis on community development. - As for safety from the project operations, prevention of explosion/ leakage, etc., a practice plan in case of accidents should be put in place as well as dissemination of knowledge to the public so as to build local people's confidence. - The economic benefit of the project will be increased income of community people from small shops around the project area, etc. due to the larger number of migrant labours. - Prevention and mitigation measures should be established as operational guidelines to reduce potential impacts from the project operation and ensure the safety system for local people. The most important thing is strictly and consistently following these measures. - The project performance should be regularly monitored to strictly control and prevent impacts. - In case dust particle/air quality is measured, measurement results should be explained to local agencies. Summary should be made and local people should be informed. - Water management should be performed for water adequacy (water reserve), water quality and good drainage so that local people will not be affected from water shortage and flood due to land leveling can be controlled. - Community relations activities, such as community development, educational promotion, quality of life development, and other activities that are focused on community development should be organized for a good relationship between the project and communities. - As for safety from the project operations, prevention of explosion/ leakage, etc., a drill plan in case of accidents should be put in place as well as dissemination of knowledge to the public so as to build local people's confidence.

- **Community information**

Communities have existed for 68.8 years on average. These were basically agricultural communities. People in communities have various occupations, namely farming, selling, work for hire and self-employed. Most of the interviewees considered themselves having moderate income and wealthy (10 interviewees and 2 interviewees, respectively), taking into account basic minimum needs, occupations, livelihood and income. Regarding the relationship of community people, all of them have always participated in community activities

- **Existing Living Conditions of Communities**

The existing environmental problems of the communities are described as follows:

– Odour (7 out of the total 12 interviewees): Odour impacts come from garbage and factories. The majority of the interviewees considered the impact level as moderate (3 out of the 7 interviewees).

– Noise (6 out of the total 12 interviewees): Noise impacts arise from car/truck traffic. The majority of the interviewees regarded the impact level as moderate (3 out of the 6 interviewees).

– General Dust (8 out of the total 12 interviewees): Impacts arise from traffic. Most respondents regarded the impact level as moderate (4 out of the 8 interviewees).

– Soot/Smoke (3 out of the total 12 interviewees): Soot/smoke impacts are generated by traffic, grass/garbage burning, and agricultural activities. The impact level is low, moderate, and undecided (cited by one respondent each).

– Solid Waste (2 out of the total 12 interviewees): Impact arises from insufficient number of garbage collection staff, and the impact level is considered as high and undecided (cited by one respondent each).

– Wastewater (1 out of the total 12 interviewees): The respondent is uncertain about the impact level.

– Flooding (3 out of the total 12 interviewees): Impacts are caused by drainage channel. Respondents considered the impact level as undecided, moderate and high (reported by one respondent each).

– Traffic (4 out of the total 12 interviewees): Impacts arise due to car/truck traffic, narrow traffic lanes, and road closure as a result of transformer explosion. Most respondents regarded the impact level as high while others were uncertain about the impact level (2 respondents each).

Public Utilities and Public Service Problems (e.g. road, electricity, water supply, solid waste management, police station, Tambon health promoting hospitals, etc.):

– Electricity (4 out of the total 12 interviewees): Impacts are caused by a storm, high electricity demand/insufficient distribution capacity, and an increase in population in the area. Most interviewees considered the impact level as moderate (2 out of the 4 interviewees). Complaints were submitted to the responsible agency to rectify the problem, but the problem has remained unsolved.

– Water Supply (5 out of the total 12 interviewees): Impacts are in the form of turbidity and water supply disruptions due to drought. Most interviewees considered the impact level as high and moderate (4 interviewees and 1 interviewee, respectively). The problem solving involved water purchase for household use and consumption as well as drilling of artesian wells. However, problems still persist.

– Road Conditions (4 out of the total 12 interviewees): Impacts arise from rutted or uneven traffic surface, and car/truck traffic. Most interviewees considered the impact level as moderate while others were uncertain about the impact level (3 interviewees and 1 interviewee, respectively). The problem was partially resolved by the relevant officers while some part remains to be solved.

– Drainage (2 out of the total 12 interviewees): Drainage problem occurs due to blocked drainage pipes/channels. The two respondents considered the impact level as moderate. The problem has not yet been solved.

– Sufficiency of Hospitals (2 out of the total 12 interviewees): Impacts occur due to the insufficient number of hospital staff. The impact level is considered to be high and undecided (one respondent each). The problem has not yet been solved.

- **Community Problems and Life and Property Safety:** The first three major problems are drugs, thefts/robberies, and labour migration into the area (8 interviewees, 7 interviewees, and 5 interviewees, respectively).

Regarding opinions about community development in the future, most community leaders mentioned that communities should be developed in the following aspects.

– Emphasis on Public Utilities Development (10 out of the total 22 interviewees): Inadequacy/poor quality of public utilities was cited as the major reason, e.g. insufficient water supply, water turbidity, undervoltage events due to high power demand, etc. Road should be improved to meet the standard and to be clean in order to reduce traffic congestion and accidents.

– Emphasis on Occupational Development/Increased Income (9 interviewees): This will help support people to get jobs/have income for better quality of life. Village development fund should be also supported.

– Emphasis on Quality of Life Development/Solving of Social Problems (2 interviewees): Thefts have occurred in the communities and there is a need for police patrols in the area.

– Emphasis on Economic-Investment Development (1 interviewee).

- **Awareness of Project Information**

All community leaders (12 respondents) have prior information on the project. The sources of information are project meetings (8 respondents); project staff and community leaders such as Chief Executive of sub-district administrative organization, sub-district headmen, etc. (7 respondents each); signboards (3 out of the total 26 respondents), and officers of district/provincial agencies (1 respondent).

- **Concerns about Project Development**

Most community leaders (8 respondents) reported no worry while some of them expressed anxiety (4 out of the total 12 respondents). The issues of concern are air pollution/dust, loud noise, odour, traffic, water pollution/effluent discharge to public waterways, and an increase in non-registered population.

- **Anticipated Impacts**

Anticipated Impacts during Construction Phase

The majority of interviewed community leaders (10 out of the total 12 respondents) expected some impacts on communities during construction phase while some (2 out of the total 12) anticipated no community impact. The top three anticipated community impacts (with details given in **Appendix 4O**) are as follows:

– Construction Dust (9 out of the total 10 respondents): It is anticipated that community impacts will be low, moderate, and high (3 respondents each). The recommendations for impact prevention are establishment of strict prevention and control measures, water spraying, materials and equipment storage to be well covered, and project staff to attend to the impact prevention issue.

– Dust from Material and Equipment Transport (8 out of the total 10 respondents): It is anticipated that community impacts will be moderate and high (3 respondents each), and low (2 respondents), respectively. The recommendations for impact prevention are establishment of strict prevention and control measures, materials and equipment to be completely covered with tarpaulin while being moved/transported.

– Soot/Smoke from Trucks Transporting Material and Equipment (8 out of the total 10 respondents). It is anticipated that community impacts will be low and high (3 respondents each), and moderate (2 respondents), respectively. The recommendations for impact prevention are establishment of strict prevention and control measures, project staff to attend to the issue, materials and equipment to be completely covered with tarpaulin while being moved/transported, and prohibition of trucks emitting black smoke/exhaust from entering the area.

– Traffic Congestion from Material and Equipment Transport (6 out of the total 10 respondents). It is anticipated that community impacts will be moderate and high (3 respondents each). The recommendations for impact prevention are establishment of strict prevention and control measures, and increase of traffic lanes.

Anticipated Impacts during Operation Phase

Half of the interviewed community leaders (6 out of the total 12 respondents) have anticipated that there may be some impacts on communities during operation phase while the remainder (6 out of the total 12 respondents) have expected no community impact. The top three anticipated impacts on communities (with details given in **Appendix 4O**) are as follows:

– Air Quality (6 out of the total 6 respondents): It is anticipated that community impacts will be moderate, high and low (3 respondents, 2 respondents and 1 respondent, respectively). The recommendations for impact prevention are establishment of strict prevention and control measures, and dust monitoring and measurement to ensure compliance with the standard.

– Insufficient Water Supply for Household Use/Consumption (5 out of the total 6 respondents): It is anticipated that community impacts will be moderate and high (3 respondents and 2 respondents). The recommendations for impact prevention are establishment of strict prevention and control measures, and provision of internal water sources for the project use in order to reduce impacts of sharing water sources with communities.

– Water Quality (3 out of the total 6 respondents): It is anticipated that community impacts will be high and low (2 respondents and 1 respondent, respectively). The recommendations for impact prevention are establishment of strict prevention and control measures, and good wastewater treatment process.

– Operating Noise (3 out of the total 6 respondents): It is anticipated that community impacts will be high and moderate (2 respondents and 1 respondent), respectively. The recommendations for impact prevention are establishment of strict prevention and control measures, and regular monitoring.

– Impacts on Agriculture/Agricultural Products (3 out of the total 6 respondents): It is anticipated that community impacts will be low, moderate and high (1 respondent each). Prevention and control measures are recommended to be established for impact prevention.

– Occupational Change (3 out of the total 6 respondents): It is anticipated that community impacts will be moderate and high (2 respondents and 1 respondent), respectively. The recommendations for impact prevention are establishment of prevention and control measures, and promotion of local employment in communities.

– Local Residents' Way of Living (3 out of the total 6 respondents): It is anticipated that community impacts will be low, moderate, and high (1 respondent each). Prevention and control measures are recommended to be established for impact prevention.

- **Public Participation**

Pre-construction Phase: The majority of community leaders expressed willingness to provide useful information to the project and willingness to help disseminate the project information in their communities (12 respondents each), and willingness to only receive the project information (5 out of the total 29 respondents).

Construction Phase: Most community leaders expressed willingness to provide useful information to the project and willingness to help disseminate the project information in their communities (12 respondents each), willingness to only receive the project information and willingness to help monitor activities that may cause any damage to the communities during construction phase (5 respondents each), and willingness to help monitor the compliance with impact mitigation measures during construction phase (4 respondents).

Operation Phase: Most community leaders expressed willingness to provide useful information to the project and willingness to help disseminate the project information in their communities (12 respondents each), willingness to help monitor activities that may cause any damage to the communities during operation phase (10 respondents), willingness to only receive the project information (5 respondents), and willingness to help monitor the compliance with impact mitigation measures during operation phase (4 respondents).

- **Public Relations (PR) Campaigns for Power Plant Project**

The community leaders recommended that appropriate public relations (PR) models or methods be adopted. The suggestions include provision of project information via sub-district headmen/village headmen/village committees, letters/ documents to directly inform the people, provision of project information through relevant local agencies, organizing of meetings to give explanation to the public, community broadcasting, preparation of project PR documents/pamphlets, etc.

Important information or major issues required for public information are impacts of the project development, environmental impact prevention and mitigation measures, the project implementation plan/duration, project details, and the development fund for communities in the power plant vicinity.

- **Additional Comments and Recommendations for the Project**

The community leaders made additional comments and suggestions on various issues.

– Organizing of site visits to power plants to promote better understanding of power plant operations;

– Organizing of public consultation with local people in every nearby village. Public consultation forums will give the project the opportunity to directly explain/ publicize the project details to the people.

– Preparation of measures for environmental impact prevention and mitigation, work with due care and caution/giving importance to work safety, and regular monitoring of work quality

– Community relations activities and community development activities should be promoted along with local people’s earnings to build good relationship between the project and community.

(c.2) Interviews with Community Leaders within 3-5 Kilometres from the Project Area Perimeter

- **General Information of Interviewees**

The interviewed community leaders consist of male and female (75.8% and 24.2%, respectively), with an average age of 49.8 years. All of them (100%) are Buddhist. The majority of interviewees completed elementary school (36.3%), followed by secondary school (27.2%), high school/vocational certificate (15.2%), bachelor’s degree (9.1%), diploma/high vocational certificate and higher than bachelor’s degree (6.1% each). The respondents are mainly assistant village headmen (69.7%), followed by village headmen (27.3%) and sub-district headmen (3.0%), respectively.

- **Community Information**

Village settlement duration is about 64.5 years on average. Most houses are located in the original community (48.6%), followed by real estate, and mixed original community and real estate (in an equal percentage of 11.4%), etc. Community members have diverse occupations, namely agriculture, general wage earners, factory workers, trade, and self-employment. The interviewed community leaders’ viewpoints on economic conditions show that community members are middle income people (97.0%), and poor people (3.0%), taking into account income, migration, occupation, livelihood, and trade. As for community relationship, most community leaders reported regular member participation in community activities (81.8%), followed by participation based on interests and no mention of participation level (15.2% and 3.0 %), respectively.

- **Existing Living Conditions of Communities**

The existing environmental problems of the communities are as follows:

– Odour (54.5%): Odour impacts come from factories, garbage, and solid waste landfill. Most respondents considered the impact level as low (38.9%), followed by high, undecided, and moderate (38.9%, 5.5%, and 16.7%, respectively).

– Noise (33.3%): Noise impacts are caused by car/truck traffic, and factories. The majority of respondents considered the impact level as low (45.4%), while others considered it as moderate and high (36.4% and 18.2%, respectively).

– General Dust (48.5%): Dust impacts are caused by car/truck traffic, factories, and construction/land leveling/filling activities, etc. Most interviewees considered the impact level as low (43.8%) while others considered it as moderate, high and undecided (25.0%, 18.8% and 12.4%, respectively).

– Smoke (6.1%): Impacts come from grass/garbage burning. The interviewees considered the impact level as low and high (50.0% each).

– Solid Waste (12.1%): There are impacts from delay in solid waste collection/uncollected solid waste (75.0%), and factories (25.0%). Most respondents regarded the impact level as low (50.0%) while others viewed it as moderate and high (in an equal percentage of 25.0%).

– Wastewater (3.0%): Impacts are generated by factories. All respondents considered the impact level as low (100.0%).

– Flooding (6.1%): Impacts are caused by factories and roads with a higher elevation than houses (50.0% each). The respondents considered the impact level as moderate and high (50.0% each).

– Traffic (18.2%): Impacts are caused by peak-period traffic congestion, car/truck volume, speed driving, and factory workers’ driving behavior. Most respondents considered the impact level as moderate (66.6%) while some considered it as low and others were uncertain (16.7% each).

- **Public Utilities and Public Service Problems:** (e.g. road; electricity; water supply; solid waste management; police station; Tambon health promoting hospitals, etc.)

- Electricity (33.3%): Impacts occurs due to frequent undervoltage and blackout events, electric power consumption of industrial plants, high power demand of the public, an increase in population, and old transformers. Most respondents considered the impact level as moderate (63.6%) while some considered it as low and others were uncertain (18.2% each).
- Water Supply (33.3%): Impacts include drought season/supply disruption, turbidity/sediment, high water demand of local communities, and closure of regulators. Most interviewees considered the impact level as high (45.4%) while some considered it as moderate and others were uncertain (36.4% and 18.2%, respectively). Previous problem-solving approaches include water purchase, artesian well drilling, and reporting to the relevant agencies. However, the problem has not been solved in some areas.
- Road Conditions (12.1%): Impacts are caused by car/truck traffic and deteriorating road conditions. The majority of interviewees considered the impact level as low (75.0%) and high (25.0%).
- Solid Waste Management (12.1%): Impacts arise due to delay in solid waste collection/uncollected solid waste, and factories. Most respondents considered the impact level as moderate (75.0%) and low (25.0%).
- Drainage (9.1%): Impacts are caused by factories. The respondents considered the impact level as low, moderate and high (in an equal percentage of 33.3%).
- Sufficiency of Fire Stations (6.1%): As there is no fire station in the vicinity of communities, all respondents regarded the impact level as high.
- Sufficiency of Hospitals (6.1%): As there is no hospital in the vicinity of communities, all respondents considered the impact level as high.
- Sufficiency of Schools (3.0%): As there is no school in the vicinity of communities, all respondents were undecided about the impact level.

Community Problems and Life and Property Safety: The top three current problems are drugs (31.5%), thefts/robberies (29.4%), and labour in-migration (17.6%).

Regarding opinions about community development in the future, most community leaders suggested that community development should focus on the following aspects.

- Emphasis on Occupational Development/Increased Income (46.5%): Local people have low income while the cost of living has risen. This will also contribute to improvement of the quality of life.

– Emphasis on Public Utilities Development (37.2%): Development of public utilities is needed, including village water supply, road improvement to meet the standard and road cleanliness, and improvement of electricity distribution system to meet demand.

– Emphasis on Quality of Life Development/Solving of Social Problems (11.6%): As a large number of non-registered people have moved into the area, thefts and lack of life and property safety have become problems. Community development activities and public information efforts should be emphasized.

– Emphasis on Natural Resources and Environmental Development (4.7%): This will emphasize conservation of natural resources, environmental improvement in the area, and support of increased tree planting in the area.

- **Awareness of Project Information**

Most community leaders (93.9%) have prior information on the project and some (6.1%) have just received the project information for the first time. As for the community leaders receiving prior project information, the main source of information is project meetings (45.8%), followed by project staff (27.1%); local community leaders, e.g. Chief Executive of sub-district administrative organization, sub-district headmen, etc. (20.3%); signboards, and local relevant agencies (3.4% each).

- **Concerns about Project Development**

Regarding concerns about the project development, most community leaders (87.9%) expressed no worry while some of them voiced anxiety (12.1%). The major concerns are air pollution, dust, unpleasant odour, water supply volume for communities, environmental pollution, water pollution, and effluent discharge to public watercourses, etc.

- **Anticipated Impacts**

Anticipated Impacts during Construction Phase

The majority of community leaders (60.6%) have anticipated that there may be no impact on communities while some (39.4%) have expected certain impacts during construction phase. The top three anticipated impacts on communities (with details given in **Appendix 4O**) are as follows:

– Construction Dust (61.5%): It is anticipated that community impacts will be low ($\bar{X}$ = 1.38, S.D. = 0.4841). The recommendations for impact prevention are establishment of strict prevention and control measures, water spraying, speed limit, dust monitoring and control to comply with the standard, and materials and equipment to be completely covered.

– Drugs Problems (53.8%): Community impacts are anticipated to be low ($\bar{X}$ = 1.43, S.D. = 0.4949). The recommendations for impact prevention are establishment of strict prevention and control measures, designated project staff to handle the issue, careful selection of qualified staff/labour, and additional provision of security system.

– Dust from Material and Equipment Transport (38.5%): Community impacts are anticipated to be low ($\bar{X}$ = 1.20, S.D. = 0.4000). The recommendations for impact prevention are establishment of strict prevention and control measures, materials and equipment to be completely covered while being moved, dust monitoring and control to comply with the standard, control of trucks entering and exiting the project area.

– Water Shortage due to Water Use/Consumption for Construction Activities (38.5%): Community impacts are anticipated to be low ($\bar{X}$ = 1.60, S.D. = 0.4899). The recommendations for impact prevention are establishment of strict prevention and control measures, provision of the project's own water sources so as not to affect the communities' water usage, and good wastewater treatment system, such as water recycle, etc.

– Thefts (38.5%): Community impacts are anticipated to be low ($\bar{X}$ = 1.60, S.D. = 0.4899). The recommendations for impact prevention are establishment of strict prevention and control measures, careful selection of project staff, and implementation of additional security measures in the area.

Anticipated Impacts during Operation Phase

Most community leaders (60.6%) have anticipated that there will be no impact on communities while some (39.4%) have expected certain impacts during operation phase. The top three anticipated impacts on communities (with details provided in **Appendix 4O**) are presented as follows:

– Air Quality (76.9%): It is anticipated that community impacts will be low ($\bar{X}$ = 1.70, S.D. = 0.4583). The recommendations for impact prevention are establishment of strict prevention and control measures, selection of advanced technology for the project operations, and dust measurement/control of air quality to ensure compliance with the standard.

– Water Supply/Water Shortage (61.5%): Community impacts are expected to be low ($\bar{X}$ = 1.63, S.D. = 0.4841). The recommendations for impact prevention are establishment of strict prevention and control measures, regular monitoring of water quality, provision of the project's own water sources so as not to affect the communities' water usage, and good wastewater treatment system, such as water recycle, etc.

– Water Quality (38.5%): It is anticipated that community impacts will be low ($\bar{X}$ = 1.60, S.D. = 0.4899). The recommendations for impact prevention are establishment of strict prevention and control measures, application of advanced technology to the project operations, and regular monitoring of water quality.

- **Public Participation**

Pre-construction Phase: The majority of community leaders expressed willingness to provide useful information to the project and willingness to help disseminate the project information in their communities (in an equal percentage of 45.8%), and willingness to only receive the project information (8.4%).

Construction Phase: Most community leaders expressed willingness to provide useful information to the project (31.2%), followed by willingness to help disseminate the project information in their communities (29.0%), willingness to help monitor activities that may cause any damage to the communities during construction phase (18.3%), willingness to help monitor the compliance with impact mitigation measures during construction phase (14.0%), and willingness to only receive the project information (7.5%), respectively.

Operation Phase: Most community leaders expressed willingness to help monitor activities that may cause any damage to the communities during operation phase (28.0%), followed by willingness to provide useful information to the project and willingness to help disseminate the project information in their communities (27.1% each), willingness to help monitor the compliance with impact mitigation measures during operation phase (12.2%), and willingness to only receive the project information (5.6%), respectively.

- **Public Relations (PR) Campaigns for Power Plant Project**

The majority of community leaders recommended that appropriate public relations (PR) models or methods be adopted. The suggestions include provision of project information via community leaders and organizing of meetings to give explanation to the public and stakeholders (24.6% each), followed by letters/documents to directly inform the people and provision of project information through relevant local agencies (14.0% each), distribution of the project PR documents (13.2%), and community broadcasting (9.6%), respectively.

Important issues for public information should cover the project development impacts and environmental impact prevention and mitigation measures (24.8% each), followed by the project implementation plan (20.8%), project details (20.0%), and details of the community development fund for communities in the power plant vicinity (9.6%), respectively.

- **Additional Comments and Recommendations for the Project**

Most community leaders made additional comments and recommendations on various issues. The first three recommendations are project operations in a prudent manner, taking into consideration environmental impacts as well as environmental protection/conservation in the area. In addition, suggestions were made for promotion/ development of local people's quality of life of such as promotion of income generation/ local employment, organizing of community development activities or community relations activities, etc.

(d) Results of Household Interviews

The Consultant conducted household interviews in the study area within 5-km radius from the project area perimeter. There are a total of 501 samples, divided into 264 samples of households within a radius of 0-3 kilometers, and 237 samples of households within a radius of 3-5 kilometers, as summarized herein.

(d.1) Household Interviews within 0-3 Kilometres from the Project Area Perimeter (The interview results are presented in detail in Appendix 4O)

- **General Information of Interviewees**

The percentage of male interviewees is higher than that of female interviewees (53.8% and 46.2%, respectively), with an average age of 51.1 years. The interviewees are mainly head of household (53.1%), followed by spouse (28.4%), and son/son-in-law/daughter-in-law (8.7%), etc. The interviewees mostly completed elementary school, secondary school, and high school/vocational certificate, etc. (37.1%, 20.1% and 15.9%, respectively). Most respondent households (98.8%) are Buddhist, followed by Christian, Muslim and unspecified (0.4% each).

Most respondent households have moved from other areas (51.5%), mainly from other provinces in the Northeast, the East, and the Central Region (38.3%, 25.7%, and 16.2%, respectively). The reasons range from search for employment, office relocation, marriage with local people, and relocation of parents/relatives, etc. (63.3%, 22.8%, and 11.0%, respectively). The average length of residence after relocation into the area is about 23 years while some interviewees have lived in the area since birth (48.5%).

With regard to the relocation issue, most respondent households have no wish to relocate (95.8%), followed by those wishing to move to other places, and those giving no information (3.4% and 0.8%, respectively). The top 3 reasons for non-relocation are housing in the area/living with family (35.3%), followed by permanent job/business operation in the area (29.7%), and birthplace (17.4%), respectively. For interviewees wishing to relocate, the main reasons are a wish to return to hometown, and a search for new house/business place (33.3% each), followed by community's existing poor environment (22.3%). About 66.7% did not specify new places of residence while 33.3% expressed a wish to move to other southern provinces.

- **Household Socio-Economics**

The average household size is 4.1 persons, 2.2 of which are male and 1.9 female, respectively. The ratio of income earners to non-earners is 2.4:1.7 persons.

Factory employment is the main occupation, followed by trade and general wage earners, etc. (45.0%, 18.2% and 10.2%, respectively). Moreover, some households (14.4%) have supplementary occupations, e.g. trade, self-employment, agriculture, etc. Most working households (91.6%) have no occupational problem while some of them (7.6%) have encountered job problems. The main reasons are irregular and inadequate income (63.1%); rather high investment costs, e.g. fertilizer/agricultural chemical prices, etc. (10.1%); low farm prices (15.8%), and insufficient agricultural water/drought (5.3%), etc.

The average household income is about 36,274 baht per month whereas the average household expenditure is about 24,339 baht. The majority of sample households (92.4%) reported that their income is adequate to meet expenses. Others reported that their income is inadequate while some expressed no opinion (7.2% and 0.4%, respectively). Solutions to insufficient income are borrowing and unspecified method (89.5% and 10.5%, respectively).

- **Health and Satisfaction with the Existing Overall Living Conditions, and Health Service and Convenience**

Household members mainly seek health services at state hospitals (56.7%), followed by Tambon health promoting hospitals (26.3%), private hospitals/clinics (13.3%), Thai traditional/herbal medicine (2.1%), etc. The majority of interviewees deemed that public health care services in the area are adequate (96.9%) while others found them inadequate and some expressed no opinion (2.3% and 0.8%, respectively). In case of service inadequacy, the reasons include an increase in population/in-migration of unregistered population, and insufficient number of physicians. As for travel convenience to hospitals in the area, most sample households (98.5%) reported that it is convenient to travel while others has no comment (1.1%) and some find it inconvenient to travel (0.4%).

- **Existing Living Conditions of Communities**

The existing environmental problems of the communities are described as follows:

– Odour (16.3%): Odour impacts come from factories, garbage, traffic, grass/garbage burning, chemicals, and wastewater. Most interviewees considered the impact level as moderate (51.2%) whereas others considered it as low and high (39.5% and 7.0%, respectively). Mitigation measures in the past include cleaning/washing of garbage bins. Nonetheless, the problem has not been addressed in some areas.

– Noise (25.4%): Noise impacts arise from traffic, factories, and construction activities. The majority of interviewees considered the impact level as moderate (56.4%) while others considered it as high and low (22.4% and 17.9%, respectively). The problem has not yet been addressed.

– General Dust (36.7%): Dust impacts are caused by traffic, factories, construction activities, agricultural activities, and grass/garbage burning. Most interviewees considered the impact level as moderate (56.2%) while others considered it as high and low (22.7% and 17.5%, respectively). Water spraying was adopted to mitigate the impact in the past. Nevertheless, the problem has not been solved in some areas.

– Smoke (8.3%): The impact is generated by grass/garbage burning, factories, traffic and agricultural activities. Most interviewees considered the impact level as moderate (40.9%) whereas others considered it as low and high (31.8% and 22.7%, respectively). No measure has been put in place to solve the problem.

– Solid Waste (9.5%): There are impacts from delay in solid waste collection/irregular solid waste collection by the responsible local agency, a large volume of garbage, and local communities. Most interviewees considered the impact level as moderate (52.0%) while others considered it as high and low (24.0% and 20.0%, respectively). The problem has not yet been solved.

– Wastewater (1.9%): The source of impact was unspecified. The majority of interviewees considered the impact level as low and moderate (60.0% and 40.0%, respectively). This problem has not yet been addressed.

– Flooding (1.9%): Flooding generally occurs due to heavy rain and lack of drainage pipes. Most interviewees considered the impact level as low and high (60.0% and 40.0%, respectively). This problem has not yet been addressed.

– Traffic (11.0%): The impact is caused by the high number of cars/traffic congestion, traffic accidents, small traffic lanes, and factories. Most interviewees considered the impact level as moderate (48.3%) while others considered it as high and low (34.5% and 13.3%, respectively). Mitigation measure in the past was to inform the concerned agency to provide traffic police to facilitate traffic.

- **Public Utilities and Social Services (e.g. electricity; water supply; road conditions; solid waste management; sufficiency of fire stations, hospitals, schools, etc.)**

  – Electricity (20.1%): There is an impact due to high electricity demand but with insufficient distribution system capacity to meet the demand, electric power consumption of factories in the area, and power outage due to a storm. Most interviewees considered the impact level as low (62.3%) while others considered it as moderate and high (30.2% and 7.5%, respectively). In the past, problems were solved by informing the concerned agency to rectify the problems and also notifying the relevant sub-district administrative organization (SAO).

  – Water Supply (24.2%): Impacts include turbidity, high water demand due to increased population, and drought/disruption of water supply delivery. Most interviewees considered the impact level as high (40.6%) while others considered it as moderate and low (37.5% and 20.3%, respectively). Previous problem-solving approaches include water purchase, and submission of complaints to the responsible agency so as to rectify the problems. Nevertheless, the problem has not been solved in most of the area.

  – Road Conditions (5.3%): Impacts are caused by deteriorating road conditions, narrow traffic lanes, and a large volume of trucks. The majority of interviewees considered the impact level as low, moderate and high (28.6% each). Road widening was implemented to solve the problem.

  – Solid Waste Management (4.5%): Impact occurs due to the delay in solid waste collection. The majority of interviewees considered the impact level as moderate (66.7%). Others considered it as low and high (16.7% each). This problem has not yet been solved.

  – Drainage (1.1%): The source of impact was not identified and no problem-solving approach has been adopted. Most interviewees considered the impact level as moderate and high (66.7% and 33.3%, respectively).

- **Community Problems and Life and Property Safety (54.2%):** The first four major problems of communities are drugs (26.3%), thefts and robberies (24.8%), youth gangs (17.1%), and quarrels and fights (15.5%), etc.

- **Water Sufficiency and Quality for Household Use:**

  Most households (88.5%) regarded that water supply is adequate. Some households considered it insufficient and some expressed no comment (11.2% and 0.3%, respectively). The reasons for insufficient water supply include inadequate water volume/unreliable water flows (55.2%), high water demand/an increase in unregistered population, and drought (13.8% each), etc. The water quality for household use is described as follows:

– Water Supply: Most customers regarded the water quality as good (48.0%), while some cited turbidity/sediment problem (41.9%) and unpleasant odour (5.4%), etc.

– Groundwater: The majority of users regarded the water quality as good (79.7%), while some cited turbidity/sediment problem (16.5%) and unpleasant taste (1.3%), etc.

– Artesian Water: Most users considered the water quality as good (82.5%), while some cited turbidity/sediment problem (13.6%), unpleasant odour, and unpleasant taste (1.0% each).

Major water sources for household use are water supply (40.3%), followed by artesian water (33.7%), and groundwater (26.0%), respectively. Water is mostly not treated before use (83.3%). In case of water treatment before use, methods adopted by most households are filtration (59.0%), followed by alum application and unspecified method (17.9% each), boiling and distillation (2.6% each), respectively.

- **Potable Water Sufficiency and Quality for Household Consumption:**

Most households (96.6%) considered that potable water supply is adequate. Some households had no opinion (2.3%) and some considered it insufficient (1.1%). Major water sources for household consumption are bottled water/water in gallons (80.9%), followed by artesian water (14.5%), groundwater (3.5%), water supply (0.7%), etc. The water quality for household consumption is presented as follows:

– Bottled Water/Water in Gallons: Most consumers regarded the water quality as good (96.9%) while some customers had no opinion and some mentioned turbidity/sediment problem (1.8% and 1.3%), respectively.

– Water Supply: All consumers regarded the water quality as good.

– Groundwater: All consumers considered the water quality as good.

– Artesian Water: The majority of consumers (97.6%) considered the water quality as good and some expressed no opinion (2.4%), respectively.

Most households do not treat water before consumption (97.3%). In case of water treatment before consumption, methods adopted by most households are filtration (83.3%) and alum application (16.7%), respectively.

When asked about satisfaction with communities, most households (49.2%) expressed moderate satisfaction with communities, followed by high satisfaction (47.0%), no mention of satisfaction (3.4%), and dissatisfaction (0.4%), respectively.

For most households' satisfaction, the main reasons include a long period of residence/familiarity, livable environment, neighbourliness, job security, etc. As for households expressing low satisfaction and dissatisfaction with communities, they cited thefts, disorder, traffic congestion, air quality/dust problem, shortage of water supply, etc.

- **Awareness of Project Information**

Most respondent households (53.8%) have prior information on the project while some households first received the project information from interviewers (46.2%). As for the households receiving prior project information, neighbours/relatives (24.6%) are the main source of information, followed by the project staff and local agencies (18.9% each); local community leaders, e.g. sub-district headmen, village headmen, etc. (27.1%); project meetings (8.2%); signboards (0.9%); community broadcasting (0.6%), etc.

- **Concerns about Project Development**

With regard to concerns about the project development, 69.7% of respondents reported no worry while some of them voiced anxiety (30.3%). The first three reasons of those without worry are the far distance of their houses from the project area (32.1%), followed by no problem from the project development (31.5%); project construction has not yet commenced (9.2%), and no anxiety because of no project information (7.1%), respectively.

As for anxieties about the project development, the issues of concern are air pollution/climate change (41.9%), environmental impacts (20.5%), wastewater discharge into public water sources/water pollution (9.1%), explosion/leakage (2.3%), loud noise (6.8%), social impacts (3.6%), etc. Mitigation measures have been suggested, i.e. strict compliance with impact mitigation measures and impact monitoring (4.8%); installation of dust collectors/air filters before being discharged from the project (2.4%); additional information (2.4%); installation of air quality monitoring devices, organizing of community relations activities, provision of wastewater treatment system, relocation of project site, driving caution (2.4% each), etc.

- **Anticipated Impacts**

Anticipated Impacts during Construction Phase

The majority of respondent households (45.1%) have anticipated that there may be no impact on communities during construction phase while some expressed uncertainty about community impact (28.0%) and some (26.9%) anticipated some impacts. The top three anticipated impacts on communities (with details given in **Appendix 4O**) are as follows:

– Construction Dust (71.8%): It is anticipated that community impacts will be moderate ($\bar{X}$ = 2.18, S.D. = 0.6775). The recommendations for impact prevention are establishment of strict prevention and control measures, water spraying, materials and equipment storage to be well covered, dust monitoring and control to comply with the standard, and project staff to attend to the impact prevention issue in cooperation with communities.

– Dust from Material and Equipment Transport (54.9%): Community impacts are anticipated to be moderate ($\bar{X}$ = 2.10, S.D. = 0.7087). The recommendations for impact prevention are establishment of strict prevention and control measures, water spraying, materials and equipment storage to be well covered, project staff to handle the impact prevention issue in cooperation with communities, organizing of joint activities between the project and communities, and relocation of the project site to be far from the communities.

– Construction Noise (45.1%): Community impacts are anticipated to be moderate ($\bar{X}$ = 2.19, S.D. = 0.7680). The recommendations for impact prevention are establishment of strict prevention and control measures, organizing of activities to promote communities' understanding, avoidance of working during nighttime, and relevant staff to jointly handle this issue and solve problems.

Anticipated Impacts during Operation Phase

Most respondent households (43.9%) have anticipated that there may be no impact on communities during operation phase while some expressed uncertainty about community impact (31.5%) and some (24.6%) anticipated some impacts. The top three anticipated impacts on communities (with details given in **Appendix 4O**) are as follows:

– Air Quality (61.6%): It is anticipated that community impacts will be high ($\bar{X}$ = 2.68, S.D. = 0.5190). The recommendations for impact prevention are establishment of strict prevention and control measures, organizing of joint meetings between the project staff and the public to promote mutual understanding and joint problem-solving, usage of fuels with least air quality impact to be considered, air quality monitoring to ensure compliance with the standard prior to release from the project, and community leaders' participatory role in the project implementation.

– Operating Noise (56.9%): Community impacts are anticipated to be high ($\bar{X}$ = 2.70, S.D. = 0.5630). The recommendations for impact prevention are establishment of strict prevention and control measures, installation of noise barriers, avoidance of nighttime transport/site access activities, organizing of joint meetings between the project staff and the public to promote mutual understanding and joint problem-solving, regular monitoring of the operations, community leaders' participatory role in the project implementation.

– Water Quality (55.3%): Community impacts are anticipated to be high ($\bar{X}$ = 2.72, S.D. = 0.5061). The recommendations for impact prevention are establishment of strict prevention and control measures, organizing of joint meetings between the project staff and the public to promote mutual understanding and joint problem-solving, water quality monitoring/wastewater treatment prior to effluent discharge to natural watercourses, provision and regular operation of the project's own wastewater holding ponds, and usage of fuels with least air quality impact to be considered.

- **Public Participation**

Pre-construction Phase: The respondent households expressed willingness to help disseminate the project information in their communities (40.2%), followed by willingness to provide useful information to the project (38.6%), and willingness to receive the project information (21.2%), respectively.

Construction Phase: The respondent households expressed willingness to help disseminate the project information in their communities (30.6%), followed by willingness to provide useful information to the project (29.4%), willingness to receive the project information only (17.1%), and willingness to help monitor the compliance with impact mitigation measures during construction phase as well as activities that may cause any damage to the communities during construction phase (12.0% and 10.9%, respectively).

Operation Phase: The respondent households expressed willingness to provide useful information to the project (29.4%), followed by willingness to help disseminate the project information in their communities (28.6%), willingness to receive the project information only (16.6%), willingness to help monitor the compliance with impact mitigation measures during operation phase (12.9%) and willingness to help monitor activities that may cause any damage during operation phase (12.5%).

- **Public Relations (PR) of Power Plant Project Information**

The respondent households recommended that appropriate public relations (PR) models or methods should be adopted. The suggestions include provision of project information via community leaders (26.1%), followed by letters/documents to directly inform the people (24.1%), provision of project information through relevant local agencies (17.3%), organizing of meetings to give explanation to the public and stakeholders (16.1%), community broadcasting (9.8%), distribution of project PR documents (6.4%), project staff's visit to provide project information to local residents and announcements by PR campaign cars equipped with loudspeakers (0.1% each), respectively.

Important issues for public information should cover project details (24.5%), impacts of the project development (23.1%), the project implementation plan (21.3%), environmental impact prevention and mitigation measures (20.4%), details of the community development fund for communities in the power plant vicinity (10.4%), etc.

- **Additional Comments and Recommendations for the Project**

The respondent households gave additional comments and suggestions on various issues. The first three recommendations are organizing of activities to promote project understanding (1.2%), continuous PR campaigns to provide project information to the public (6.4%), impact monitoring and mitigation throughout the project operation (3.2%), preparation of measures for mitigation of project development impacts (2.4%), emphasis to be put on impacts that may disturb nearby communities (0.8%), etc.

(d.2) Household Interviews within 3-5 Kilometres from the Project Area Perimeter (The interview results are presented in detail in **Appendix 4O**)

- **General Information of Interviewees**

The percentage of female interviewees is higher than that of male interviewees (51.5% and 48.5%, respectively), with an average age of 46.9 years. The interviewees are mainly head of household (51.1%), followed by spouse (23.2%), son/son-in-law/daughter-in-law (10.5%), household head's parents (9.3%), etc. The interviewees mostly completed elementary school (41.9%), secondary school, and high school/vocational certificate, (22.4% and 14.3%, respectively), diploma/high vocational certificate (8.4%), etc. Most of the interviewees (98.8%) are Buddhist, followed by Muslim and unspecified (0.8% and 0.4%, respectively).

Most interviewed households moved from other areas (51.5%), and some have lived in the area since birth (48.5%). Most of the in-migrating households (99.2%) did not give information on their former place of residence whereas some moved from northern provinces (0.8%). The reasons range from business operation/search for employment (56.5%), relocation of parents/relatives (18.9%), marriage with local people (16.4%), etc. The average length of residence after relocation into the area is about 25 years.

With regard to the relocation issue, most respondent households have no wish to relocate (95.8%), followed by those wishing to move to other places (4.2%), respectively. The reasons for non-relocation are housing in the area/a long period of residence (24.2%), followed by job/business operation in the area (27.5%), and birthplace (24.6%), respectively. For interviewees wishing to relocate, the main reasons are a wish to return to hometown (50.0%), followed by office relocation/change of job, and change in the environment (20.0% each), and unspecified reason (10.0%), respectively.

- **Household Socio-Economics**

The average household size is 4 persons, and the ratio of male to female is 2.1 to 1.9. The population consists mainly of children, elderly people, and working age people, respectively. The ratio of income earners to non-earners is 2.3:1.7 persons.

Factory employment is the main occupation of the respondent households (30.4%), followed by trade (19.8%), self-employment and agriculture (14.8% each), general wage earners (10.1%), government/state enterprise officers (3.8%), farm work (3.0%), fishing and private firm employees (0.4% each). Moreover, some households (20.7%) have supplementary occupations such as trade, general wage earners, agriculture, self-employment, fishing, etc.

Most respondent households (91.9%) have no occupational problem. Some households have encountered job problems while some did not report whether they had any occupational problem (6.8% and 1.3%, respectively). For those having job problems, the main reasons are low income/poor economy/poor trade performance (45.6%), followed by lack of capital (18.2%), high prices of fertilizer/agricultural chemicals and low farm prices (13.6% each), etc.

The average household income is about 25,338 baht per month whereas the average household expenditure is about 18,605 baht per month. The majority of sample households (87.7%) considered that their income is adequate to meet expenses. Others reported that their income is inadequate (11.0%) and some gave no information (1.3%), respectively. Solutions to insufficient income are borrowing (73.2%) and earning of supplementary income (11.5%), etc.

- **Health and Satisfaction with the Existing Overall Living Conditions, and Health Service and Convenience**

Household members mainly seek health services at state hospitals (68.6%), followed by Tambon health promoting hospitals and private hospitals/clinics (13.8% each), Thai traditional/herbal medicine (2.1%), etc. The majority of interviewees viewed that public health care services in the area are adequate (97.0%) while others found them inadequate and some expressed no opinion (1.7% and 1.3%, respectively). In case of service inadequacy, the reasons include an increase in unregistered population and in-migration of foreign labourers. As for convenience of health service, most sample households (95.7%) found it convenient while others found it inconvenient and some had no comment (3.0% and 1.3%, respectively).

- **Existing Living Conditions of Communities**

The existing environmental problems of the communities are as follows:

– Odour (18.1%): Odour impacts come from factories, traffic, garbage, agricultural activities, and grass/garbage burning. Most interviewees considered the impact level as moderate (55.8%) whereas others considered it as low and high (34.9% and 9.3%, respectively). Mitigation measures in the past include cleaning of garbage bins. Nonetheless, the problem has not been addressed in some areas.

– Noise (23.2%): Noise impacts are caused by traffic, factories, communities, and construction activities. The majority of respondents considered the impact level as moderate (58.2%) while others considered it as high and low (23.6% and 18.2%, respectively). Mitigation measures in the past include reporting to the authorities, and closing of house doors. However, the problem has not been addressed in some areas.

– General Dust (38.0%): Dust impacts are caused by traffic, factories, and construction activities. Most interviewees considered the impact level as moderate (56.6% each) while others considered it as high and low (27.8% and 15.6%, respectively). To mitigate the impact in the past, measures adopted include water spraying, closing of house windows and doors, and reporting to relevant authorities. Nevertheless, the problem has not been solved in some areas.

– Smoke (4.6%): The impact is generated by traffic, factories, and grass/garbage burning. Most interviewees considered the impact level as low and moderate (45.5% each) while others considered it as high (9.0%), respectively. Closing of house doors was adopted to mitigate the impact in the past. Nevertheless, the problem has not been solved in some areas.

– Solid Waste (3.0%): There are impacts from a large volume of solid waste, lack of communities' cooperation in proper solid waste disposal, improper solid waste collection method, and delay in solid waste collection. Most respondents considered the impact level as moderate (57.1%) while others considered it as low and high (28.6% and 14.3%, respectively). The problem has not yet been solved.

– Flooding (0.8%): Flooding generally occurs due to a storm and lack of drainage pipes. Most interviewees considered the impact level as moderate and this problem has not yet been addressed.

– Traffic (3.8%): The impact is caused by the high number of cars/ traffic congestion, traffic accidents, and speed driving. Most interviewees considered the impact level as moderate (66.7%) while others considered it as low and high (11.1% and 22.2%, respectively). No mitigation measure has been implemented.

Public Utilities and Social Services (e.g. road; electricity; water supply; solid waste management; police station; Tambon health promoting hospitals, etc.)

– Electricity (26.6%): There are impacts due to undervoltage events during a storm, inadequate electricity supply to meet demand of local people, electric power consumption of industrial plants, and construction activities. Most interviewees considered the impact level as moderate (49.2%) while others considered it as low and high (39.7% and 11.1%, respectively). In the past, problems were solved by informing the concerned agency to rectify the problems. The problems have largely remained unsolved.

– Water Supply (11.8%): Impacts include turbidity, supply disruption, water main breaks, and occasional water pipe repair/installation. Most interviewees considered the impact level as moderate (46.4%) while others considered it as low and high (28.6% and 21.4%, respectively). Previous problem-solving approaches include water pipeline repair/ improvement, water purchase, chlorine application, and use of artesian water. However, the problem has not been solved in some areas.

– Road Conditions (3.0%): Impacts are caused by car/truck traffic, construction activities, and erosion of traffic surface. The majority of interviewees considered the impact level as high and moderate (57.1% and 42.9%, respectively). The problem has not yet been solved.

– Solid Waste Management (2.5%): Impact occurs due to solid waste disposal by shops and delay in solid waste collection by responsible agency. The majority of interviewees considered the impact level as moderate and low (83.3% and 16.7, respectively). This problem has not yet been solved.

– Drainage (0.4%): Most respondents considered the impact level as low and the problem has not yet been addressed.

– Community Problems and Life and Property Safety (57.0%): The existing community problems are thefts/robberies (32.4%), drugs (28.8%), youth gangs (14.7%), quarrels and fights as well as labour in-migration (9.0% each), unemployment of local residents (6.1%), respectively.

- **Water Sufficiency and Quality for Household Use:**

Most households (89.0%) viewed that water supply is adequate for household use while some households (11.0%) considered it insufficient. The reasons for insufficient water supply include drought (33.3%), high water demand (26.7%), scheduled water distribution (13.3%), inadequate service coverage of water supply system/irregular water flows (6.7%), etc.

Major water sources for household use are water supply (47.3%), followed by artesian water (35.8%), groundwater (15.70%), and canals (1.2%), respectively. Water is generally treated before use, with the methods adopted by most households being filtration (63.0%), followed by alum application and chlorine application (11.1% each), etc.

– Water Supply: Most customers regarded the water quality as good (61.7%), while some cited turbidity/sediment problem (23.4%), unpleasant odour (7.0%), and unpleasant taste (0.8%), respectively.

– Artesian Water: Most users considered the water quality as good (88.0%), while some cited turbidity/sediment problem (8.7%), unpleasant taste (1.1%), etc.

– Groundwater: The majority of users regarded the water quality as good (75.0%), while some cited unpleasant odour (11.4%), turbidity/sediment problem and unpleasant taste (6.8% and 4.5%), etc.

– Canal: Most users considered the water quality as poor with turbidity/sediment (66.7%) while some considered the water quality as good (33.3%).

- **Potable Water Sufficiency and Quality for Household Consumption:**

Nearly all households (96.6%) considered that potable water supply is adequate. Some households had no opinion and some considered it insufficient (3.0% and 0.4%, respectively).

Major water sources for household consumption are bottled water/ water in gallons (82.4%), followed by artesian water (11.6%), groundwater (4.4%), water supply and rain water (1.2% and 0.4%), respectively. Water is generally treated before use, with the methods adopted by most households being filtration (77.7%), followed by alum application and boiling (16.7% and 5.6%, respectively.

– Bottled Water/Water in Gallons: Most consumers regarded the water quality as good (95.1%).

– Artesian Water: The majority of users (89.7%) considered the water quality as good and some cited turbidity/sediment problem (10.3%), etc.

– Groundwater: Most users (90.9%) considered that the water quality is good.

– Water Supply: Most consumers regarded the water quality as good (66.7%) while some cited turbidity/sediment problem (33.3%).

– Rain water: All consumers reported unpleasant taste (100%).

Regarding community satisfaction, most households expressed moderate satisfaction with communities (52.8%), followed by high satisfaction (45.1%) and dissatisfaction (2.1%), respectively. For those who are satisfied with communities, the main reasons include housing/a long period of residence, livable environment, community development, and neighbourliness. As for households expressing dissatisfaction, they cited unregistered population/in-migration of labourers, drugs problems, frequent accidents, and traffic congestion.

- **Awareness of Project Information**

Most respondent households (54.4%) have just received the project information for the first time while some have prior information on the project (45.6%). As for the households receiving prior information, neighbours/co-workers/relatives (28.8%) are the main source of information, followed by local community leaders, e.g. Chief Executive of sub-district administrative organization, sub-district headmen, etc. (22.4%); project meetings (17.8%); the project staff (17.2%); local agencies (12.1%); signboards, and community broadcasting (1.1% and 0.6%), respectively.

- **Concerns about Project Development**

With regard to concerns about the project development, most respondent households (84.0%) expressed no worry while some of them voiced anxiety (16.0%). As for anxieties about the project development impacts, the major concerns are air/dust pollutants and environmental pollution (23.7% each), loud noise (7.9%), water pollution/wastewater discharge from the project to public watercourses (5.3%), safety of project development (2.6%), etc. Mitigation measures to address communities' anxiety are good control and prevention measures (8.6%), air quality monitoring prior to release from the project, installation of dust filters, provision of additional information to the public (2.9% each), etc.

- **Anticipated Impacts**

Anticipated Impacts during Construction Phase

The majority of respondent households (50.6%) have anticipated that there may be no impact on communities during construction phase. Some respondents (33.80%) expressed uncertainty about community impact and some (15.6%) anticipated some impacts during construction phase. The top three anticipated impacts on communities (with details given in **Appendix 4O**) are as follows:

– Construction Dust (54.1%): It is anticipated that community impacts will be high ($\overline{X}$ = 2.45, S.D. = 0.5895). The recommendations for impact prevention are establishment of strict prevention and control measures, project staff to handle the impact prevention issue in cooperation with communities, water spraying, and relocation of the project site to be far from the communities.

– Dust from Material and Equipment Transport (48.7%): Community impacts are anticipated to be high ($\overline{X}$ = 2.50, S.D. = 0.6009). The recommendations for impact prevention are establishment of strict prevention and control measures, water spraying, project staff to handle the impact prevention issue in cooperation with communities, and relocation of the project site to be far from the communities.

– Construction Noise (46.0%): Community impacts are anticipated to be high ($\overline{X}$ = 2.53, S.D. = 0.4991). The suggestions for impact prevention are establishment of strict prevention and control measures, control of construction noise, avoidance of nighttime working, relevant staff to jointly handle this issue and solve problems in cooperation with communities, and relocation of the project site to be far from the communities.

Anticipated Impacts during Operation Phase

Most respondent households (49.0%) have anticipated that there may be no impact on communities during operation phase while some expressed uncertainty about community impact (27.8%) and some (23.2%) anticipated some impacts. The top three anticipated impacts on communities (with details given in **Appendix 4O**) are as follows:

– Air Quality (81.1%): It is anticipated that community impacts will be high ($\overline{X}$ = 2.60, S.D. = 0.5763). The recommendations for impact prevention are establishment of strict prevention and control measures, project staff taking responsibility for impact prevention in cooperation with communities, selection of fuels with least air quality impact, avoidance of garbage burning, and relocation of the project site to be far from the communities.

– Water Quality (69.1%): Community impacts are anticipated to be high ($\overline{X}$ = 2.66, S.D. = 0.6188). The recommendations for impact prevention are establishment of strict prevention and control measures, project staff taking responsibility for impact prevention in cooperation with the communities, inspection of project implementation to prevent impacts, and good management system.

– Operating Noise (63.7%): Community impacts are anticipated to be high ($\overline{X}$ = 2.77, S.D. = 0.4832). The recommendations for impact prevention are establishment of strict prevention and control measures, project staff taking responsibility for impact prevention in cooperation with communities, and installation of noise barriers.

– Solid Waste/Industrial Waste from the Project Operation (63.6%): Community impacts are anticipated to be high ($\overline{X}$ = 2.74, S.D. = 0.4982). The recommendations for impact prevention are establishment of strict prevention and control measures, project staff taking responsibility for impact prevention in cooperation with communities, inspection of project implementation to prevent impacts, and relocation of the project site to be far from the communities.

- **Public Participation**

Pre-construction Phase: The respondent households expressed willingness to help disseminate the project information in their communities (38.4%), followed by willingness to provide useful information to the project (34.7%), and willingness to receive the project information (26.9%), respectively.

Construction Phase: The respondent households expressed willingness to help disseminate the project information in their communities (28.1%), followed by willingness to provide useful information to the project (26.3%), willingness to receive the project information only (20.3%), and willingness to help monitor the compliance with impact mitigation measures during construction phase as well as activities that may cause any damage to the communities during construction phase (14.9% and 10.4%, respectively).

Operation Phase: The respondent households expressed willingness to help disseminate the project information in their communities (27.7%), followed by willingness to provide useful information to the project (27.6%), willingness to receive the project information (19.3%), and willingness to help monitor the compliance with impact mitigation measures during operation phase (14.5%) and to monitor activities that may cause any damage to the communities during operation phase (10.9%).

- **Public Relations (PR) of Power Plant Project Information**

The respondent households recommended that appropriate public relations (PR) models or methods be adopted. The suggestions include provision of project information via community leaders (25.7%), followed by provision of project information through relevant local agencies (20.6%), letters/documents to directly inform the people (20.2%), organizing of meetings to give explanation to the public and stakeholders (16.5%), community broadcasting (10.8%), distribution of the project PR documents (5.7%), PR campaigns via electronic media (0.3%), and project staff's visit to provide project information to local residents and announcements by PR campaign cars equipped with loudspeakers (0.1% each), respectively.

Important issues for public information should cover project details (25.1%), impacts of the project development (23.9%), the project implementation plan (22.1%), environmental impact prevention and mitigation measures (21.1%), details of the community development fund for communities in the power plant vicinity (7.8%), respectively.

- **Additional Comments and Recommendations for the Project**

The respondent households gave additional comments and recommendations on various issues. The first three recommendations are preparation of measures for mitigation of project development impacts (2.8%), followed by emphasis on impacts that may disturb nearby communities (1.9%), and organizing of activities to promote project understanding or continuous PR campaigns to provide project information to the public (1.4%), etc.

(d.3) Summary of the Overall Opinions of Households in the Study Area

The overall opinions about the project development are summarized by sample group based on study zones as follows:

- Households within 0-3 km radius of the study area
- Households within 3-5 km radius of the study area

Overall, the majority of households in both study zones expressed no anxiety over the project development in line with the views about anticipated impacts during construction and operation phases. Most sample households expected no impact on the communities whereas some expressed uncertainty about community impact, and some anticipated certain project impacts, respectively, with details described herein.

Concerns about the Project Development: The majority of respondent households within radius of 0-3 km and 3-5 km from the project site perimeter expressed no worry about the project development (69.7% and 84.0%, respectively). Some sample households (within 0-3 km and 3-5 km radius of the study area) voiced their concerns (30.3% and 16.0%, respectively). It can be concluded that most respondent households within 0-5 km radius from the project site perimeter expressed no anxiety over the project development **(Figure 4.4.1-3)**. However, the issues of concern are air pollution, water pollution, health and social impacts, loud noise, life and property safety, explosion/leakage accidents, etc.

Anticipated Impacts during Construction Phase: The majority of respondent households within radius of 0-3 km and 3-5 km from the project area have anticipated no community impact during construction phase (45.1% and 50.6%, respectively), followed by those with uncertainty about community impact and those expecting some impacts during construction phase (with details shown in **Figure 4.4.1-4**). The anticipated impacts during construction phase are air/dust pollution, loud noise, traffic accidents, and deteriorating road conditions due to material and equipment transport, etc. Positive impacts arising from the project development include an increase in employment, improved economic situation in the area, etc.

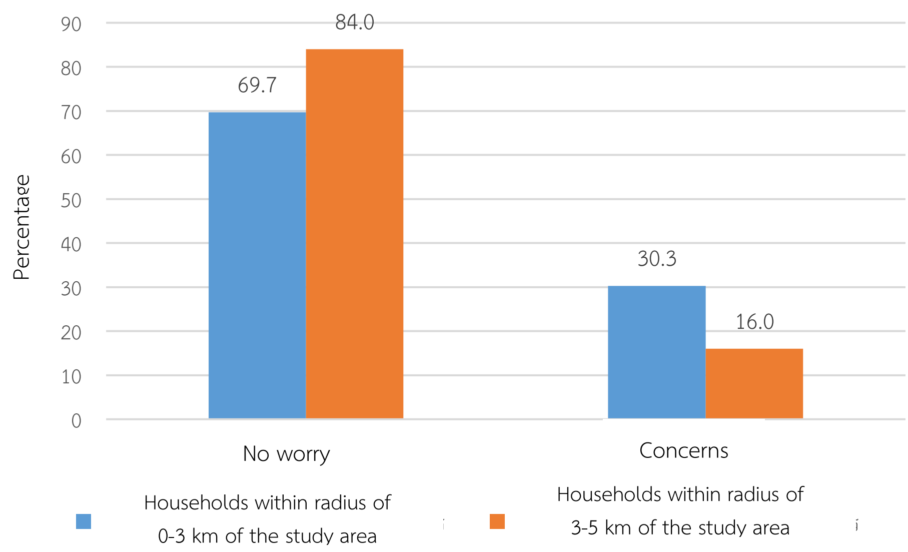


FIGURE 4.4.1-3 : CONCERNS ABOUT THE PROJECT DEVELOPMENT

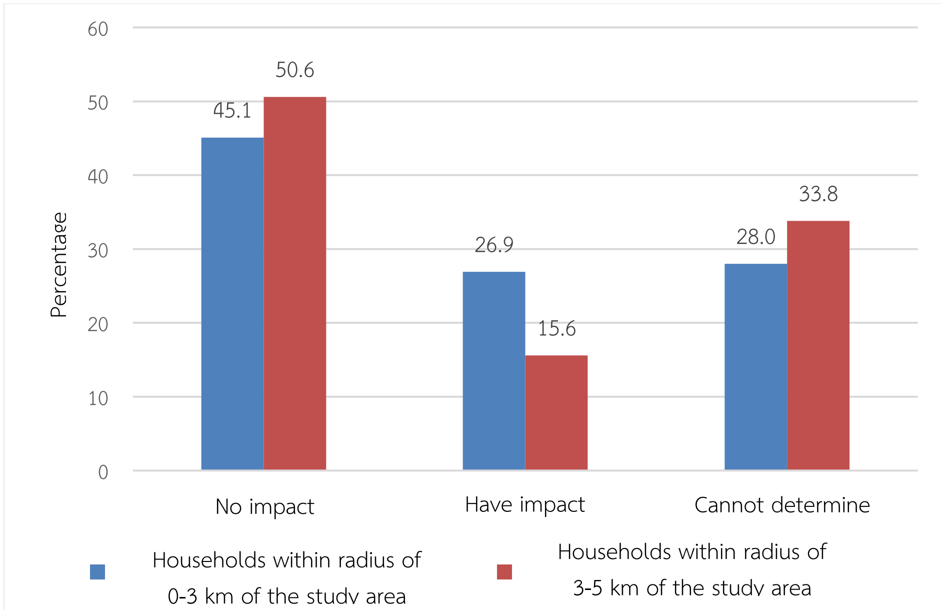


FIGURE 4.4.1-4 : ANTICIPATED IMPACTS DURING CONSTRUCTION PHASE

Anticipated Impacts during Operation Phase: The majority of respondent households within radius of 0-3 km and 3-5 km from the project area have anticipated no community impact during operation phase (43.9% and 49.0%, respectively), followed by those with uncertainty about community impact and those expecting some impacts during operation phase (with details shown in **Figure 4.4.1-5**). The anticipated impacts during operation phase are air/dust pollution, loud noise, adequacy of water supply in the area, effluent discharge from the project area into public watercourses, and project operational safety (explosion/leakage), etc. However, the project development will have positive impacts, i.e. sufficient electric power supply in the area, promotion of industrial business growth, enhancement of the country's power security, improved trade/economic conditions, and community growth and convenience, etc.

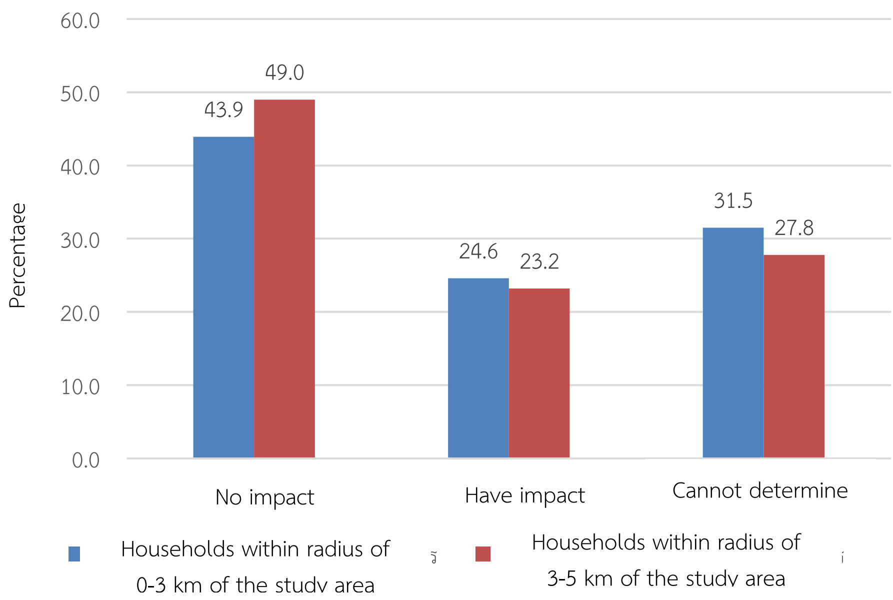


FIGURE 4.4.1-5 : ANTICIPATED IMPACTS DURING OPERATION PHASE

(e) Interview Results of Huai Phu Sai Water User Group

The field survey along the Huai Phu Sai stream which is located in the project study area shows that 7 households normally draw water from Huai Phu Sai. These households were then interviewed, the results of which are presented in **Appendix 4O**, and summarized as follows:

For Huai Phu Sai sample households, the percentage of male respondents is higher than that of female respondents (71.4% and 28.6%, respectively). All of them (100%) use water from Huai Phu Sai and the main water uses are consumption and fishery (50.0% and 35.7%, respectively) while there is an equal percentage of agriculture and consumption (7.1%).

– **Huai Phu Sai Water Users for Agricultural Production:** There is only one respondent (7.1%) who draws water from Huai Phu Sai for agricultural use during dry season. The streamflow volume of Huai Phu Sai is sufficient to provide supplies for farming purpose and there is no water quality problem. The agricultural water user reported farm problems arising from low farm prices offered by middlemen. Regarding chemical use in farming, the respondent stated that no chemicals are applied to farming.

– **Huai Phu Sai Water Users for Fishery:** Fishing is carried out all year round and types of catches consist of the following.

- Fish, such as Nile tilapia, Jullien's mud carp, Giant gourami, Common silver barb, Giant catfish and Striped tiger nandit. Each catch averages 3.5 kilogrammes, with fishing frequency of daily and 2-3 times per week (40.0% each), and once a month (20.0%). Fishing tools are fishing nets, traps, and hooks and lines.
- Mollusks: River snail, with an average daily catch of 2 kilogrammes, using scoop nets.
- Prawns: Giant Malaysian prawn and Krill. Each catch averages 2 kilogrammes, with fishing frequency of daily and 2-3 times per week (50.0% each), using nets as tools.

– **Huai Phu Sai Water Users for Consumption (Drinking):** All water users stated that the streamflow volume of Huai Phu Sai is sufficient to meet demand and there is no water quality problem.

– **Huai Phu Sai Water Users for Household Use (Washing/ Cleaning):** 57.1% of respondents reported that the streamflow volume is sufficient for household use (washing/cleaning) while 42.9% said that it is inadequate. About 71.4% said that there is turbidity problem.

Huai Phu Sai Water Use Problem: Regarding the use of Huai Phu Sai water, 71.4% mentioned turbidity problem. Only a minority of interviewees (28.6%) said that there is no problem.

Concerns about the Project Development: Respondents of Huai Phu Sai water users (57.1%) expressed no worry about the project development. The remainder (42.9%) expressed anxiety over the project development. The issues of concern are water pollution and water shortage.

Change in the Way of Life due to Project Development: Regarding this issue, most respondents (51.7%) think that in case of project development, there will be no change in the way of life because their houses are far from the project site. About 42.9% stated that their way of life will change because of anxiety over the power plant, job creation, and possible improvement of the environment.

Recommendations/Comments on the Project Development

– Pollution issues should be properly taken care of and managed.

– Water and air quality monitoring should be regularly carried out.

4.4.2 Health

(1) Introduction

The project development will probably cause health risks among staff and workers in the project area and local people residing near the project area during the construction and operation periods. In an effort to monitor the health impact, it was vital to conduct assessment of the impacts in terms of public health/occupational health and safety, and to determine the impact prevention and mitigation measures and monitoring measures.

In this project, the assessment of public health/occupational health and safety impacts was performed following the health impact assessment guidelines in the Environmental Impact Assessment in Thailand Report (the Environmental Impact Evaluation Bureau, the Office of Natural Resources and Environmental Policy and Planning, the Ministry of Natural Resources and Environment, June 2008), and the Notification of Ministry of Natural Resources and Environment Subject regarding Criteria, Procedure, Regulation and Guideline to Prepare Environmental Impact Assessment Report for a Project or an Activity That May Cause Severe Impact to Quality of Environment, Natural Resources and Health of a Community B.E. 2552, dated 29th December 2009. The public health analysis was conducted within the study area, comprising public health resources, health status of people in the study area, the project feature, and other environmental impacts. Fundamental health data were collected for impact assessment, e.g. the existing health conditions of people who would be affected and local health services.

(2) Methodology

(a) Collection of Secondary Data

- Collection of data on annual population from local public health units to study the likelihood of morbidity rate in the study area covering 4 sub-districts, 2 districts, 1 province: Map Yang Phon, Pluak Daeng, Mae Nam Khu sub-districts in Pluak Daeng district, Phana Nikhom sub-district in Nikhom Phatthana district, Rayong province.
- Collection of public health data from public health facilities in the study area, including.
  - Public health facilities in the study area in 2016
  - Number of public health and medical personnel in 2016
  - Vital statistics, consisting of mortality rate and birth rate in the study area during 2011-2015, as well as population pyramid in 2015
  - Top three disease groups, outpatient statistics (from outpatient report (Ror.Ngor. 504)), top 10 groups of inpatients (from inpatient report (Ror.Ngor. 505)), and data on diseases under epidemiological surveillance (Ror.Ngor. 506) during 2011-2015 in the study area

- Number of deaths and mortality rate per 100,000 population by leading cause group during 2011-2015, as well as accidents caused by land transportation
- Data on mental health of people in Rayong province during 2009-2013
- Criminal statistics in the study area during 2011-2015
- Traffic accident statistics in the study area during 2011-2015

(b) Collection of Primary Data

Interview of medical and public health personnel in the study area was conducted during 7th-11th April 2016. Questionnaires and interview were the sampling methods. The collected data on medical and public health personnel comprised number of medical and public health personnel, adequacy of services, likelihood of diseases, emergency medicine service system, the existing conditions, anxieties, suggestions, etc.

(3) Study Result

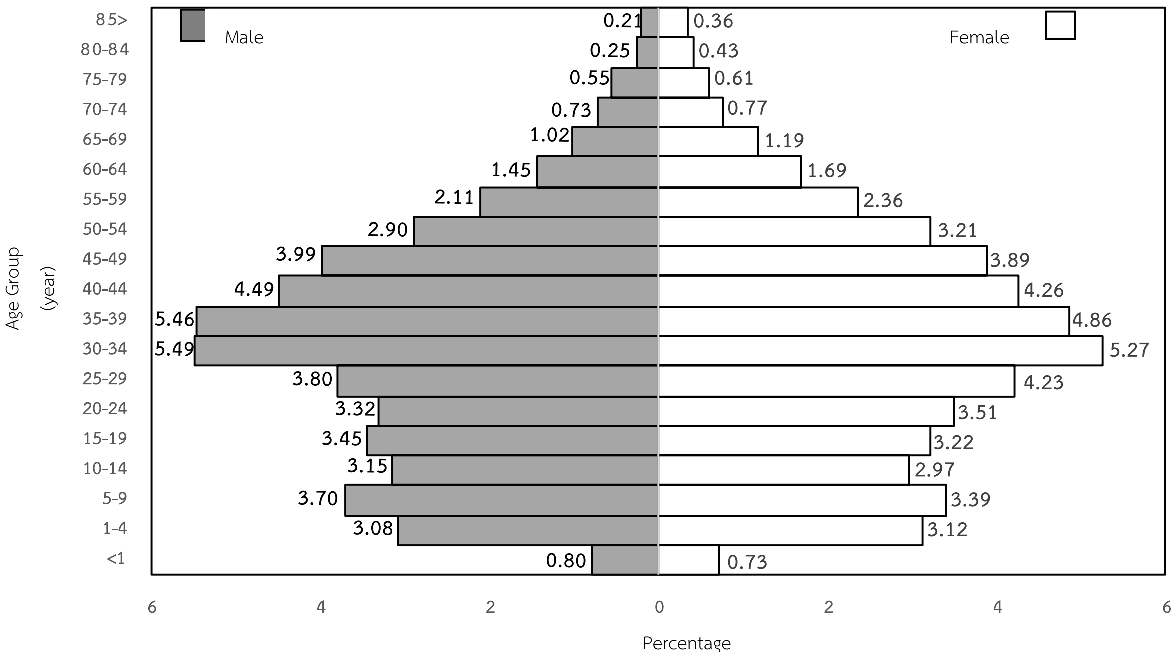
(a) Secondary Data

- **Population and Population Composition**

The project development will probably impact on people in the study area during the construction and operation periods, especially the groups that are sensitive to health threat (children aged 0-14 years, and elderly aged 60 years and over). According to the population data collection from the districts (Pluak Daeng and Nikhom Phattana districts, Rayong province) in the study area as presented in **Figure 4.4.2-1**, the population distribution by age group and gender in the study area in 2015 (population data as of December 2015: the Department of Provincial Administration, the Ministry of Interior, 2016), is presented in the form of the constrictive population pyramid which indicated the lower birth rate and mortality rate. The proportions of males and females are nearly similar (49.96% and 50.04%, respectively). Working group takes the largest proportion (69.82%), followed by the population groups which are sensitive to health threat (children aged 0-14 years, and elderly aged 60 years and over) of 30.18%.

- **Public Health Resources**

During the construction period when workers will migrate to the project site and the operation period when the project employees will travel for work, the project development will probably affect public health services, e.g. sub-district health promoting hospitals, general hospitals, etc. Consequently, related secondary data, e.g. readiness to provide services of public health facilities, personnel, and health status of local people were gathered from local public health units.



Source: Department of Provincial Administration, Ministry of Interior, 2016

FIGURE 4.4.2- 1: POPULATION PYRAMID OF THE DISTRICTS IN THE STUDY AREA

- **Public Health Facilities in the Study Area**

The study area covers partial areas of Pluak Daeng and Nikhom Phatthana districts in Rayong province. There are 2 public hospitals, each with 30 beds, as presented in **Table 4.4.2-1**, and 5 sub-district health promoting hospitals as demonstrated in **Table 4.4.2-2**.

- **Public Health Personnel**

According to the collected data on proportion of medical personnel in local public health facilities by specialty in 2016, Pluak Daeng Hospital lacks medical personnel: physician, dentist, and professional nurse as required by the World Health Organization (http://www.who.int, 2559), and the number of medical personnel is lower than the standards as stipulated in the National Economic and Social Development Plans No. 8 and 9. Nikhom Phattana Hospital is also short of medical personnel: physician and professional nurse as required by the World Health Organization (http://www.who.int, 2559), except for the number of dentists which meets the dentist to population ratio of 1:7,500 as stipulated by WHO.) However, the number of physicians, dentists and professional nurse meet the standards stipulated in the National Economic and Social Development Plans No. 8 and 9 as presented in **Table 4.4.2-1**.

TABLE 4.4.2-1

HOSPITALS AND MEDICAL PERSONNEL IN THE STUDY AREA CATEGORIZED BY DISTRICT IN 2016

Province	District	Population	Hospital	Public/ Private	Number of Beds	Physician		Dentist		Pharmacist		Professional Nurse	
						Number	Ratio	Number	Ratio	Number	Ratio	Number	Ratio
Rayong	Pluak Daeng	56,519	Pluak Daeng	Public	30	6	1 : 9,420	4	1 : 14,130	5	1 : 11,304	55	1 : 1,028
	Nikhom Phatthana	16,608	Nikhom Phatthana	Public	30	3	1 : 5,536	3	1 : 5,536	2	1 : 8,304	32	1 : 519
National Economic and Social Development Plan				No.	-	9		8		8		8	
				Ratio	-	1 : 6,000		1 : 6,000		1 : 5,200		1 : 900	
WHO's Standards						1 : 5,000		1 : 7,500		-		1 : 500	

Source: World Health Organization, 2016 (www.who.int) Nikhom Phatthana Hospital, 2016 Pluak Daeng Hospital, 2016

TABLE 4.4.2-2

RESPONSIBLE AREAS, DISTANCE AND TIME FOR REFERRAL OF PATIENTS FROM THE PROJECT AREA TO LOCAL PUBLIC HEALTH FACILITIES

No.	Sub-district Health Promoting Hospital	Responsible Areas	Sub-district	District	Distance and Time for Referral of Patient (from the Project Area to Sub-district Health Promoting Hospital) [1/]	Referral to Hospital	Distance and Time for Referral of Patient (from Sub-district Health Promoting Hospital to General Hospital) [1/]
1.	Phana Nikhom Sub-district Health Promoting Hospital	Villages Nos. 1-8	Phana Nikhom	Nikhom Phatthana	9.0 km (9 minutes)	Nikhom Phatthana Hospital	4.6 km (6 minutes)
2.	Dok Krai Sub-district Health Promoting Hospital	Villages Nos. 4, 6, 7	Mae Nam Khu	Pluak Daeng	16.3 km (21 minutes)	Pluak Daeng Hospital	20.7 km (25 minutes)
3.	Mae Nam Khu Sub-district Health Promoting Hospital	Villages Nos. 1, 2, 3, 5	Mae Nam Khu	Pluak Daeng	16.7 km (17 minutes)		13.0 km (16 minutes)
4.	Map Yang Phon Sub-district Health Promoting Hospital	Villages Nos. 1, 2, 6, 7	Map Yang Phon	Pluak Daeng	8.3 km (10 minutes)		11.8 km (17 minutes)
5.	Ban Huai Prap Sub-district Health Promoting Hospital	Villages Nos. 3, 4, 5	Map Yang Phon	Pluak Daeng	12.4 km (17 minutes)		15.9 km (25 minutes)

Remark: [1/]Calculation of distance based on Google Map (https:///www.google.co.th/maps/@13.8387038, 100.6365593z?hl=en) on 19 April 2016

Source: Sub-district health promoting hospitals in the study area, 2016

TABLE 4.4.2-3

VITAL STATISTICS OF POPULATION IN THE STUDY AREA DURING 2010–2014

Year	Population (person)	Number of Births (person)	Birth Rate/ per 1,000 Population	Number of Deaths (person)	Mortality Rate per 1,000 Population	Natural Growth Rate per 1,000 Population
2010	82,152	422	5.14	437	5.32	-0.18
2011	85,644	495	5.78	466	5.44	0.34
2012	89,064	595	6.68	505	5.67	1.01
2013	92,588	585	6.32	273	2.95	3.37
2014	97,202	565	5.81	439	4.52	1.30

Source: Database, the Bureau of Registration Administration, Department of Provincial Administration, Ministry of Interior, 2010-2014 (www.dopa.go.th)

- **Vital Statistics**

Vital statistics indicate the general conditions of public health status in a community, e.g. birth rate, mortality rate, and natural growth rate. According to the vital statistics in the study area, including Pluak Daeng and Nikhom Phatthana districts in Rayong province as presented in **Table 4.4.2-3**, the natural growth rate was in a range between -0.18 and 3.37 per 1,000 population during 2010-2014.

- **Health Status**

Health status data are significant for health impact assessment. This is because the data show the morbidity status of local people in the study area before the project development. As a result, they are the fundamental data for comparison and health impact assessment in case of project development during the construction and operation periods. Details about the existing health status of people in the study area are narrated below.

1. Causes and Rates of Morbidity of Outpatients (Ror.Ngor.504)

1.1 Hospital

Causes and rates of morbidity of outpatients (Ror.Ngor.504) in Nikhom Phatthana Hospital and Pluak Daeng Hospital during 2011-2015 **(Table 4.4.2-4)** can be summarized below.

Nikhom Phatthana Hospital in Nikhom Phatthana District

There are four major causes of morbidity among outpatients: (1) endocrine, nutritional and metabolic diseases, (2) diseases of the respiratory system, (3) diseases of the circulatory system, and (4) diseases of the digestive system. The top three causes of morbidity are endocrine, nutritional and metabolic diseases; diseases of the respiratory system; and diseases of the digestive system and oral cavity, respectively.

TABLE 4.4.2-4

CAUSES AND RATES OF MORBIDITY OF OUTPATIENTS PER 100,000 POPULATION (ROR.NGOR.504) IN HOSPITALS IN THE STUDY AREA

Hospital	Rank	Causes and Rates of Morbidity of Outpatients per 100,000 Population (Ror.Ngor.504)					
		2011	2012	2013	2014	2015	5-Year Period
Nikhom Phatthana Hospital	1	Diseases of the respiratory system (5,136)	Diseases of the respiratory system (65,425)	Diseases of the digestive system (64,182)	Endocrine, nutrition and metabolic diseases (70,644)	Endocrine, nutrition and metabolic diseases (66,992)	Endocrine, nutrition and metabolic diseases (53,072)
	2	Diseases of the digestive system (3,898)	Endocrine, nutrition and metabolic diseases (60,598)	Endocrine, nutrition and metabolic diseases (63,733)	Diseases of the circulatory system (64,858)	Diseases of the circulatory system (59,941)	Diseases of the respiratory system (49,724)
	3	Diseases of the circulatory system (3,513)	Diseases of the digestive system (55,398)	Diseases of the respiratory system (58,151)	Diseases of the respiratory system (63,039)	Diseases of the respiratory system (56,870)	Diseases of the digestive system (47,592)
Pluak Daeng Hospital	1	Diseases of the respiratory system (39,958)	Diseases of the respiratory system (35,368)	Other external causes of morbidity and mortality (34,020)	Other external causes of morbidity and mortality (33,678)	Other external causes of morbidity and mortality (30,696)	Other external causes of morbidity and mortality (33,726)
	2	Other external causes of morbidity and mortality (35,687)	Other external causes of morbidity and mortality (34,549)	Diseases of the respiratory system (29,699)	Diseases of the respiratory system (26,633)	Diseases of the respiratory system (28,159)	Diseases of the respiratory system (31,963)
	3	Endocrine, nutrition and metabolic diseases (26,985)	Endocrine, nutrition and metabolic diseases (26,951)	Diseases of the digestive system (25,231)	Endocrine, nutrition and metabolic diseases (23,852)	Endocrine, nutrition and metabolic diseases (24,850)	Endocrine, nutrition and metabolic diseases (25,393)

Source: Nikhom Phatthana Hospital, 2016 Pluak Daeng Hospital, 2016

Pluak Daeng Hospital in Pluak Daeng District

There are four major causes of morbidity among outpatients: (1) other external causes of morbidity and mortality, (2) diseases of the respiratory system, (3) endocrine, nutritional and metabolic diseases, and (4) diseases of the digestive system and oral cavity. The top three causes of morbidity are other external causes of morbidity and mortality; diseases of the respiratory system; and endocrine, nutritional and metabolic diseases, respectively.

1.2 Sub-district Health Promoting Hospital

Causes and rates of morbidity of outpatients (Ror.Ngor.504) in Phana Nikhom, Dok Krai, Mae Nam Khu, Map Yang Phon, and Huai Prap sub-district health promoting hospitals during 2011-2015 **(Table 4.4.2-5)** can be summarized below.

Nikhom Phatthana District

- **Phana Nikhom Sub-District Health Promoting Hospital in Phana Nikhom Sub-district**

There are four major causes of morbidity among outpatients: (1) diseases of the respiratory system, (2) other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified, (3) diseases of the circulatory system, and (4) diseases of the digestive system and oral cavity. The top three causes of morbidity are diseases of the respiratory system; other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified; and diseases of the digestive system and oral cavity, respectively.

Pluak Daeng District

- **Dok Krai Sub-District Health Promoting Hospital in Mae Nam Khu Sub-district**

There are 6 major causes of morbidity among outpatients: (1) other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified, (2) diseases of the respiratory system, (3) diseases of the musculoskeletal system and connective tissue, (4) diseases of the digestive system and oral cavity, (5) endocrine, nutritional and metabolic diseases, (6) diseases of the circulatory system. The top three causes of morbidity are other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified; diseases of the respiratory system; and diseases of the musculoskeletal system and connective tissue, respectively.

TABLE 4.4.2-5
CAUSES AND RATES OF MORBIDITY OF OUTPATIENTS PER 100,000 POPULATION (ROR.NGOR.504) IN SUB-DISTRICT HEALTH PROMOTING HOSPITALS IN THE STUDY AREA

Sub-district Health Promoting Hospital	Rank	Causes and Rates of Morbidity of Outpatients per 100,000 Population (Ror.Ngor.504)					
		2011	2012	2013	2014	2015	5-Year Period
Phana Nikhom Sub-district Health Promoting Hospital	1	Diseases of the respiratory system (14,441)	Diseases of the respiratory system (13,460)	-	Diseases of the respiratory system (12,077)	Diseases of the respiratory system (11,230)	Diseases of the respiratory system (12,802)
	2	Diseases of the digestive system (4,241)	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (3,904)	-	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (9,758)	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (7,753)	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (6,351)
	3	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (3,987)	Diseases of the digestive system (3,525)	-	Diseases of the circulatory system (6,233)	Diseases of the digestive system (4,384)	Diseases of the digestive system (4,027)
Dok Krai Sub-district Health Promoting Hospital	1	-	Diseases of the digestive system (16,467)	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (19,889)	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (32,037)	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (23,509)	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (21,291)
	2	-	Endocrine system (14,354)	Diseases of the respiratory system (18,149)	Diseases of the respiratory system (14,930)	Diseases of the respiratory system (14,526)	Diseases of the respiratory system (12,151)
	3	-	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (9,729)	Diseases of the musculoskeletal system and connective tissue (7,473)	Diseases of the musculoskeletal system and connective tissue (7,737)	Diseases of the circulatory system (10,283)	Diseases of the musculoskeletal system and connective tissue (6,726)

TABLE 4.4.2-5
CAUSES AND RATES OF MORBIDITY OF OUTPATIENTS PER 100,000 POPULATION (ROR.NGOR.504) IN SUB-DISTRICT HEALTH PROMOTING HOSPITALS IN THE STUDY AREA (CONT'D)

Sub-district Health Promoting Hospital	Rank	Causes and Rates of Morbidity of Outpatients per 100,000 Population (Ror.Ngor.504)					
		2011	2012	2013	2014	2015	5-Year Period
Mae Nam Khu Sub-district Health Promoting Hospital	1	Diseases of the respiratory system (21,311)	Diseases of the respiratory system (29,178)	Diseases of the respiratory system (32,987)	Diseases of the respiratory system (30,468)	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (27,149)	Diseases of the respiratorysystem (28,103)
	2	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (15,918)	Diseases of the digestive system (21,255)	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (24,846)	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (17,498)	Diseases of the respiratory system (26,573)	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (21,108)
	3	Diseases of the digestive system (7,699)	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (20,127)	Diseases of the musculoskeletal system and connective tissue (9,825)	Diseases of the musculoskeletal system and connective tissue (10,100)	Diseases of the circulatory system (10,177)	Diseases of the digestive system (10,505)
Map Yang Phon Sub-district Health Promoting Hospital	1	Diseases of the respiratory system (50,166)	Diseases of the respiratory system (62,311)	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (78,095)	Diseases of the respiratory system (93,836)	Diseases of the respiratory system (96,532)	Diseases of the respiratory system (75,609)
	2	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (25,542)	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (45,353)	Diseases of the respiratory system (75,199)	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (57,232)	Diseases of the digestive system (63,436)	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (53,270)
	3	Diseases of the digestive system (21,126)	Diseases of the digestive system (25,192)	Diseases of the musculoskeletal system and connective tissue (26,395)	Diseases of the musculoskeletal system and connective tissue (30,781)	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (60,128)	Diseases of the digestive system (31,508)

TABLE 4.4.2-5

CAUSES AND RATES OF MORBIDITY OF OUTPATIENTS PER 100,000 POPULATION (ROR.NGOR.504) IN SUB-DISTRICT HEALTH PROMOTING HOSPITALS IN THE STUDY AREA (CONT'D)

Sub-district Health Promoting Hospital	Rank	Causes and Rates of Morbidity of Outpatients per 100,000 Population (Ror.Ngor.504)					
		2011	2012	2013	2014	2015	5-Year Period
Ban Huai Prap Sub-district Health Promoting Hospital	1	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (15,700)	Diseases of the respiratory system (45,574)	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (33,457)	Diseases of the respiratory system (12,535)	Diseases of the respiratory system (7,049)	Diseases of the respiratory system (19,884)
	2	Diseases of the respiratory system (12,400)	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (30,396)	Diseases of the respiratory system (21,861)	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (11,356)	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (5,250)	other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (19,232)
	3	Diseases of the digestive system (3,997)	Diseases of the musculoskeletal system and connective tissue (20,723)	Diseases of the digestive system (12,050)	Diseases of the digestive system (5,966)	Diseases of the digestive system (5,032)	Diseases of the digestive system (8,727)

Remark: - means no data.

Source: Phana Nikhom Sub-district Health Promoting Hospital, Dok Krai Sub-district Health Promoting Hospital, Mae Nam Khu Sub-district Health Promoting Hospital, Map Yang Phon Sub-district Health Promoting Hospital, and Ban Huai Prap Sub-district Health Promoting Hospital, 2016

➢ **Mae Nam Khu Sub-District Health Promoting Hospital in Mae Nam Khu Sub-district**

There are 5 major causes of morbidity among outpatients: (1) diseases of the respiratory system, (2) other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified, (3) diseases of the digestive system and oral cavity, (4) diseases of the circulatory system, and (5) diseases of the musculoskeletal system and connective tissue. The top three causes of morbidity are diseases of the respiratory system; other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified; and diseases of the digestive system and oral cavity, respectively.

➢ **Map Yang Phon Sub-District Health Promoting Hospital in Map Yang Phon Sub-district**

There are 4 major causes of morbidity among outpatients: (1) diseases of the respiratory system, (2) other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified, (3) diseases of the digestive system and oral cavity, and (4) diseases of the musculoskeletal system and connective tissue. The top three causes of morbidity are diseases of the respiratory system; other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified; and diseases of the digestive system and oral cavity, respectively.

➢ **Ban Huai Prap Sub-District Health Promoting Hospital in Map Yang Phon Sub-district**

There are 4 major causes of morbidity among outpatients: (1) diseases of the respiratory system, (2) other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified, (3) diseases of the digestive system and oral cavity, and (4) diseases of the musculoskeletal system and connective tissue. The top three causes of morbidity are diseases of the respiratory system; other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified; and diseases of the digestive system and oral cavity, respectively.

2. Causes and Rates of Morbidity of Inpatients (Ror.Ngor.505)

➢ **Hospital**

Causes and rates of morbidity of inpatients (Ror.Ngor.505) in Nikhom Phatthana Hospital and Pluak Daeng Hospital during 2011-2015 **(Table 4.4.2-6)** can be summarized below.

➢ **Nikhom Phatthana Hospital in Nikhom Phatthana District**

There are six major causes of morbidity among inpatients: (1) endocrine, nutritional and metabolic diseases, (2) other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified, (3) other intestinal infectious diseases, (4) hypertensive diseases, (5) organic, including symptomatic, mental disorders, and (6) injury in transport accidents. The top three causes of morbidity are endocrine, nutritional and metabolic diseases; other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified; and other intestinal infectious diseases, respectively.

TABLE 4.4.2-6

CAUSES AND RATES OF MORBIDITY OF INPATIENTS PER 100,000 POPULATION (ROR.NGOR.505) IN HOSPITALS IN THE STUDY AREA DURING 2011-2015

Hospital	Rank	Causes and Rate of Morbidity of Inpatients per 100,000 Population (Ror.Ngor.505)					
		2011	2012	2013	2014	2015	5-Year Period
Nikhom Phatthana Hospital	1	Injury in transport accidents (1,385)	Endocrine, nutritional and metabolic diseases (1,529)	Endocrine, nutritional and metabolic diseases (1,913)	Endocrine, nutritional and metabolic diseases (2,678)	Endocrine, nutritional and metabolic diseases (3,119)	Endocrine, nutritional and metabolic diseases (1,967)
	2	Organic, including symptomatic, mental disorders (1,141)	Injury in transport accidents (1,095)	Other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (1,646)	Other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (2,154)	Other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (1,939)	Other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (1,913)
	3	Endocrine, nutritional and metabolic diseases (595)	'Other intestinal infectious diseases (895)	Hypertensive diseases (1,151)	Other intestinal infectious diseases (1,333)	Other intestinal infectious diseases (1,174)	Other intestinal infectious diseases (1,005)
Pluak Daeng Hospital	1	Endocrine, nutritional and metabolic diseases (1,912)	Single spontaneous delivery (1,536)	Single spontaneous delivery (1,513)	Single spontaneous delivery (1,379)	Single spontaneous delivery (2,332)	Single spontaneous delivery (1,616)
	2	Single spontaneous delivery (1,322)	Endocrine, nutritional and metabolic diseases (1,395)	Endocrine, nutritional and metabolic diseases (1,300)	Endocrine, nutritional and metabolic diseases (1,048)	Endocrine, nutritional and metabolic diseases (2,072)	Endocrine, nutritional and metabolic diseases (1,545)
	3	Other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (1,198)	Other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (934)	Other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (702)	Other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (691)	Other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (1,247)	Other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (954)

Source: Nikhom Phatthana Hospital, 2016 Pluak Daeng Hospital, 2016

- **Pluak Daeng Hospital in Pluak Daeng District**

There are three major causes of morbidity among inpatients: (1) single spontaneous delivery, (2) endocrine, nutritional and metabolic diseases, and (3) other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified.

3. Causes and Rates of Morbidity for Diseases under Epidemiological Surveillance (Ror.Ngor.506)

3.1 Hospital

Causes and rates of morbidity for diseases under epidemiological surveillance (Ror.Ngor.506) in Nikhom Phatthana Hospital and Pluak Daeng Hospital during 2011-2015 **(Table 4.4.2-7)** can be summarized below.

- **Nikhom Phatthana Hospital in Nikhom Phatthana District**

There are 5 major causes of morbidity for diseases under epidemiological surveillance: (1) fever or fever of unknown origin, (2) acute diarrhea, (3) haemorrhagic conjunctivitis, (4) food poisoning, and (5) dengue fever. The top three causes of morbidity are fever or fever of unknown origin; acute diarrhea; and haemorrhagic conjunctivitis, respectively.

- **Pluak Daeng Hospital in Pluak Daeng District**

There are 4 major causes of morbidity for diseases under epidemiological surveillance: (1) acute diarrhea, (2) fever or fever of unknown origin, (3) haemorrhagic conjunctivitis, and (4) pneumonia. The top three causes of morbidity are fever or fever of unknown origin; acute diarrhea; and haemorrhagic conjunctivitis, respectively.

3.2 Sub-district Health Promoting Hospital

Causes and rates of morbidity for diseases under epidemiological surveillance (Ror.Ngor.506) in Phana Nikhom, Dok Krai, Mae Nam Khu, Map Yang Phon, and Ban Huai Prap sub-district health promoting hospitals during 2011-2015 **(Table 4.4.2-8)** can be summarized below.

Nikhom Phatthana District

- **Phana Nikhom Sub-District Health Promoting Hospital in Phana Nikhom Sub-district**

There are 7 major causes of morbidity for diseases under epidemiological surveillance: (1) acute diarrhea, (2) fever or fever of unknown origin, (3) haemorrhagic conjunctivitis, (4) dengue hemorrhagic fever, (5) dengue fever, (6) food poisoning, and (7) varicella. The top three causes of morbidity are acute diarrhea; fever or fever of unknown origin; and haemorrhagic conjunctivitis, respectively.

TABLE 4.4.2-7

CAUSES AND RATES OF MORBIDITY FOR DISEASES UNDER EPIDEMIOLOGICAL SURVEILLANCE (ROR.NGOR.506) PER 100,000 POPULATION IN HOSPITALS IN THE STUDY AREA DURING 2011-2015

Hospital	Rank	Causes and Rate of Morbidity for Diseases under Epidemiological Surveillance (Ror.Ngor.506) per 100,000 Population					
		2011	2012	2013	2014	2015	5-Year Period
Nikhom Phatthana Hospital	1	Acute diarrhea (1,812)	Fever or fever of unknown origin (1,769)	Acute diarrhea (2,524)	Fever or fever of unknown origin (1,870)	Food poisoning (1,728)	Fever or fever of unknown origin (1,612)
	2	Fever or fever of unknown origin (1,399)	Acute diarrhea (1,729)	Fever or fever of unknown origin (2,017)	Food poisoning (1,042)	Dengue haemorrhagic fever (1,234)	Acute diarrhea (1,273)
	3	Haemorrhagic conjunctivitis (1,253)	Dengue haemorrhagic fever (674)	Dengue haemorrhagic fever (670)	Haemorrhagic conjunctivitis (505)	Fever or fever of unknown origin (1,006)	Haemorrhagic conjunctivitis (686)
Pluak Daeng Hospital	1	-	-	Acute diarrhea (3,165)	Acute diarrhea (3,182)	Acute diarrhea (2,242)	Acute diarrhea (2,863)
	2	-	-	Fever or fever of unknown origin (1,358)	โรคHaemorrhagic conjunctivitis (1,285)	Fever or fever of unknown origin (869)	Fever or fever of unknown origin (1,049)
	3	-	-	Pneumonia (421)	Fever or fever of unknown origin (920)	Pneumonia (582)	Haemorrhagic conjunctivitis (600)

Source: Nikhom Phatthana Hospital, 2016 Pluak Daeng Hospital, 2016

TABLE 4.4.2-8

CAUSES AND RATES OF MORBIDITY FOR DISEASES UNDER EPIDEMIOLOGICAL SURVEILLANCE (ROR.NGOR.506) PER 100,000 POPULATION IN SUB-DISTRICT HEALTH PROMOTING HOSPITALS IN THE STUDY AREA DURING 2011-2015

Sub-district Health Promoting Hospital	Rank	Causes and Rate of Morbidity for Diseases under Epidemiological Surveillance (Ror.Ngor.506) per 100,000 Population					
		2011	2012	2013	2014	2015	5-Year Period
Phana Nikhom	1	Acute diarrhea (1,150)	Acute diarrhea (1,194)	Acute diarrhea (621)	Acute diarrhea (680)	Acute diarrhea (406)	Acute diarrhea (810)
	2	Fever or fever of unknown origin (284)	Fever or fever of unknown origin (335)	Food poisoning (56)	Haemorrhagic conjunctivitis (153)	Dengue hemorrhagic fever (95)	Fever or fever of unknown origin (124)
	3	Haemorrhagic conjunctivitis (164)	Haemorrhagic conjunctivitis (131)	Haemorrhagic conjunctivitis (28) Dengue hemorrhagic fever (28)	Food poisoning (14) Varicella (14)	Dengue fever (68)	Haemorrhagic conjunctivitis (95)
Mae Nam Khu	1	Acute diarrhea (1,578)	Acute diarrhea (964)	Acute diarrhea (2,535)	Acute diarrhea (2,041)	Acute diarrhea (1,418)	Acute diarrhea (1,707)
	2	-	Haemorrhagic conjunctivitis (147)	Haemorrhagic conjunctivitis (94)	Haemorrhagic conjunctivitis (614)	Varicella (103)	Haemorrhagic conjunctivitis (171)
	3	-	Varicella (16)	Food poisoning (31) Dysentery (31)	Varicella (61)	-	Varicella (36)
Map Yang Phon	1	Acute diarrhea (1,388)	Acute diarrhea (2,319)	Acute diarrhea (10,282)	Acute diarrhea (12,951)	Acute diarrhea (9,408)	Acute diarrhea (7,269)
	2	Varicella (78) Conjunctivitis (78)	Fever or fever of unknown origin (216)	Food poisoning (2,430)	Haemorrhagic conjunctivitis (1,645)	Food poisoning (1,689)	Food poisoning (964)
	3	Mycoses (59) Other intestinal infectious diseases (59)	Conjunctivitis (216)	Conjunctivitis (428)	Conjunctivitis (1,153)	Conjunctivitis (391)	Conjunctivitis (493)

TABLE 4.4.2-8

CAUSES AND RATES OF MORBIDITY FOR DISEASES UNDER EPIDEMIOLOGICAL SURVEILLANCE (ROR.NGOR.506) PER 100,000 POPULATION IN SUB-DISTRICT HEALTH PROMOTING HOSPITALS IN THE STUDY AREA DURING 2011-2015 (Cont'd)

Sub-district Health Promoting Hospital	Rank	Causes and Rate of Morbidity for Diseases under Epidemiological Surveillance (Ror.Ngor.506) per 100,000 Population					
		2011	2012	2013	2014	2015	5-Year Period
Ban Huai Prap	1	-	Acute diarrhea (1,434)	Acute diarrhea (707)	Acute diarrhea (2,611)	Acute diarrhea (1,556)	Acute diarrhea (1,577)
	2	-	-	Conjunctivitis (17)	Conjunctivitis (351)	Conjunctivitis (122)	Conjunctivitis (163)
	3	-	-	-	-	Food poisoning (109)	Food poisoning (109)

Remark: - means no patient in this rank and no data from Dok Krai Sub-district Health Promoting Hospital

Source: Phana Nikhom Sub-district Health Promoting Hospital, Mae Nam Khu Sub-district Health Promoting Hospital, Map Yang Phon Sub-district Health Promoting Hospital, and Ban Huai Prap Sub-district Health Promoting Hospital, 2016

Pluak Daeng District

- **Mae Nam Khu Sub-District Health Promoting Hospital in Mae Nam Khu Sub-district**

There are 5 major causes of morbidity for diseases under epidemiological surveillance: (1) acute diarrhea, (2) haemorrhagic conjunctivitis, (3) varicella, (4) food poisoning, and (5) dysentery. The top three causes of morbidity are acute diarrhea; haemorrhagic conjunctivitis; and varicella, respectively.

- **Map Yang Phon Sub-District Health Promoting Hospital in Map Yang Phon Sub-district**

There are 8 major causes of morbidity for diseases under epidemiological surveillance: (1) acute diarrhea, (2) food poisoning, (3) conjunctivitis, (4) fever or fever of unknown origin, (5) varicella, (6) mycoses, (7) other intestinal infectious diseases, and (8) haemorrhagic conjunctivitis. The top three causes of morbidity are acute diarrhea; food poisoning; and conjunctivitis, respectively.

- **Ban Huai Prap Sub-District Health Promoting Hospital in Map Yang Phon Sub-district**

There are 3 major causes of morbidity for diseases under epidemiological surveillance which are also the top three causes of morbidity: (1) acute diarrhea, (2) conjunctivitis, and (3) food poisoning.

4. Causes and Rates of Mortality

4.1 Hospital

Causes and rates of mortality in Nikhom Phatthana Hospital and Pluak Daeng Hospital during 2011-2015 **(Table 4.4.2-9)** can be summarized below.

- **Nikhom Phatthana Hospital in Nikhom Phatthana District**

There are 4 major causes of mortality: (1) accidents and poisoning, (2) hypertensive and cerebrovascular diseases, (3) heart diseases, and (4) injury from suicide, murder, and others. The top three causes of mortality are accidents and poisoning; hypertensive and cerebrovascular diseases; and heart diseases, respectively.

- **Pluak Daeng Hospital in Pluak Daeng District**

There are 5 major causes of mortality: (1) malignant neoplasms, (2) septicaemia, (3) transport accidents, (4) pneumonia, and (5) cerebrovascular diseases. The top three causes of mortality are malignant neoplasms; septicaemia; and transport accidents, respectively.

TABLE 4.4.2-9

CAUSES AND RATES OF MORTALITY PER 100,000 POPULATION IN HOSPITALS IN THE STUDY AREA DURING 2011-2015

Hospital	Rank	Causes and Rates of Mortality per 100,000 Population					
		2011	2012	2013	2014	2015	5-Year Period
Nikhom Phatthana	1	Accidents and poisoning (24,477)	Accidents and poisoning (30,790)	Accidents and poisoning (29,105)	Accidents and poisoning (38,654)	Accidents and poisoning (35,350)	Accidents and poisoning (31,675)
	2	Suicide/murder (2,981)	Hypertensive/ cerebrovascular diseases (11,356)	Hypertensive/ cerebrovascular diseases (12,555)	Heart diseases (13,291)	Heart diseases (13,307)	Hypertensive/ cerebrovascular diseases (10,308)
	3	Hypertensive/cerebrovascular diseases (1,288)	Suicide/murder (2,123)	Suicide/murder (2,043)	Hypertensive/ cerebrovascular diseases (13,178)	Hypertensive/ cerebrovascular diseases (13,162)	Heart diseases (5,839)
Pluak Daeng	1	-	Malignant neoplasms (1,182)	Malignant neoplasms (1,071)	Malignant neoplasms (1,103)	-	Malignant neoplasms (1,119)
	2	-	Septicaemia (847)	Septicaemia (618)	Septicaemia (702)	-	Septicaemia (723)
	3	-	Transport accidents (465)	Hypertensive/ cerebrovascular diseases (411)	Pneumonia (465)	-	Transport accidents (418)

Remark: -Means no data.

Source: Nikhom Phatthana Hospital, 2016 Pluak Daeng Hospital, 2016

4.2 Sub-district Health Promoting Hospital

Causes and rates of mortality in Phana Nikhom Sub-district Health Promoting Hospital and Mae Nam Khu Sub-district Health Promoting Hospital during 2011-2015 **(Table 4.4.2-10)** can be summarized below.

➢ **Phana Nikhom Sub-district Health Promoting Hospital in Phana Nikhom Sub-district**

There are 5 major causes of mortality: (1) heart diseases, (2) hypertensive and cerebrovascular diseases, (3) senility, (4) diseases of liver and pancreas, and (5) malignant neoplasms. The top three causes of mortality are heart diseases; hypertensive and cerebrovascular diseases; and senility, respectively.

➢ **Mae Nam Khu Sub-district Health Promoting Hospital in Mae Nam Khu Sub-district**

There are 6 major causes of mortality: (1) diseases of the circulatory system, (2) other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified, (3) diseases of the digestive system and oral cavity, (4) diseases of the respiratory system, (5) certain infectious and parasitic diseases, and (6) external causes of morbidity and mortality. The top three causes of mortality are diseases of the circulatory system; other symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified; and diseases of the digestive system and oral cavity, respectively.

5. Morbidity Causes and Morbidity Rates of Psychopathologic Disorders

The statistics on mental health status collected by the Department of Mental Health, Ministry of Public Health, were considered to assess the mental health status of local people since the project may cause anxiety and stress on their mental health during the construction period. Moreover, since the project operation period is long, chronic mental health problems may be generated. Thus, it was essential to conduct the mental health impact assessment. The morbidity rates of psychopathologic disorders per 100,000 population in Rayong province during 2009-2013 are presented in **Table 4.4.2-11**.

➢ **Morbidity Rates of Psychopathologic Disorders**

According to the study of the psychopathologic disorders classified into 9 categories i.e. psychotic disorder, anxiety disorder, depressive disorder, mental retardation, epilepsy, substance-induced disorder, other mental illnesses, attempted suicide, and autistics, during 2009-2013, the morbidity rate per 100,000 population ranged between 1,147.6 and 3,775.75. The morbidity rate per 100,000 population in 2013 was the highest at 3,775.75. Major psychopathologic disorders in the area are other mental illnesses; psychotic disorders; and anxiety disorder, respectively.

TABLE 4.4.2-10

CAUSES AND RATES OF MORTALITY PER 100,000 POPULATION IN SUB-DISTRICT HEALTH PROMOTING HOSPITALS IN THE STUDY AREA DURING 2011-2015

Sub-district Health promoting Hospital	Rank	Causes and Rates of Mortality per 100,000 Population					
		2011	2012	2013	2014	2015	5-Year Period
Phana Nikhom	1	Heart diseases (448)	Heart diseases (350)	Heart diseases (169)	Hypertensive/cerebrovascular diseases (97)	Hypertensive/cerebrovascular diseases (81)	Heart diseases (213)
	2	Malignant neoplasms (15) diseases of liver and pancreas (15)	Malignant neoplasms (44)	Hypertensive/cerebrovascular diseases (28)	Heart diseases (28) Malignant neoplasms (28) Senility (28)	Heart diseases (68)	Hypertensive/cerebrovascular diseases (59)
	3	Senility (30)	Hypertensive/cerebrovascular diseases (29)	Malignant neoplasms (16)	diseases of liver and pancreas (14)	diseases of liver and pancreas (27) Senility (27)	Senility (45)
Mae Nam Khu	1	Diseases of the circulatory system (1,890)	Other symptoms, signs and abnormal clinical and laboratory findings (343)	Diseases of the circulatory system (520)	Diseases of the circulatory system (123)	Diseases of the circulatory system (118)	Diseases of the circulatory system (579)
	2	Other symptoms, signs and abnormal clinical and laboratory findings (243)	Diseases of the circulatory system (245)	Other symptoms, signs and abnormal clinical and laboratory findings (142)	Other symptoms, signs and abnormal clinical and laboratory findings (92)	Other symptoms, signs and abnormal clinical and laboratory findings (74)	Other symptoms, signs and abnormal clinical and laboratory findings (179)
	3	External causes of morbidity and mortality (52)	Certain infectious and parasitic diseases (98)	Certain infectious and parasitic diseases (31)	diseases of the digestive system (61)	diseases of the digestive system (59) Diseases of the respiratory system (59)	diseases of the digestive system (46)

Remark: No data on causes of mortality from Dok Krai Sub-district Health Promoting Hospital, Map Yang Phon Sub-district Health Promoting Hospital, and Ban Huai Prap Sub-district Health Promoting Hospital

Source: Phana Nikhom Sub-district Health Promoting Hospital, Mae Nam Khu Sub-district Health Promoting Hospital, 2016

TABLE 4.4.2-11

MORBIDITY RATES OF PSYCHOPATHOLOGIC DISORDERS IN RAYONG PROVINCE DURING 2009-2013

Year	Morbidity Rate per 100,000 Population										
	Psychotic disorder	Anxiety disorder	Depressive disorder	Mental retardation	Epilepsy	Substance-induced disorder	Other mental health problems	Attempted suicide		Autistics	Total
								Completed Suicide	Attempted suicide		
2009	199.25	461.38	332.30	12.71	8.91	3.63	8.75	16.01	102.84	1.82	**1,147.60**
2010	206.22	291.16	430.04	11.47	148.73	21.64	99.31	9.85	71.38	2.26	**1,292.05**
2011	423.85	480.80	240.01	36.70	300.76	66.61	323.70	13.45	77.36	0.79	**1,964.03**
2012	433.41	464.33	268.68	31.70	310.80	46.93	643.51	12.28	69.93	52.52	**2,334.09**
2013	958.68	569.70	562.90	63.52	274.04	62.16	1,166.18	8.17	44.92	65.49	**3,775.75**
5-Year Period	**444.28**	**453.47**	**366.79**	**31.22**	**208.65**	**40.19**	**448.29**	**11.95**	**73.29**	**24.58**	**2,102.70**

Source: Mental Health Centers 1-19, and Information Technology Center, Planning Division, Department of Mental Health, Ministry of Public Health

➢ **Completed Suicide Rate**

According to the study of attempted suicide data, the completed suicide rate per 100,000 population has tended to be higher in a range between 8.17 and 16.01. However, the attempted suicide rate has tended to decrease.

- **Accident and Safety**

- **Criminal Statistics**

Social safety is another important data for health impact assessment of the project, specifically during the construction period when foreign workers will be brought into the project area. This may affect the safety in the project area. Thus, relevant data were collected to reflect the safety conditions of communities in the study area. Criminal statistics by type during 2011-2015 were gathered from responsible police stations, i.e. Nikhom Phatthana and Pluak Daeng police stations. Major crimes in the study area are offences against the state (e.g. illegal possession of weapon, gambling, drug), followed by offences against properties (e.g. gang-robbery, robbery, snatching, theft, extortion, cheating and fraud, misappropriation, mischief, receiving of stolen items, kidnapping, and arson) as presented in **Table 4.4.2-12.**

- **Statistics on Road Accidents**

The project's construction and operation activities require vehicles for transportation, such as hauling of construction materials and equipment and transportation of workers during the construction period, and conveyance of chemicals and transportation of employees during the operation period. Increase in the number of vehicles in the study area will cause more risks of road accidents. Therefore, statistics on road accidents were gathered as the fundamental data for assessment of health impact. According to the accident statistics from the Accident Data Center, during the past five years (2011-2015), there were totally 171 reported road accidents in the study area (Nikhom Phattana and Pluak Daeng districts in Rayong province). The vehicle type with the highest number of accidents was motorcycle. Major causes of accidents were driving faster than the speed limit prescribed by law, suddenly cutting in other vehicle, etc. There were 40 minor injuries, 57 serious injuries, and 134 deaths as presented in **Table 4.4.2-13**.

(b) Collection of Primary Data on Public Health

Public health-related data were surveyed by conducting in-depth interview with 9 public health personnel working in the public health units in the study area during 7th-11th April 2016 **(Table 4.4.2-14)**. Photos of visits to local public health units are illustrated in **Photo 4.4.2-1**. The questionnaire structure consists of questions useful for health impact assessment. Questionnaires for in-depth interview with public health personnel are presented in **Appendix 4P**.

TABLE 4.4.2-12

STATISTICS OF REPORT AND ARRESTS OF THE 4 OFFENCE CATEGORIES DURING 2011-2015

Police Station	Offence Categories	Statistics of Report and Arrests of the 4 Offence Categories									
		2011		2012		2013		2014		2015	
		Report (case)	Arrest (case)	Report (case)	Arrest (case)	Report (case)	Arrest (case)	Report (case)	Arrest (case)	Report (case)	Arrest (case)
Nikhom Phatthana	1. Offences against life, body and sex[1]	28	25	20	17	21	19	70	66	59	56
	2. Offences against properties[2]	81	65	84	72	69	54	69	63	87	77
	3. Special cases[3]	14	14	11	9	12	12	11	9	14	11
	4. Offences against the state[4]	-	549	-	679	-	545	-	596	-	637
Pluak Daeng	1. Offences against life, body and sex[1]	30	18	24	19	32	18	369	31	44	38
	2. Offences against properties[2]	262	145	177	94	162	98	129	94	164	112
	3. Special cases[3]	13	10	7	1	21	20	23	21	23	20
	4. Offences against the state[4]	-	1,630	-	1,138	-	782	-	822	-	944

Remark: 1 comprises murder, (serious offences), assault causing death, attempted murder, assault and rape.

2 comprises gang-robbery, robbery, snatching, theft, extortion, cheating and fraud, misappropriation, mischief, receiving of stolen items, kidnapping ,and arson.

3 comprises Anti-human Trafficking Act, Child Protection Act, Copyright Act, Patent Act, Trademark Act, Computer-related Crime Act, Forest Act, National Reserved Forest Act, National Park Act, etc.

4 means drug, weapons, explosives, gambling, offences on pornographic and obscene materials, media, publication, offences on entertainment places, etc.

- No report

Sources: Nikhom Phatthana Police Station, 2016 Pluak Daeng Police Station, 2016

TABLE 4.4.2-13
ROAD ACCIDENTS DURING 2011-2015

Number of Accident Case/Cause of Accident/Damage	Police Station	
	Nikhom Phatthana	Pluak Daeng
Total Reported Accidents (Case)	**92**	**79**
Number of Accidents		
Pedestrian	8	5
Bicycle	-	1
Motorcycle	11	31
Motor-Tricycle	-	1
Passenger car	1	24
Minibus (Van)	2	2
Light truck (pickup)	8	25
Bus	1	2
Six-wheeled truck	3	2
Ten-wheeled truck or trailer	-	5
Others	-	10
Causes of Accidents		
Fast driving	22	12
Suddenly cutting in other vehicle	16	23
Illegal overtaking	3	19
Driving within turning on headlights	1	1
Failure to give signal when parking/slowing down/making turn	1	4
Violation of stopping sign at junction	2	1
Violation of traffic lights/signals	8	1
Failure to drive in the ultimate left lane	2	-
Failure to give light/signal of disabled vehicle		1
Defective driving device	3	1
Drunken	4	2
Falling asleep at wheel	1	2
Driving in incorrect lane/driving across lane divider	4	5
Closely following front vehicle	1	4
Failure to yield the right of way	3	-
Others	28	7
Not reported	21	2
Total Accident Damage		
Deaths	70	64
Serious injuries	23	34
Minor injuries	29	11
Damaged property value	3,385,000	5,819,628
Alleged Offenders		
Arrested	59	60
Escaped	7	6

Sources: Nikhom Phatthana Police Station, 2016 Pluak Daeng Police Station, 2016

TABLE 4.4.2-14

LIST OF PUBLIC HEALTH UNITS IN THE STUDY AREA

No.	Public Health Unit	Position	Term of Office (year)
1	Nikhom Phatthana District Public Health Office	Head of District Public Health Office	4
2	Pluak Daeng District Public Health Office	Public Health Technical Officer	3
3	Nikhom Phatthana Hospital	Director	3
4	Pluak Daeng Hospital	Director	8
5	Phana Nikhom Sub-district Health Promoting Hospital	Public Health Technical Officer	40
6	Dok Krai Sub-district Health Promoting Hospital	Public Health Technical Officer	6
7	Mae Nam Khu Sub-district Health Promoting Hospital	Director	34
8	Map Yang Phon Sub-district Health Promoting Hospital	Director	21
9	Ban Huai Prap Sub-district Health Promoting Hospital	Director	3

Source: Interview during 7th-11th April 2016 by TEAM Consulting Engineering and Management Ltd.

 Head of Nikhom Phatthana District Public Health Office	 Public Health Technical Officer of Pluak Daeng District Public Health Office
 Public Health Technical Officer of Nikhom Phatthana Hospital	 Director of Pluak Daeng Hospital
 Public Health Technical Officer of Phana Nikhom Sub-district Health Promoting Hospital	 Public Health Technical Officer of Dok Krai Sub-district Health Promoting Hospital

PHOTO 4.4.2-1 : PHOTOS OF VISITS TO REPRESENTATIVES OF PUBLIC HEALTH UNITS IN THE STUDY AREA

Director of Mae Nam Khu Sub-district Health Promoting Hospital

Director of Map Yang Phon Sub-district Health Promoting Hospital

Director of Ban Huai Prap Sub-district Health Promoting Hospital

PHOTO 4.4.2-1 : PHOTOS OF VISITS TO REPRESENTATIVES OF PUBLIC HEALTH UNITS IN THE STUDY AREA (CONT'D)

Study Result

Photos of visits to representatives of the public health units in the study area are presented in **Picture 4.4.2-1**. Public health survey result can be summarized below.

- **Sufficiency of Medical Personnel and Equipment**

  According to the local public health personnel opinion survey, 88.9% of the interviewees stated the inadequacy of medical personnel and medical devices. Inadequate medical personnel included professional nurse, dental health officer/dental nurse, public health technical officer/public health officer, etc. Inadequate medical devices included dental equipment, medical ventilator, dressing set, etc.

- **Changes in Health Determinants**

  Illness as a Result of the Existing Environment

  66.7% of local public health personnel viewed that the existing environment causing health impact to people comprised air quality, water quality, chemicals, etc.

Health Promotion Plans or Activities

Public health facilities in the study area have health promotion plans or activities, such as health screening, health education and exercise promotion, etc.

Behaviors That May Lead to Health Risks

Some behaviors of local people may lead to health risks, such as eating, alcohol drinking, violation of traffic rules, smoking drug abuse, etc.

Social Problems and Crime

According to the opinion survey, 88.9% of interviewees expressed social problems and crime, such as theft/robbery/plunder and quarrel and fight among teenagers in entertainment venues.

Advantages, Disadvantages, Concerns and Recommendations for the Project during the Construction Period

According to the opinion survey, 55.6% stated that during the construction period, the project would bring about advantages in socio-economic aspect to the study area. The remaining interviewees viewed that the project would cause problems to the study area, such as dust, traffic congestion, migrant and foreign workers, etc. Besides, nearly all public health personnel (88.9%) expressed their concerns about air quality (dust), noise from construction material and equipment transportation, blockage of drainage channel, increased number of workers, contagious diseases from workers, increased number of patients, accident at work, and accident during construction materials and equipment transportation. Furthermore, they were concerned about additional responsibilities during the project construction period. Recommendations for the project during the construction period are summarized below.

- Activities that benefit community should be initiated.
- Local workers should be employed.
- There should be programs that promote and enhance the quality of life of community people, such as sponsorship of vaccine, contraceptive drug, etc.
- Water use should be suitably managed since the area is currently dry and short of water supply.
- Migrant and foreign workers should be controlled to mitigate community impacts, e.g. contagious diseases and conflicts in communities.
- The project should be responsible for medical treatment to foreign workers to reduce the financial burden of local public health facilities.
- Strict transportation measures should be established to reduce accidents since the project area currently has quite high traffic volume.

- Relevant rules, regulations, requirements and proposed measures should be strictly adhered to.

Advantages, Disadvantages, Concerns and Recommendations for the Project during the Operation Period

According to the opinion survey, 77.8% of interviewees stated that the project would bring about advantages to the study area in terms of socio-economic conditions and energy security. The remaining interviewees viewed that the project would cause problems to the study area, e.g. air pollution, acid rain, health problem, foreign workers, problems in case of emergency or major hazards. Furthermore, almost all public health personnel (66.7%) expressed their concerns about air quality, contaminated cooling water, cooling water temperature, climate change which may lead to higher temperature and impacts on people and agriculture, fire or explosion, health problems, such as increased number of patients, public health service problems and social problems. Recommendations for the project during the operation phase are summarized below.

- Public health-related CSR plan should be prepared, such as support for medical personnel, etc.
- All aspects of the project impacts should be realized and impact mitigation measures should be established to relieve anxiety.
- Local people should be employed first.
- Correct understanding and knowledge should be provided to local people. Good relationship between the project and communities should be enhanced.
- The established measures should be strictly followed.
- Material Safety Data Sheet (MSDS) should be prepared and informed to the public health facilities.
- Project descriptions, impacts, advantages and disadvantages should be communicated to local agencies and people.
- Emergency response plan should be prepared.
- Air quality or other environmental quality measurement result should be reported to local agencies.
- Air and water quality controls should be implemented in all operating steps to reduce probable impacts in short term and the long run.
- The Community Development Committee should consist of members who are local people.
- The power development fund should be allocated throughout the area and in a fair manner. This is because some hospitals in the study area have never received the fund.

- The power plant representative should participate in the meeting for fund approval and should also investigate whether the agencies requesting for support from the power development fund are located in the study area.
- Due to difficult and complicated working processes of the power development fund, local power plants should assemble to mutually survey demands and problems in locality, and to prepare CSR plans to support local public health facilities by themselves.
- Due to shortage of medical personnel in the study area, scholarship should be given to medical students so that they will work in local hospitals after graduation.

- **Capability to Handle Emergency Cases in the Study Area**

According to the opinion survey among public health personnel, general hospitals and sub-district health promoting hospitals in the study area are able to provide medical treatment to patients suffering from minor injuries and illnesses. Phana Nikhom Sub-District Health Promoting Hospital is the closest medical establishment-about 9 km far from the project area and it takes about 9 minutes to reach the hospital. In emergency cases, Phana Nikhom Sub-District Health Promoting Hospital will contact local agencies for assistance and will refer patients to the general hospital in the district.

4.4.3 Archaeology and Historical Treasure

(1) Introduction

The existing conditions of tourist destinations are to be studied, covering both historical and natural attractions, and man-made tourist sites of aesthetic value in the study area. The study results will be adopted as baseline data for assessment of project impacts on tourism and aesthetics, and recommendation of measures for prevention and mitigation as well as monitoring of probable environmental impacts that may arise.

(2) Methodology

Data were collected on tourist sites in Pluak Daeng and Nikhom Phatthana districts, Rayong, as follows:

- Collected and studied data on tourist attractions in Pluak Daeng and Nikhom Phatthana districts obtained from documents of relevant agencies, i.e. Tourism Authority of Thailand, Rayong Provincial Office of Tourism and Sports (Rayong POTS), and tourism-related reports and printed materials such as Osotho magazine, Thailand tourism books, etc.;
- Conducted a field survey to observe the existing conditions of tourist sites in the surrounding areas of the study area.

(3) Study Results

Rayong province has a multitude of natural attractions, resulting in a large number of visitors in each year. Hotels and restaurants are located in significant communities, particularly along the seaside-the major destination. The results of tourist attraction survey in the study area show that there is no natural tourist site or historically important site within 5-km radius of Pluak Daeng district. Rayong's important tourist destinations are presented in **Figure 4.4.3-1**.

4.4.4 Aesthetics and Tourism

(1) Introduction

The project development may have an impact on historical and archaeological sites including historically valuable objects. Consequently, it is essential to study the locations and existing conditions of historical and archaeological places as well as relevant objects of historical value in the project vicinity so as to assess probable impacts and recommend mitigation measures to bring about a low level of impact.

(2) Study Methodology

- Collected secondary data and studied the locations of historical and archaeological sites in the project's surrounding areas, using a 1:50,000 scale topographic map of the Royal Thai Survey Department. Secondary data were also gathered from related documents;
- Conducted a field survey to observe the existing conditions of historical and archaeological sites including objects of historical value in the project's surrounding areas;
- Analysed the data gathered from documents and field survey regarding the existing conditions of historical and archaeological sites including objects of historical value in the project area and related areas. The analysis also covered problems and impacts which may arise during project construction and operation phases.

(3) Study Results

The field survey in the study area within 5-km radius of the project area reveals that neither archaeological site nor historically valuable object is found in the study area. There are 4 religious places in the study area (**Figure 4.4.4-1**) as follows:

- Wat Map Yang Phon, Mu 6, Map Yang Phon subdistrict, Pluak Daeng district, Rayong province, about 3.50 kilometres northwest of the project site;
- Wat Map Toei, Mu 4, Map Yang Phon subdistrict, Pluak Daeng district, Rayong province, about 1.30 kilometres east of the project site;
- Wat Wang Pradu, Mu 7, Mae Nam Khu subdistrict, Pluak Daeng district, Rayong province, about 3.30 kilometres southeast of the project site;
- Wat Prasittharam, Mu 7, Phana Nikhom subdistrict, Nikhom Phatthana district, Rayong province, about 2.60 kilometres southwest of the project site;

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FIGURE 4.4.3-1 : IMPORTANT TOURIST DESTINATIONS IN RAYONG PROVINCE

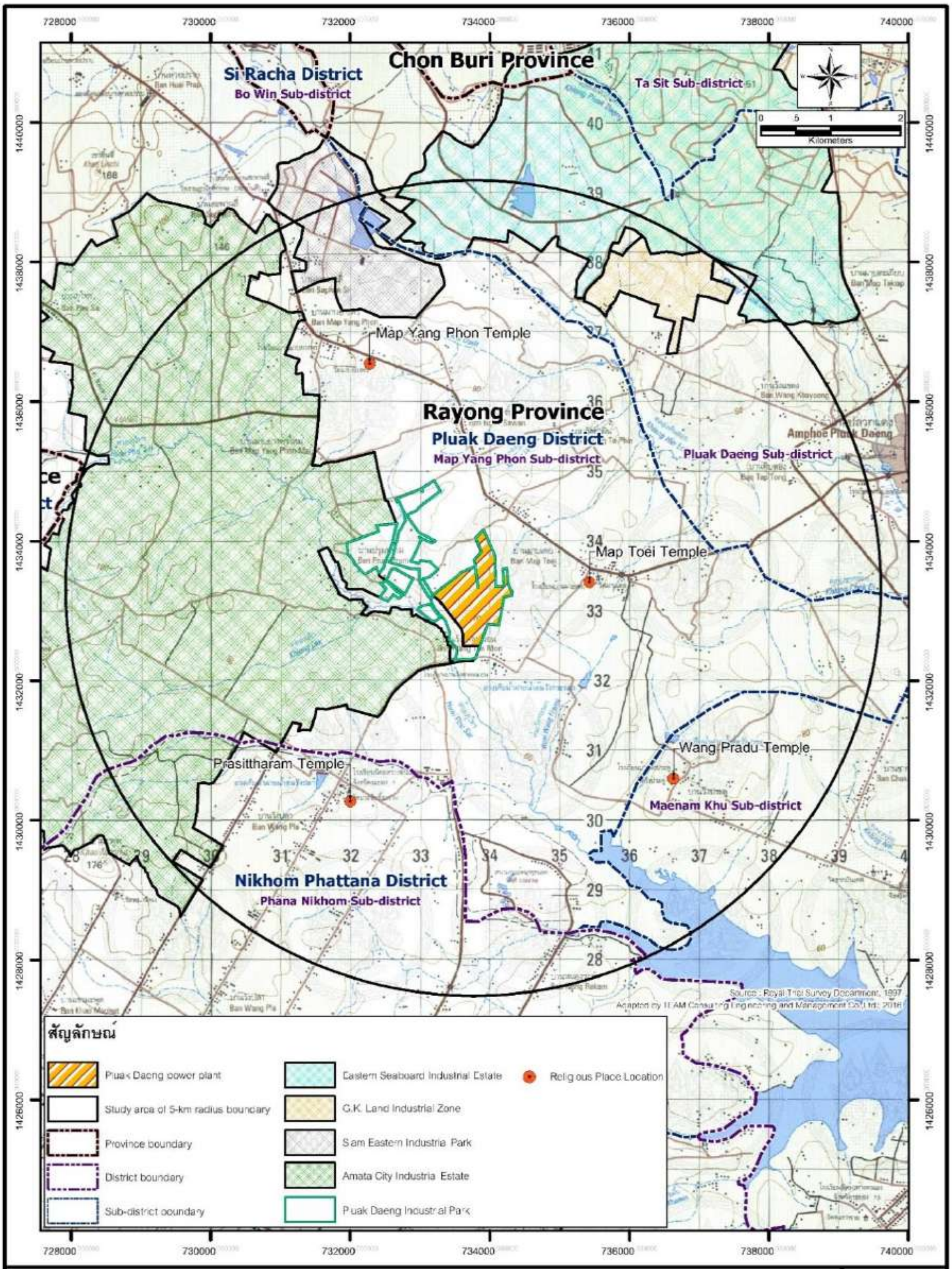


FIGURE 4.4.4-1 : RELIGIOUS PLACES IN THE STUDY AREA WITHIN 5-KM RADIUS FROM THE PROJECT AREA PERIMETER

10P2809/Damrongsak.B/15-08-60/P2809-027 (English).mxd

CHAPTER 5

ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATIONS

CHAPTER 5
ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATIONS

5.1 PHYSICAL RESOURCES

5.1.1 Air Quality and Greenhouse Gas (GHGs)

5.1.1.1 Air Quality

(1) Construction phase

The meteorological condition in the project area will not be affected or changed by the construction activities during the Construction Phase, but the air quality may. The main activities attributing to dispersal of dust particles are foundation building and strengthening as well as pond excavation, as these involve digging, ploughing, levelling, and compacting the ground. The amount of dust particles dispersed into the ambience depends on the duration of the construction phase, wind speed, wind direction, soil moisture, and the construction sites in the project. In addition, there are pollutants released from the construction tools and machines employed. It is thus necessary to assess the air quality impact in the Construction Phase. The AERMOD mathematical model, version 9.1, which is the latest model (according to the information retrieved in July 2016), is used for the assessment, the details of which are as follows:

(1.1) Selection of the model

As the sources of air pollutants incurred from the execution of the project are point sources and area sources, in the selection of the model to be used, concentration of pollutants from multiple sources must be able to be calculated and the location of the receptors and the pollutant sources must be able to be freely selected. Consequently, the consultant team select the AERMOD mathematical model, which is widely recognized and used. With this model, concentration of air pollutants is calculated based on the theory of the planetary boundary layer, the range of which is about 100 meters during nighttime and possibly 1-2 kilometers during daytime; and can be classified into the Convective Boundary Layer (CBL) - the part of the atmosphere caused by the movement of air masses because of sensible heat flux, and the Stable Boundary Layer (SBL) - the part of the atmosphere affected by surface drag, but not influenced by sensible heat flux. AERMOD is a steady-state plume model. In the stable boundary layer (SBL), it assumes the concentration distribution to be Gaussian in both the vertical and horizontal distribution. In the convective boundary layer (CBL), the horizontal distribution is also assumed to be Gaussian, but the vertical distribution is described with a bi-Gaussian probability density function.

(1.2) Input data used in the model

(a) Meteorological data

Meteorological data are important input used in the mathematical model in the investigation and assessment of air pollutant concentration, especially data on the wind speed and wind direction as they influence the dispersion of pollutants released into the ambience. In the investigation, the consultant team use the AERMET program to collect the meteorological data during 2013-2015 and refer to the Guideline Manual on the Use of Models to Assess Air Pollutant Dispersion prepared by the Office of Natural Resources and Environmental Policy and Planning (ONEP) dated 24th September 2013 in calculating the factors of the atmospheric boundary layer that is in contact with the planetary surface, which are to be used as input data in the AERMOD mathematical model. The meteorological data used in the assessment are retrieved from the Air Quality Monitoring stations situated the nearest to the project location. The surface data are derived from three sources, which are 1) Pluak Daeng District Public Health Office's Air Quality Monitoring Station, Rayong Province, which is under the charge of the Pollution Control Department 2) Ta Sit Sub-district Administrative Organization's Air Quality Monitoring Station, Pluak Daeng District, Rayong Province, which is under the charge of the Pollution Control Department, and 3) Huay Pong Air Quality Monitoring Station, Mueang Rayong District, Rayong Province, which is under the charge of the Meteorological Department; the details of which are shown in **Table 5.1.1-1**. For the upper air data, the source is Bangna Air Quality Monitoring Station. The details are as follows:

TABLE 5.1.1-1
DETAILS OF THE AIR QUALITY MONITORING STATIONS WHICH ARE THE DATA SOURCES IN PLUAK DAENG POWER PLANT PROJECT'S AIR QUALITY ASSESSMENT

Air Quality Monitoring station	Distance from Pluak Daeng Power Plant Project (kilometer)	Compass point direction
Pluak Daeng District Public Health Office's Air Quality Monitoring Station, Rayong Province, under the charge of the Pollution Control Department	6.6	East-Southeast (ESE)
Ta Sit Sub-district Administrative Organization's Air Quality Monitoring Station, Pluak Daeng District, Rayong Province, under the charge of the Pollution Control Department	13.0	East-Northeast (ENE)
Huay Pong Air Quality Monitoring Station, Mueang Rayong District, Rayong Province, under the charge of the Meteorological Department	24.6	Southwest (SW)

- **The surface data**; which include wind speed and direction per hour, as shown in **Figure 5.1.1-1** to **Figure 5.1.1-4**, dry bulb temperature and relative humidity, as well as the surface features of the area under study; are derived from Pluak Daeng District Public Health Office's Air Quality Monitoring Station, Rayong Province, under the charge of the Pollution Control Department. As the monitoring of Pluak Daeng District Public Health Office's Air Quality Monitoring Station just started on 16th July 2014, in order to have the data that cover the period of three years, the consultant team decide to use the data derived from Ta Sit Sub-district Administrative Organization's Air Quality Monitoring Station, about 9.2 kilometers away from Pluak Daeng District Public Health Office's Air Quality Monitoring Station, to supplement the missing time period. Therefore, data on the said factors per hour are those from the monitoring of Pluak Daeng District Public Health Office's Air Quality Monitoring Station between 16th July 2014 and 31st December 2015 and those from the monitoring of Ta Sit Sub-district Administrative Organization's Air Quality Monitoring Station between 1st January 2013 and 15th July 2014. For the cloud cover and ceiling height per every three hours, the data are from the monitoring of Huay Pong Air Quality Monitoring Station, under the administration of the Meteorological Department, between 2013 and 2015. The details are shown in **Table 5.1.1-2**.

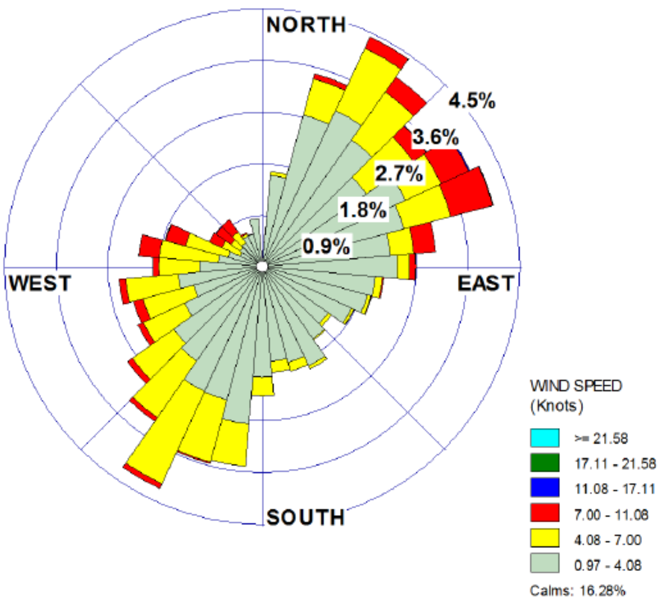


FIGURE 5.1.1-1 : WIND SPEED AND WIND DIRECTION FROM PLUAK DAENG DISTRICT PUBLIC HEALTH OFFICE'S AIR QUALITY MONITORING STATION, 2013

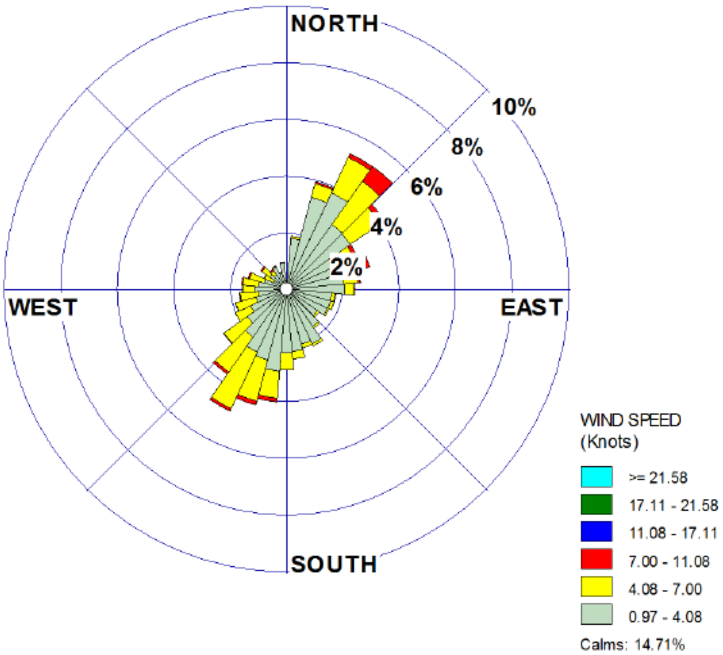


FIGURE 5.1.1-2 : WIND SPEED AND WIND DIRECTION FROM PLUAK DAENG DISTRICT PUBLIC HEALTH OFFICE'S AIR QUALITY MONITORING STATION, 2014

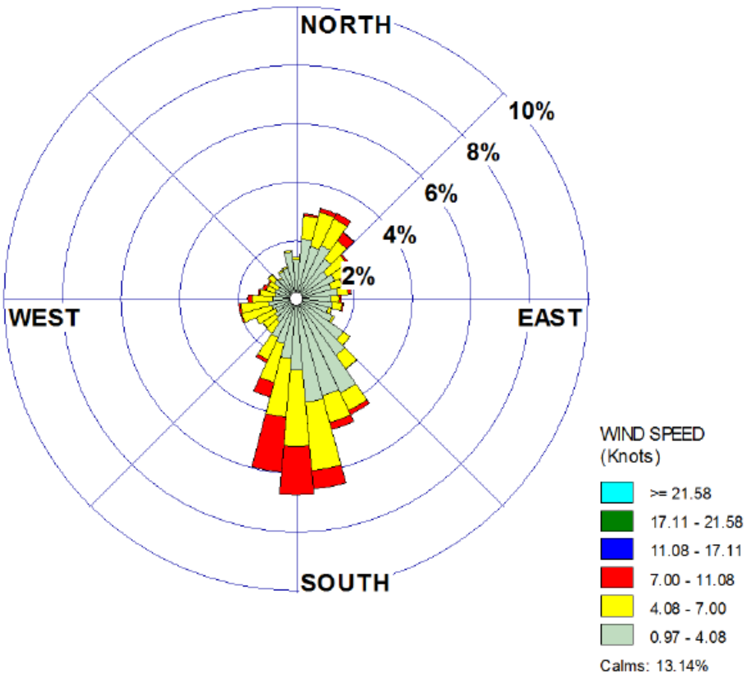


FIGURE 5.1.1-3 : WIND SPEED AND WIND DIRECTION FROM PLUAK DAENG DISTRICT PUBLIC HEALTH OFFICE'S AIR QUALITY MONITORING STATION, 2015

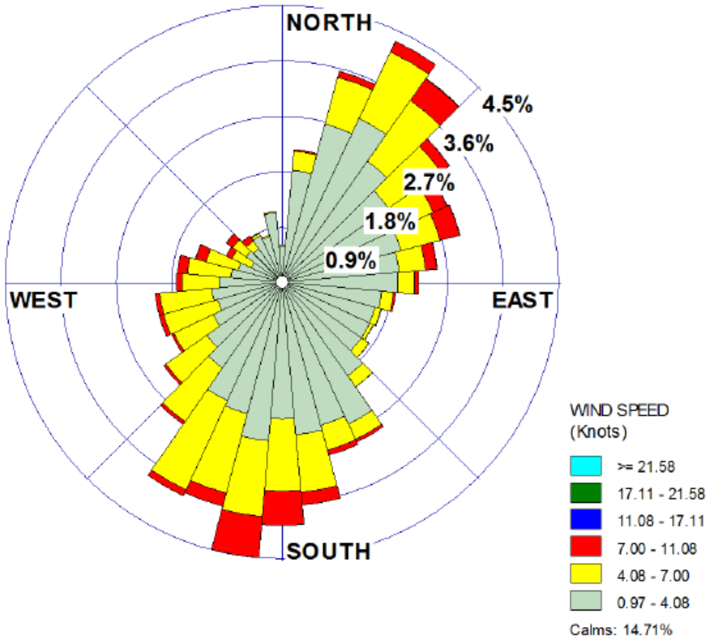


FIGURE 5.1.1-4 : WIND SPEED AND WIND DIRECTION FROM PLUAK DAENG DISTRICT PUBLIC HEALTH OFFICE'S AIR QUALITY MONITORING STATION, 2013-2015

TABLE 5.1.1-2
DETAILS ABOUT THE USE OF SURFACE METEOROLOGICAL DATA IN PLUAK DAENG POWER PLANT PROJECT

Details	Pluak Daeng District Public Health Office's Air Quality Monitoring Station 1/			Ta Sit Sub-district Administrative Organization's Air Quality Monitoring Station 2/			Huay Pong Air Quality Monitoring Station		
	2013	2014	2015	2013	2014	2015	2013	2014	2015
wind speed and direction	-	Starting from 16/07/2014	√	√	Starting from 1/01/2014 to 15/07/2014	-	-	-	-
dry bulb temperature	-	Starting from 16/07/2014	√	√	Starting from 1/01/2014 to 15/07/2014	-	-	-	-
relative humidity	-	Starting from 16/07/2014	√	√	Starting from 1/01/2014 to 15/07/2014	-	-	-	-
cloud cover	-	-	-	-	-	-	√	√	√
ceiling height	-	-	-	-	-	-	√	√	√

Remark: 1/ The monitoring of Pluak Daeng District Public Health Office's Air Quality Monitoring Station started on 16th July 2014, the Pollution Control Department (2016)

2/ The monitoring of Ta Sit Sub-district Administrative Organization's Air Quality Monitoring Station was conducted until 15th July 2014 when it was permanently closed. The monitoring was then conducted at Pluak Daeng District Public Health Office's Air Quality Monitoring Station instead, the Pollution Control Department (2016)

For the surface meteorological data derived from Huay Pong Air Quality Monitoring Station, the monitoring is conducted every 3 hours, which is different from at Pluak Daeng District Public Health Office's Air Quality Monitoring Station where the monitoring is conducted on an hourly basis. In this way, the data derived from Huay Pong Air Quality Monitoring Station must be first converted to per hour basis before they can be fed into the AERMET program. Preparation of the data is as follows:

- For ceiling height, if there are data covering all the time period required, step-wise linear interpolation is to be employed. If there are data missing, data from the previous year will be used. If there are no data from the previous year, the hourly average in the monitoring in each month will be used.
- For cloud cover, the data are derived from the monitoring which is conducted every 3 hours and there are no data missing. Step-wise linear interpolation is employed so as to convert the data to per hour basis.

- **The upper data;** which are derived from the monitoring conducted at different standard pressure levels starting from the level of about 100 meters above the surface up to the level of about 20 kilometers (up to the level of about 3,000 meters for the data required for the AERMET program); include wind speed and direction, temperature, and dynamic height. The data are retrieved from Bangna Air Quality Monitoring Station, Bangkok, where the monitoring is conducted on a daily basis. Preparation of the data is as follows:

- In the event that 1 value is missing, linear interpolation of the value before and after the missing value is to be used.
- If more than 1 value is missing, the data from the same period of the previous year are to be used.

Meteorological data of the area with respect to land utilization, which include surface roughness length, Bowen ratio, and albedo; are examined based on the land utilization around Pluak Daeng District Public Health Office's Air Quality Monitoring Station through the use of the Land Development Department's most recent land utilization map covering Rayong Province (2013). With the site of Pluak Daeng District Public Health Office's Air Quality Monitoring Station being specified, the values of the three variables are calculated for two periods, which are May – October (wet season) and November – April (dry season). The QGIS program is applied to convert the Land Development Department's data on land cover classification in Rayong Province to those applicable to USGS NLCD92 (National Land Cover Dataset 1992), which is a 21-class land cover classification scheme (the details of which are shown in **Appendix 5 A-1**). Then the converted data are fed into the AERSURFACE program to calculate the values of surface roughness length, Bowen ratio, and albedo (the details of which are shown in **Appendix 5A-2**) according to the direction prescribed in U.S.EPA AERSURFACE User's Guide (as revised on 01/16/2013). In calculating the surface roughness length value, weighted geometric mean is used, the inverse distance is within 3 km radius and is applied for eight different land use categories. In calculating the Bowen ratio, unweighted geometric mean is used. In calculating the albedo value, unweighted geometric mean is used within the area of 10x10 kilometers.

Details of land utilization within a three-kilometer radius of Pluak Daeng District Public Health Office's Air Quality Monitoring Station and in the area of 10x10 kilometers around it as investigated by the AERSURFACE program are shown in **Figure 5.1.1-5.**

- **Data on topography and ground height level of the study area** to be applied to the AERMAP model are retrieved from the Seamless Shuttle Radar Topography Mission (SRTM) - N12E101 and N13E101, at a resolution of 90x90 meters.

(b) Data on potentially affected receptors

The consultant team prescribe that the investigation of impacts of air pollutants released from the project covers the area within a fifteen-kilometer radius of the project's fence line. ("Fence line" means the project's boundary inaccessible to the public, unless authorized.) The grid receptors are defined as follows:

- From the project site to the distance of 1.5 km away from the fence line, at a resolution of 100 meters.
- From the distance of 1.5–3.0 km away from the fence line, at a resolution of 250 meters.
- From the distance of 3.0–15.0 km away from the fence line, at a resolution of 500 meters.

In addition, data on ground height level from SRTM3/SRTM1 are used to assess the air quality in the project area. The study area is classified as elevated terrain and further investigation is conducted on sensitive receptors affected by air pollutants released from the project, which include hospitals, temples and schools in the study area; with a view to assessing the likelihood of the direct impact of the said air pollutants to the health of the people living in the area under study. The sensitive receptor sample groups, 31 in total, are shown in **Table 5.1.1-3.**

(c) Selection of existing data on ambient air quality monitoring

Existing data on ambient air quality monitoring are used in assessing the air quality impact in this study. The highest values in the monitoring by the station or the monitoring point at the receptor as designated by the project are to be used in the assessment. In the event that there is no monitoring result from the designated monitoring point, the project will consider using existing data on ambient air quality monitoring from the station or the monitoring point near the receptor. The details are as follows:

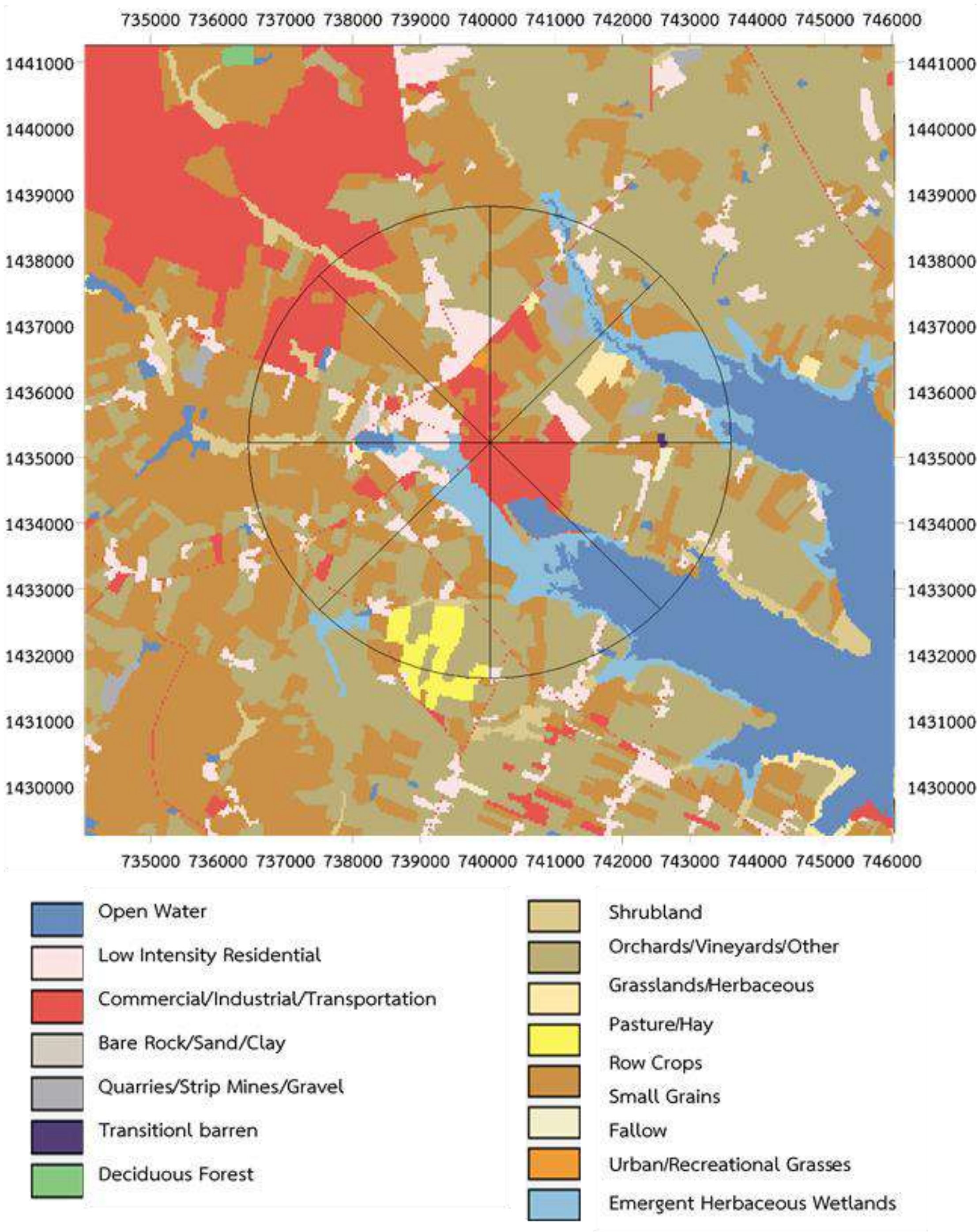


FIGURE 5.1.1-5 : DETAILS OF LAND UTILIZATION WITHIN A THREE-KILOMETER RADIUS OF PLUAK DAENG DISTRICT PUBLIC HEALTH OFFICE'S AIR QUALITY MONITORING STATION AND IN THE AREA OF 10 X10 KILOMETERS AROUND IT

TABLE 5.1.1-3
GRID REFERENCE AND DISTANCE OF THE SENSITIVE RECEPTORS FROM THE PROJECT LOCATION

	Sensitive receptor	Grid reference		Distance from the project location (km) / direction
		E	N	
1	Map Yang Phon Sub-district Administrative Organization	735565	1433613	1.29/east
2	Ban Map Toei School	735503	1433533	1.21/ east
3	Map Toei Temple	735430	1433415	1.12/ east
4	Nikhom Sang Ton Eng 9 School	731947	1430451	2.64/ southwest
5	Prasitharam Temple	732002	1430278	2.75/ southwest
6	Map Yang Phon Sub-district Health Promoting Hospital	731401	1437012	3.80/ north-northwest
7	Ban Map Yang Phon School	731692	1436797	3.45/ north-northwest
8	Map Yang Phon Temple	732279	1436548	2.90/north-northwest
9	Pluak Daeng Sub-district Administrative Organization	739055	1434753	4.96/ east
10	Orawin Witthaya School	739058	1434108	4.81/ east
11	Pluak Daeng High Voltage Electricity Station	737778	1436539	4.54/ northeast
12	Wang Pradu Temple	736636	1430603	3.33/ southeast
13	Wang Pradu School (closed down)	736715	1430692	3.33/ southeast
14	Village No.5, Ban Khlong Plu	733193	1429939	2.58/ south-southwest
15	Village No.7, Ban Wang Pla	732270	1430365	2.78/ southwest
16	Village No. 8, Ban Soi 13	731436	1430734	2.60/ south-southwest
17	Village No.7, Ban Wang Pradu	736569	1430927	3.10/ southeast
18	Village No.4, Ban Khao Mapud	730854	1431065	3.17/ southwest
19	Village No. 5, Ban Wang Tan Mon	732762	1431786	1.26/ southwest
20	Village No.1, Ban Map Toei	735578	1432703	1.46/ east
21	Village No.7, Ban Chak Oi	737267	1433299	3.08/ east
22	Village No.6, Ban Map Yang Mai	731490	1434612	2.25/ northwest
23	Village No 6, Ban Thab Tong	736907	1434627	2.89/ northeast
24	Village No.2, Ban Noen Sawan	733690	1434855	0.81/ north
25	Village No.4, Ban Wang Ta Phin	736444	1435467	2.94/northeast
26	Village No.3, Ban Map Yang Phon	733404	1436506	2.49/ north
27	Village No.6, Ban Nong Rakam	734378	1428021	4.52/south
28	Village No.5, Ban Khlong Phlu	732735	1428558	4.04/ south-southwest
29	Village No.7, Ban Wang Pla	731629	1429178	2.52/ southwest
30	Village No.8 , Ban Soi 13	730774	1429714	3.97/ southwest
31	Village No.4, Ban Chak Manthed	738538	1430469	5.02/ southeast

(c.1) The highest values in the monitoring in the project area at 5 monitoring points, during 2 periods of time – the first period is between 9th-16th September 2015, which is considered representative of the monitoring during the time of the southwest monsoon; the second period is between 13th-20th February 2016, which is considered representative of the monitoring during the time of the northeast monsoon. The five monitoring points are situated at (1) Pluak Daeng Power Plant Project site (2) Village No.2, Ban Noen Sawan (3) Prasitharam Temple (4) Ban Map Toei School (5) the community in the west of the project site in Village No.5, Map Yang Phon Sub-district. The monitoring results are shown in **Table 5.1.1-4**. The highest values registered in the monitoring are shown in **Table 5.1.1-5**.

(c.2) The highest values registered by the air quality monitoring system (AQMS) of the stations situated near the project area, 3 stations in total, which are (1) Pluak Daeng District Public Health Office's Air Quality Monitoring Station, under the charge of the Pollution Control Department (2) Eastern Seaboard Industrial Estate's Air Quality Monitoring Station (Rayong Province), and (3) Amata City Industrial Estate's Air Quality Monitoring Station (Rayong Province). Among the data collected by Pluak Daeng District Public Health Office's. Air Quality Monitoring Station, under the charge of the Pollution Control Department; and the report on the results of the implementation in compliance with measures for environmental impact prevention and reduction and measures for environmental quality follow-up (operation phase) of Eastern Seaboard Industrial Estate Project (Rayong Province) and Amata City Industrial Estate Project (Rayong Province), (extension) Phase 5 (1st implementation), the air quality monitoring system data collected by Pluak Daeng District Public Health Office's Air Quality Monitoring Station are considered most complete and up-to-date, the details of which are shown in **Table 5.1.1-6**. Therefore, the consultant team choose the data collected by Pluak Daeng District Public Health Office's Air Quality Monitoring Station in assessing the project's air quality impact.

With reference to the highest values in the monitoring of ambient air quality by Pluak Daeng District Public Health Office's Air Quality Monitoring Station, under the charge of the Pollution Control Department, which is about 6.6 kilometers away from the project location to the east-northeast (ENE), the levels of NO_2, SO_2, and PM-10 as measured in 2015 are within the established national standard levels. However, investigation of the data on the monitoring results reveals that certain values are unusually high when compared to the data from nearby stations. Thus, such unusually high values are ignored and the second highest applicable values are used instead. The details are shown in **Figure 5.1.1-6** to **Figure 5.1.1-12** and **Table 5.1.1-5.**

TABLE 5.1.1-4
AMBIENT AIR QUALITY MONITORING

Station	Date	Ambient Concentration of the Air Pollutant ($\mu g/m^3$)						
		TSP Avg. 24 hr.	PM-10 Avg. 24 hr.	NO_2 Avg. 1 hr.	SO_2 Avg. 24 hr.	SO_2 Max. 1 hr.	CO Max. 8 hr.	CO Max. 1 hr.
Pluak Daeng Power Plant Project Area	9th-16th/09/15	26-41	15-27	12.04-27.47	4.19-4.98	4.45-5.24	458.24-801.92	458.24-801.92
	13th-20th/02/16	71-106	36-63	16.37-40.65	4.19-6.03	6.03-11.01	458.24-1,031.04	572.80-1,145.60
Ban Noen Sawan Community	9th-16th/09/15	33-63	18-38	21.26-57.96	5.24-4.71	6.29-11.79	687.36-1,031.04	1,145.60-2,062.09
Village No.2, Ban Map Yang Phon	13th-20th/02/16	90-144	58-78	25.40-44.98	4.72-6.55	6.29-8.12	572.80-1,031.04	1,145.60-1,947.53
Prasitharam Temple Area	9th-16th/09/15	30-42	17-28	10.35-24.84	4.72-4.98	4.98-5.50	343.68-687.36	458.24-687.36
	13th-20th/02/16	73-128	42-88	24.28-34.44	3.93-5.24	4.98-6.55	458.24-801.92	687.36-1,145.60
Ban Map Toei School	9th-16th/09/15	33-57	20-29	25.40-41.40	4.45-4.98	4.98-7.08	458.24-687.36	572.80-801.92
	13th -20th/02/16	71-138	42-88	24.28-34.44	3.93-5.24	4.98-6.55	458.24-801.92	687.36-1,145.60
Western Community of Project	9th-16th/09/15	29-50	15-29	19.76-38.58	4.98-5.50	6.81-10.74	458.24-572.80	458.24-916.48
Village No.5, Ban Map Yang Phon	13th -20th/02/16	62-110	37-65	19.38-48.36	4.72-5.50	5.24-7.86	458.24-687.36	458.24-916.48
National Standard		**330[1/]**	**120[1/]**	**320[2/]**	**300[1/]**	**780[3/]**	**10,260[4/]**	**34,200[4/]**
WHO[5/]		-	50	200	20	-	-	-

Remark: 1/ Announcement of the National Environment Board No.24 (2004) on ambient air quality standard specification
2/ Announcement of the National Environment Board No. 33 (2009) on nitrogen dioxide ambient concentration standard specification
3/ Announcement of the National Environment Board No. 12 (1995) on sulfur dioxide ambient concentration standard specification
4/ Announcement of the National Environment Board No. 10 (1995) on ambient air quality standard specification
5/ WHO Ambient Air Quality Guidelines in Environmental, Health, and Safety (EHS) Guidelines for International Finance Corporation (2007)

Source : Field survey Team Consulting Engineering and Management Co., Ltd., 2016

Table 5.1.1-5

HIGHEST VALUES IN THE EXISTING DATA ON THE AMBIENT AIR QUALITY MONITORING IN THE PROJECT'S VICINITY

Station	Ambient Concentration of the Air Pollutant ($\mu g/m^3$)[1/]											
	NO_2 Avg. 1 hr.	NO_2 Avg. 1 year[2/]	SO_2 Avg. 1 hr.	SO_2 Avg. 24 hr.	SO_2 Avg. 1 year[2/]	TSP Avg. 8 hr.[2/]	TSP Avg. 24 hr.	TSP Avg. 1 year[2/]	PM-10 Avg. 24 hr.	PM-10 Avg. 1 year[2/]	CO Avg. 1 hr.	CO Avg. 8 hr.[2/]
1. Pluak Daeng Power Plant Project Area	40.65	6.62	11.01	6.03	1.79	132.04	106.00	32.57	63.00	19.36	1,145.60	755.81
2. Ban Noen Sawan Community Village No.2, Ban Map Yang Phon	57.96	9.43	11.79	47.17	1.92	179.38	144.00	44.25	78.00	23.97	2,062.09	1,360.47
3. Prasitharam Temple Area	34.44	5.60	6.55	5.24	1.07	159.45	128.00	39.33	88.00	27.04	1,145.60	755.81
4. Ban Map Toei School	41.40	6.74	7.08	5.24	1.15	171.91	138.00	42.41	88.00	27.04	1,145.60	755.81
5. Western Community of Project Village No.5, Ban Map Yang Phon	48.36	7.87	10.74	5.50	1.75	137.03	110.00	33.80	65.00	19.97	916.48	604.65
6. AQMS Public Health Pluak Daeng District	67.74	11.02	39.83	7.88	6.48	-	-	-	86.50	26.58	-	-
Maximum	67.74	11.02	39.83	47.17	6.48	179.38	144.00	44.25	88.00	27.04	2,062.09	1,360.47
National Standard[3/]	320	57	780	300	100	15,000	330	100	120	50	34,200	10,260
WHO[4/]	200	40	-	20	-	-	-	-	50	20	-	-

Remark : 1/ The highest values in the monitoring used in assessing the project's air quality impact are as follows:

- The highest values registered by the project's monitoring points; which are Pluak Daeng Power Plant Project site, Village No. 2, Ban Noen Sawan, Prasitharam Temple, Ban Map Toei School, and the community in the west of the project site in Village No.5 in Map Yang Phon Sub-district; during two periods – the first between 9th-16th September 2015, and the second between 13th-20th February 2016.
- The highest values registered by Pluak Daeng District Public Health Office's AQMS in 2015. In case of unusually high values, the second highest applicable values are to be used instead.

2/ The equation applied in the calculation is $C_1/C_2 = (t_2/t_1)^n$ (reference - Air Pollution: Original and Control, 2nd Edition, Harper Collins Publisher, 1981)

where

C_1 and C_2 = concentration value at t_1 and t_2

N = constant, which is 0.17-0.20 (n =0.2)

t_1 and t_2 = a particular period (minute)

- the 1-year average value of NO_2 is calculated from the 1-hour average value of NO_2
- the 1-year average value of SO_2 is calculated from the 1-hour average value of SO_2
- the 8-hour average value of TSP is calculated from the 24-hour average value of TSP
- the 1-year average value of TSP is calculated from the 24-hour average value of TSP
- the 1-year average value of PM-10 is calculated from the 24-hour average value of PM-10
- the 8-hour average value of CO is calculated from the 1-hour average value of CO

3/ National Standards referred to :

- Announcement of the National Environment Board No. 10 (1995) on ambient air quality standard specification
- Announcement of the National Environment Board No. 33 (2009) on nitrogen dioxide ambient concentration standard specification
- Announcement of the National Environment Board No. 21 (2001) on sulfur dioxide ambient concentration standard specification
- OSHA Standard, Part title: Safety and health regulations for construction, Subpart title: Occupational health and environmental controls, Standard number 1926.55 App A

4/ WHO Ambient Air Quality Guidelines in Environmental, Health, and Safety (EHS) Guidelines for International Finance Corporation (2007)

TABLE 5.1.1-6
DETAILS ABOUT THE STATIONS WITH AIR QUALITY MONITORING SYSTEM (AQMS) SITUATED NEAR THE PROJECT AREA

Station	Direction and distance from the project location (kilometer)	Data acquisition details	Month/year			
			Jan.-Jun. 2014	Jul.-Dec. 2014	Jan.-Jun. 2015	Jul.-Dec. 2015
Pluak Daeng District Public Health Office's Air Quality Monitoring Station [1/]	ENE / 6.6 kilometer	data generated by AQMS on an hourly basis	-	-	✓	✓
Eastern Seaboard Industrial Estate's Air Quality Monitoring Station (Rayong Province) [2/]	N / 5.0 kilometer	data generated by AQMS on an hourly basis	✓	✓	-	-
Amata City Industrial Estate's Air Quality Monitoring Station (Rayong Province)[2/]	NW / 3.5 kilometer	data generated by AQMS on an hourly basis	✓	✓	✓	-

Source: 1/ Pollution Control Department, 2016
2/ Bureau of Environmental Impact Evaluation, Office of Natural Resources and Environmental Policy and Planning, 2016

To conclude, the highest values in existing data on ambient air quality monitoring by the station or the monitoring point at the receptor as designated by the project are to be used. For a sensitive receptor where no monitoring result is available, the project will consider using existing data on ambient air quality monitoring from the station or the monitoring point near that receptor, as shown in **Table 5.1.1-7** and the summary of the monitoring results is shown in **Table 5.1.1-8**.

(d) Pollutant sources during the construction phase

Pollutants released into the air during the construction phase are caused by topsoil excavation in the construction areas and vehicles and engines employed in the construction activities. The air quality assessment in the construction phase is thus based on the impacts incurred by each activity. The details of the air pollutant emission rate of each activity are as follows:

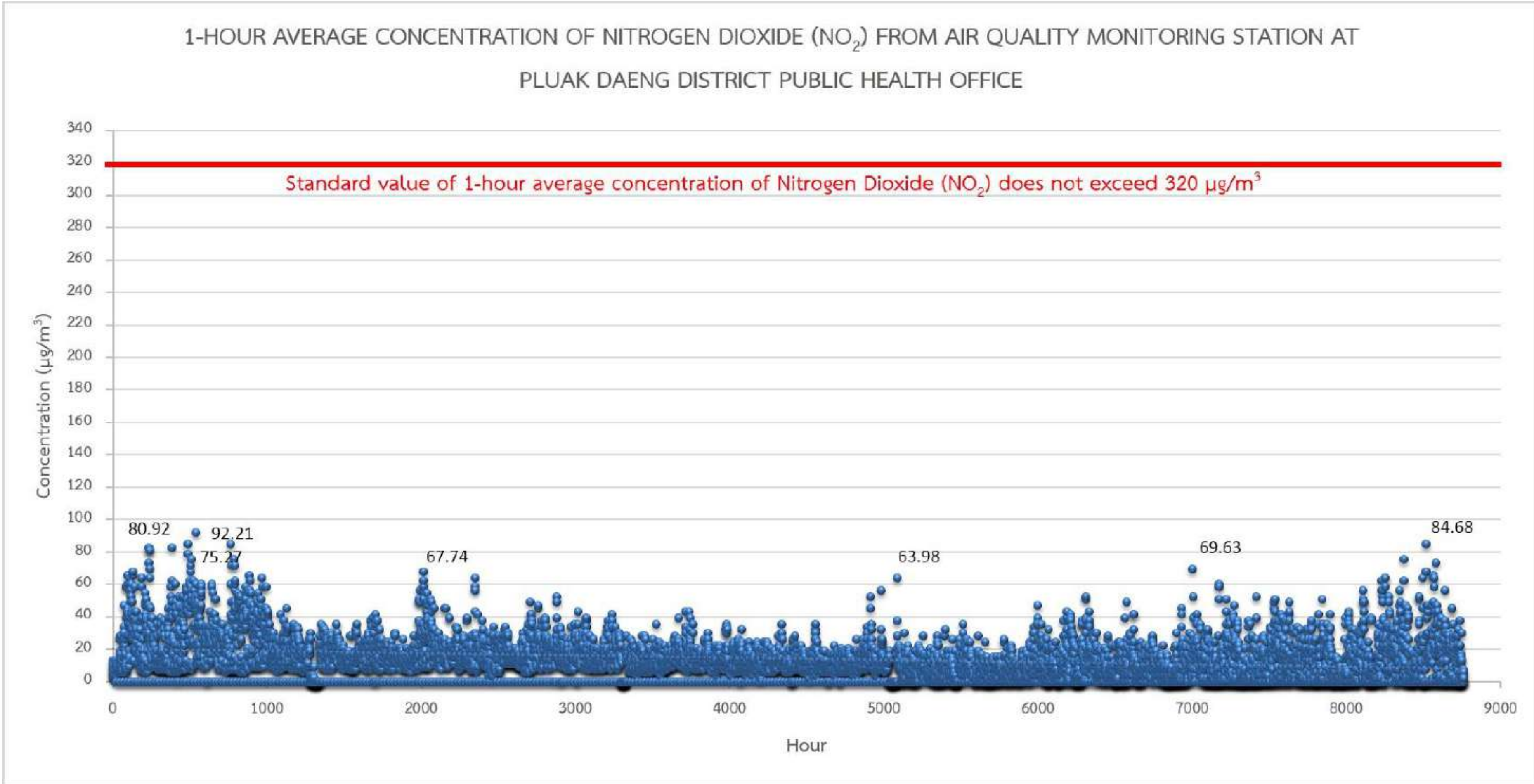


FIGURE 5.1.1-6 : 1-HOUR AVERAGE CONCENTRATION OF NITROGEN DIOXIDE (NO_2) FROM AIR QUALITY MONITORING STATION AT PLUAK DAENG DISTRICT PUBLIC HEALTH OFFICE IN 2015

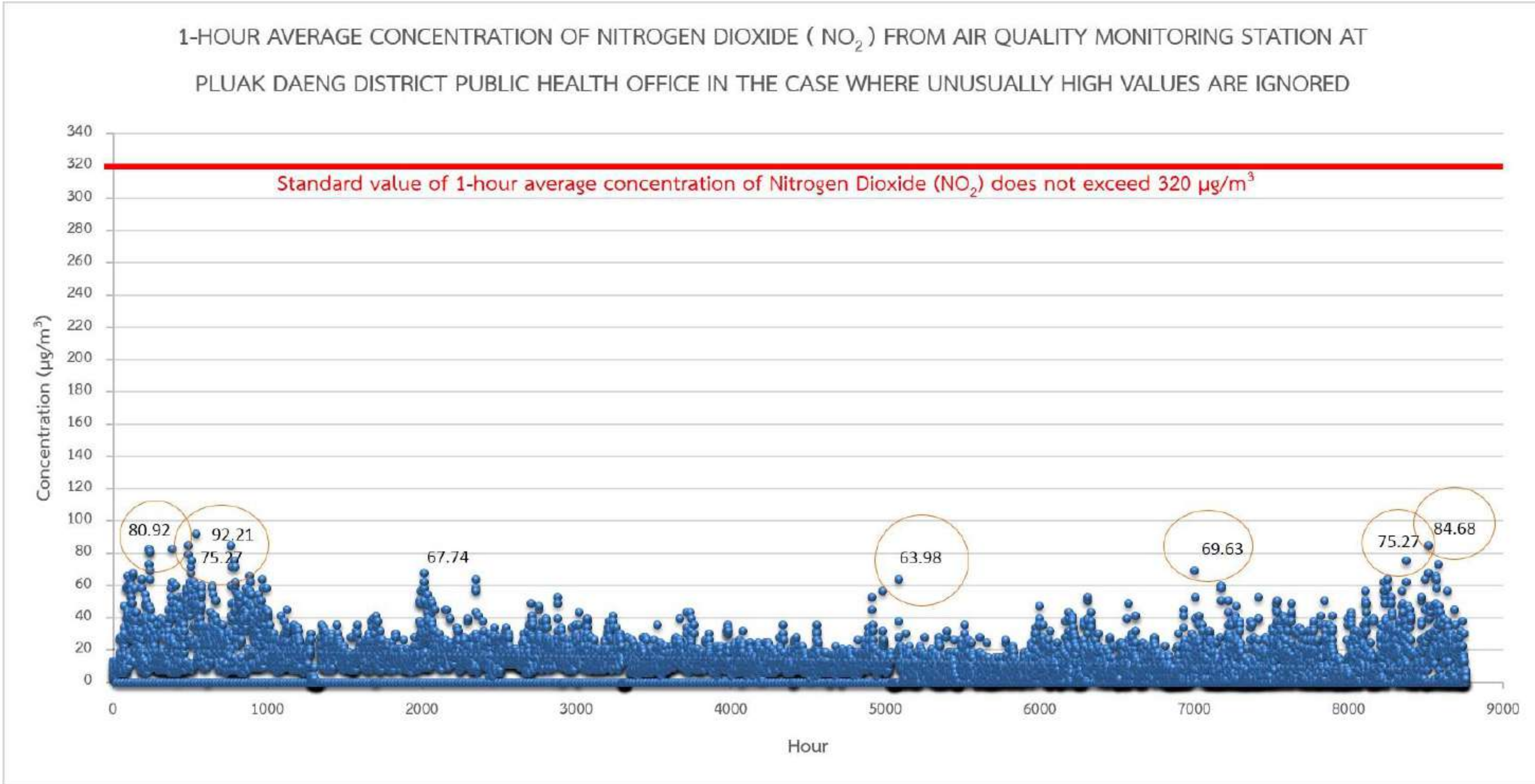


FIGURE 5.1.1-7 : 1-HOUR AVERAGE CONCENTRATION OF NITROGEN DIOXIDE (NO_2) FROM AIR QUALITY MONITORING STATION AT PLUAK DAENG DISTRICT PUBLIC HEALTH OFFICE IN 2015 IN THE CASE WHERE UNUSUALLY HIGH VALUES ARE IGNORED

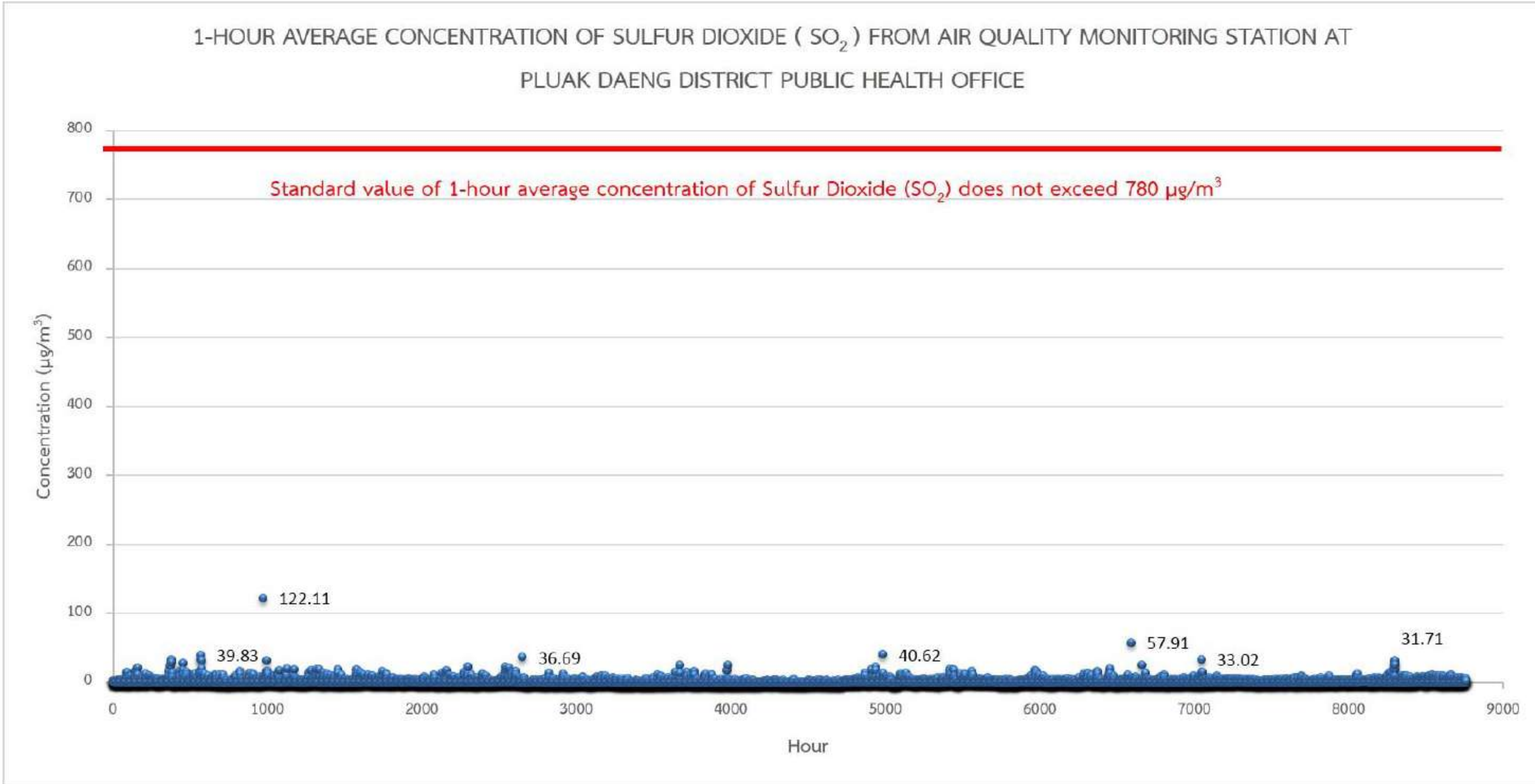


FIGURE 5.1.1-8 : 1-HOUR AVERAGE CONCENTRATION OF SULFUR DIOXIDE (SO_2) FROM AIR QUALITY MONITORING STATION AT PLUAK DAENG DISTRICT PUBLIC HEALTH OFFICE IN 2015

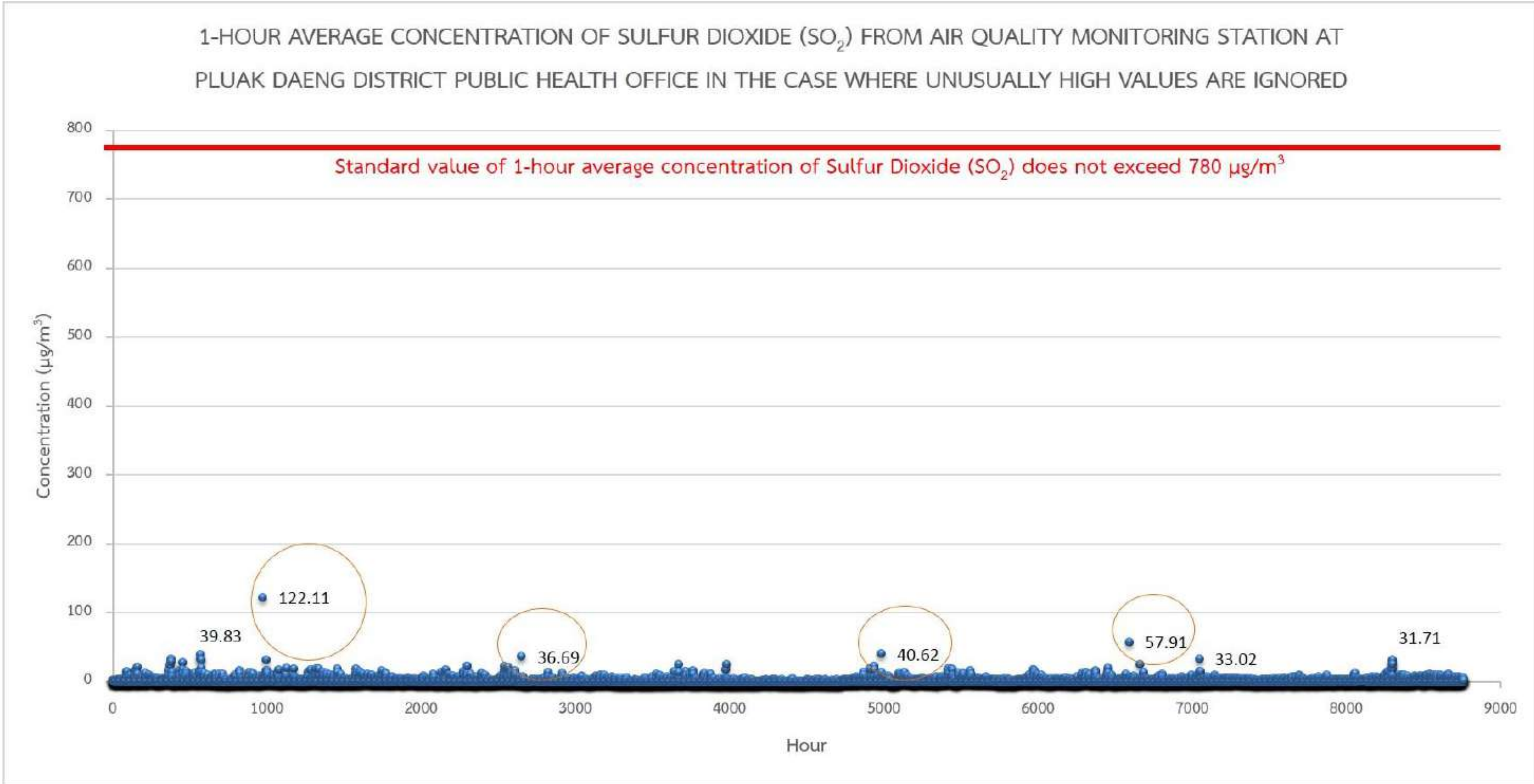


FIGURE 5.1.1-9 : 1-HOUR AVERAGE CONCENTRATION OF SULFUR DIOXIDE (SO_2) FROM AIR QUALITY MONITORING STATION AT PLUAK DAENG DISTRICT PUBLIC HEALTH OFFICE IN 2015 IN THE CASE WHERE UNUSUALLY HIGH VALUES ARE IGNORED

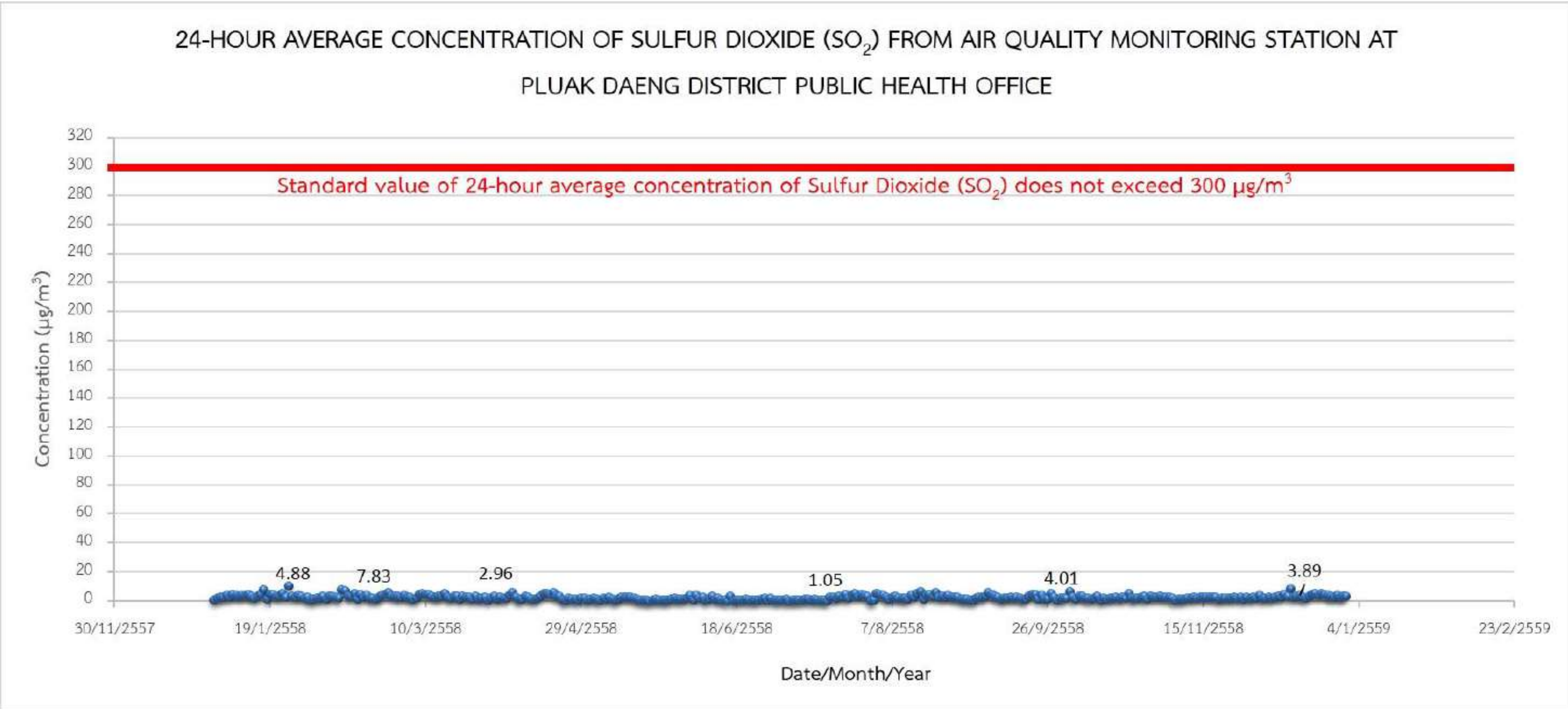


FIGURE 5.1.1-10 : 24-HOUR AVERAGE CONCENTRATION OF SULFUR DIOXIDE (SO_2) FROM AIR QUALITY MONITORING STATION AT PLUAK DAENG DISTRICT PUBLIC HEALTH OFFICE IN 2015

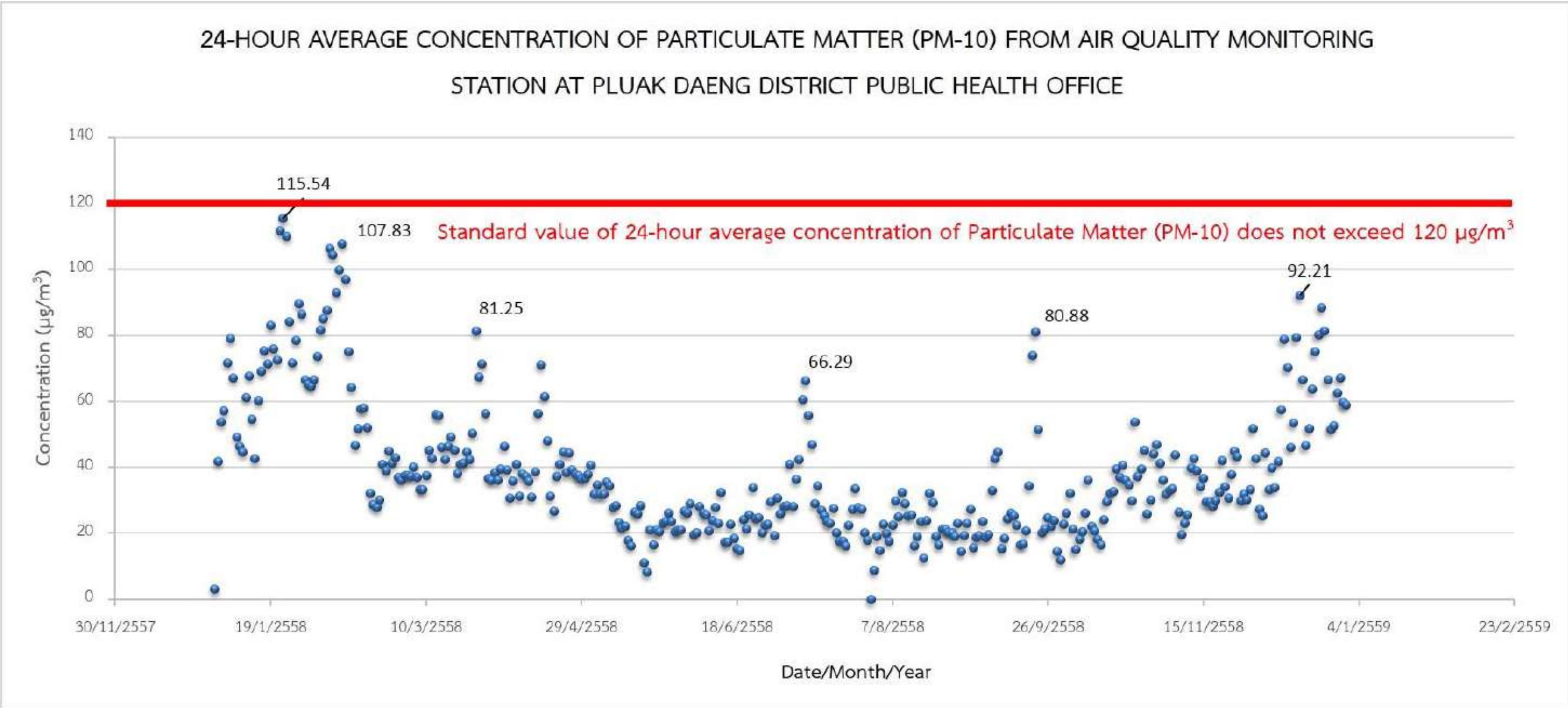


FIGURE 5.1.1-11 : 24-HOUR AVERAGE CONCENTRATION OF PARTICULATE MATTER (PM-10) FROM AIR QUALITY MONITORING STATION AT PLUAK DAENG DISTRICT PUBLIC HEALTH OFFICE IN 2015

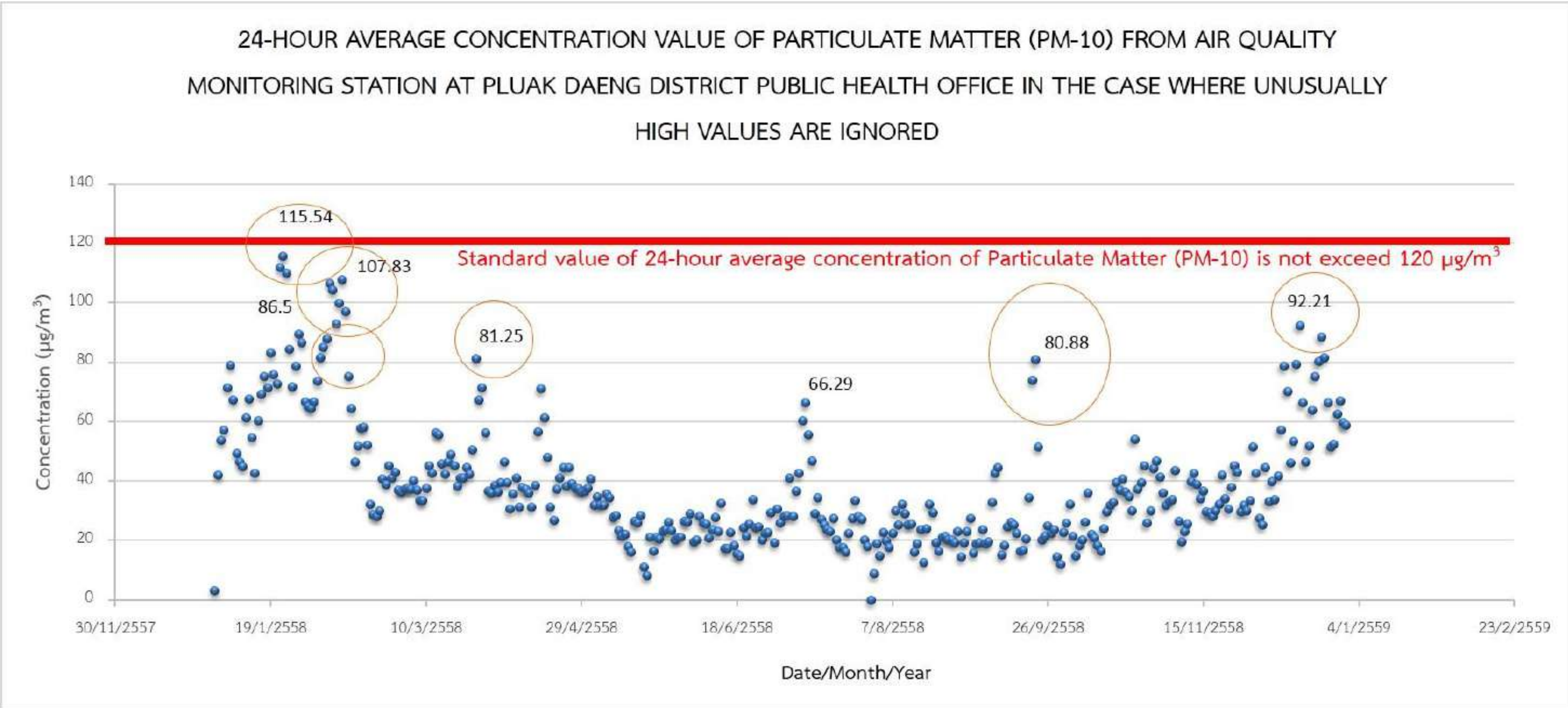


FIGURE 5.1.1-12 : 24-HOUR AVERAGE CONCENTRATION VALUE OF PARTICULATE MATTER (PM-10) FROM AIR QUALITY MONITORING STATION AT PLUAK DAENG DISTRICT PUBLIC HEALTH OFFICE IN 2015 IN THE CASE WHERE UNUSUALLY HIGH VALUES ARE IGNORED

TABLE 5.1.1-7

DISTANCE FROM THE SENSITIVE RECEPTOR TO THE AIR QUALITY MONITORING POINT/STATION

Sensitive receptor	Distance from the receptor to the air quality monitoring point/station (kilometer)						Air quality monitoring point/ station situated closest to the receptor
	Pluak Daeng Power Plant Project site	Village No.2, Ban Noen Sawan	Prasitharam Temple	Ban Map Toei School	community in the west of the project site	Pluak Daeng District Public Health Office	
1. Map Yang Phon Sub-district Administrative Organization	1.29	2.82	4.90	0.09	3.63	4.79	Ban Map Toei School
2. Ban Map Toei School	1.21	2.84	4.80	0	3.55	4.88	Ban Map Toei School
3. Map Toei Temple	1.12	2.88	4.67	0.15	3.46	4.99	Ban Map Toei School
4. Nikhom Sang Ton Eng 9 School	2.64	5.42	0.10	4.72	2.45	9.43	Prasitharam Temple
5. Prasitharam Temple	2.75	5.57	0	4.79	2.62	9.47	Prasitharam Temple
6. Map Yang Phon Sub-district Health Promoting Hospital	3.80	2.59	6.67	5.37	4.15	8.85	Village No.2, Ban Noen Sawan
7. Ban Map Yang Phon School	3.45	2.22	6.44	5.01	3.91	8.52	Village No.2, Ban Noen Sawan
8. Map Yang Phon Temple	2.90	1.60	6.20	4.41	3.66	7.90	Village No.2, Ban Noen Sawan
9. Pluak Daeng Sub-district Administrative Organization	4.96	5.54	8.39	3.75	7.29	1.13	Pluak Daeng District Public Health Office
10. Orawin Witthaya School	4.81	5.68	8.08	3.59	7.16	1.52	Pluak Daeng District Public Health Office
11. Pluak Daeng High Voltage Electricity Station	4.54	4.30	8.53	3.75	6.82	2.63	Pluak Daeng District Public Health Office
12. Wang Pradu Temple	3.33	5.87	4.74	3.15	5.17	5.77	Ban Map Toei School
13. Wang Pradu School (closed down)	3.33	5.84	4.82	3.10	5.20	5.65	Ban Map Toei School
14. Village No. 5, Ban Khlong Plu	2.58	5.69	1.35	4.29	3.19	8.68	Prasitharam Temple
15. Village No. 7, Ban Wang Pla	2.78	5.41	0.36	4.54	2.55	9.20	Prasitharam Temple

TABLE 5.1.1-7

DISTANCE FROM THE SENSITIVE RECEPTOR TO THE AIR QUALITY MONITORING POINT/STATION (CONT'D)

Sensitive receptor	Distance from the receptor to the air quality monitoring point/station (kilometer)						Air quality monitoring point/ station situated closest to the receptor
	Pluak Daeng Power Plant Project site	Village No.2, Ban Noen Sawan	Prasitharam Temple	Ban Map Toei School	community in the west of the project site	Pluak Daeng District Public Health Office	
16. Village No. 8, Ban Soi 13	2.60	5.33	<u>0.60</u>	4.95	2.24	9.74	Prasitharam Temple
17. Village No. 7, Ban Wang Pradu	3.10	5.56	4.70	<u>2.83</u>	4.97	5.56	Ban Map Toei School
18. Village No. 4, Ban Khao Mapud	3.17	5.31	<u>1.27</u>	5.28	2.17	10.12	Prasitharam Temple
19. Village No. 5, Ban Wang Tan Mon	<u>1.26</u>	3.92	1.66	3.26	1.35	8.08	Pluak Daeng Power Plant Project site
20. Village No. 1, Ban Map Toei	1.46	3.54	4.36	<u>0.85</u>	3.58	5.16	Ban Map Toei School
21. Village No. 7, Ban Chak Oi	3.08	4.36	6.11	<u>1.78</u>	5.28	3.41	Ban Map Toei School
22. Village No. 6, Ban Map Yang Mai	2.25	2.32	4.27	4.16	<u>1.79</u>	8.60	community in the west of the project site
23. Village No. 6, Ban Thab Tong	2.89	3.47	6.58	<u>1.77</u>	5.20	3.22	Ban Map Toei School
24. Village No. 2, Ban Noen Sawan	0.81	<u>0</u>	4.84	2.24	2.58	6.39	Village No. 2, Ban Noen Sawan
25. Village No. 4, Ban Wang Ta Phin	2.94	2.87	6.83	<u>2.13</u>	5.13	3.63	Ban Map Toei School
26. Village No. 3, Ban Map Yang Phon	2.49	<u>0.90</u>	6.33	3.63	3.87	6.79	Village No. 2, Ban Noen Sawan
27. Village No. 6, Ban Nong Rakam	<u>4.52</u>	7.64	3.40	5.64	5.43	9.19	Pluak Daeng Power Plant Project site
28. Village No. 5, Ban Khlong Phlu	<u>4.04</u>	7.11	1.98	5.71	4.40	9.92	Pluak Daeng Power Plant Project site
29. Village No. 7, Ban Wang Pla	2.52	6.73	<u>1.21</u>	5.84	3.74	10.39	Prasitharam Temple
30. Village No. 8, Ban Soi 13	3.97	6.54	<u>1.30</u>	6.09	3.42	10.81	Prasitharam Temple
31. Village No. 4, Ban Chak Manthed	5.02	7.15	6.63	<u>4.32</u>	6.97	5.01	Ban Map Toei School

Note: The underlined figure is the closest distance from the sensitive receptor to the air quality monitoring station.

TABLE 5.1.1-8

HIGHEST VALUES IN THE EXISTING DATA ON AIR QUALITY MONITORING WHICH ARE USED TO REPRESENT EACH RECEPTOR'S AIR POLLUTANT CONCENTRATION LEVEL

Sensitive receptor	Monitoring point/ station	Ambient concentration of the air pollutant ($\mu g/m^3$)[1/]											
		1-hour average NO_2	1-year average NO_2[11/]	1-hour average SO_2	24-hour average SO_2	1-year average SO_2[11/]	8-hour average TSP[11/]	24-hour average TSP	1-year average TSP[11/]	24-hour average PM-10	1-year average PM-10[11/]	1-hour average CO	8-hour average CO[11/]
1. Map Yang Phon Sub-district Administrative Organization	4/	41.40	6.74	7.08	5.24	1.15	110.78	138.00	42.41	88.00	27.04	1,145.60	755.81
2. Ban Map Toei School	4/	41.40	6.74	7.08	5.24	1.15	110.78	138.00	42.41	88.00	27.04	1,145.60	755.81
3. Map Toei Temple	4/	41.40	6.74	7.08	5.24	1.15	110.78	138.00	42.41	88.00	27.04	1,145.60	755.81
4. Nikhom Sang Ton Eng 9 School	3/	34.44	5.60	6.55	5.24	1.07	102.75	128.00	39.33	88.00	27.04	1,145.60	755.81
5. Prasitharam Temple	3/	34.44	5.60	6.55	5.24	1.07	102.75	128.00	39.33	88.00	27.04	1,145.60	755.81
6. Map Yang Phon Sub-district Health Promoting Hospital	2/	57.96	9.43	11.79	47.17	1.92	115.59	144.00	44.25	78.00	23.97	2,062.09	1,360.47
7. Ban Map Yang Phon School	2/	57.96	9.43	11.79	47.17	1.92	115.59	144.00	44.25	78.00	23.97	2,062.09	1,360.47
8. Map Yang Phon Temple	2/	57.96	9.43	11.79	47.17	1.92	115.59	144.00	44.25	78.00	23.97	2,062.09	1,360.47
9. Pluak Daeng Sub-district Administrative Organization	6/	67.74	11.02	39.83	7.88	6.48	110.78	138.00	42.41	86.50	26.58	1,145.60	755.81
10. Orawin Witthaya School	6/	67.74	11.02	39.83	7.88	6.48	110.78	138.00	42.41	86.50	26.58	1,145.60	755.81

TABLE 5.1.1-8

HIGHEST VALUES IN THE EXISTING DATA ON AIR QUALITY MONITORING WHICH ARE USED TO REPRESENT EACH RECEPTOR'S AIR POLLUTANT CONCENTRATION LEVEL (CONT'D)

Sensitive receptor	Monitoring point/ station	Ambient concentration of the air pollutant ($\mu g/m^3$)[1/]											
		1-hour average NO_2	1-year average NO_2[11/]	1-hour average SO_2	24-hour average SO_2	1-year average SO_2[11/]	8-hour average TSP[11/]	24-hour average TSP	1-year average TSP[11/]	24-hour average PM-10	1-year average PM-10[11/]	1-hour average CO	8-hour average CO[11/]
11. Pluak Daeng High Voltage Electricity Station	6/	67.74	11.02	39.83	7.88	6.48	110.78	138.00	42.41	86.50	26.58	1,145.60	755.81
12. Wang Pradu Temple	4/	41.40	6.74	7.08	5.24	1.15	110.78	138.00	42.41	88.00	27.04	1,145.60	755.81
13. Wang Pradu School (closed down)	4/	41.40	6.74	7.08	5.24	1.15	110.78	138.00	42.41	88.00	27.04	1,145.60	755.81
14. Village No.5, Ban Khlong Plu	3/	34.44	5.60	6.55	5.24	1.07	102.75	128.00	39.33	88.00	27.04	1,145.60	755.81
15. Village No.7, Ban Wang Pla	3/	34.44	5.60	6.55	5.24	1.07	102.75	128.00	39.33	88.00	27.04	1,145.60	755.81
16. Village No.8, Ban Soi 13	3/	34.44	5.60	6.55	5.24	1.07	102.75	128.00	39.33	88.00	27.04	1,145.60	755.81
17. Village No.7, Ban Wang Pradu	4/	41.40	6.74	7.08	5.24	1.15	110.78	138.00	42.41	88.00	27.04	1,145.60	755.81
18. Village No.4, Ban Khao Mapud	3/	34.44	5.60	6.55	5.24	1.07	102.75	128.00	39.33	88.00	27.04	1,145.60	755.81
19. Village No.5, Ban Wang Tan Mon	1/	40.65	6.62	11.01	6.03	1.79	85.09	106.00	32.57	63.00	19.36	1,145.60	755.81
20. Village No.1, Ban Map Toei	4/	41.40	6.74	7.08	5.24	1.15	110.78	138.00	42.41	88.00	27.04	1,145.60	755.81

TABLE 5.1.1-8

HIGHEST VALUES IN THE EXISTING DATA ON AIR QUALITY MONITORING WHICH ARE USED TO REPRESENT EACH RECEPTOR'S AIR POLLUTANT CONCENTRATION LEVEL (CONT'D)

Sensitive receptor	Monitoring point/ station	Ambient concentration of the air pollutant ($\mu g/m^3$)[1/]											
		1-hour average NO_2	1-year average NO_2[11/]	1-hour average SO_2	24-hour average SO_2	1-year average SO_2[11/]	8-hour average TSP[11/]	24-hour average TSP	1-year average TSP[11/]	24-hour average PM-10	1-year average PM-10[11/]	1-hour average CO	8-hour average CO[11/]
21. Village No.7, Ban Chak Oi	4/	41.40	6.74	7.08	5.24	1.15	110.78	138.00	42.41	88.00	27.04	1,145.60	755.81
22. Village No.6, Ban Map Yang Mai	5/	48.36	7.87	10.74	5.50	1.75	88.30	110.00	33.80	65.00	19.97	916.48	604.65
23. Village No.6, Ban Thab Tong	4/	41.40	6.74	7.08	5.24	1.15	110.78	138.00	42.41	88.00	27.04	1,145.60	755.81
24. Village No.2, Ban Noen Sawan	2/	57.96	9.43	11.79	47.17	1.92	115.59	144.00	44.25	78.00	23.97	2,062.09	1,360.47
25. Village No.4, Ban Wang Ta Phin	4/	41.40	6.74	7.08	5.24	1.15	110.78	138.00	42.41	88.00	27.04	1,145.60	755.81
26. Village No.3, Ban Map Yang Phon	2/	57.96	9.43	11.79	47.17	1.92	115.59	144.00	44.25	78.00	23.97	2,062.09	1,360.47
27. Village No.6, Ban Nong Rakam	1/	40.65	6.62	11.01	6.03	1.79	85.09	106.00	32.57	63.00	19.36	1,145.60	755.81
28. Village No.5, Ban Khlong Phlu	1/	40.65	6.62	11.01	6.03	1.79	85.09	106.00	32.57	63.00	19.36	1,145.60	755.81
29. Village No.7, Ban Wang Pla	3/	34.44	5.60	6.55	5.24	1.07	102.75	128.00	39.33	88.00	27.04	1,145.60	755.81
30. Village No. 8, Ban Soi 13	3/	34.44	5.60	6.55	5.24	1.07	102.75	128.00	39.33	88.00	27.04	1,145.60	755.81

TABLE 5.1.1-8

HIGHEST VALUES IN THE EXISTING DATA ON AIR QUALITY MONITORING WHICH ARE USED TO REPRESENT EACH RECEPTOR'S AIR POLLUTANT CONCENTRATION LEVEL (CONT'D)

Sensitive receptor	Monitoring point/ station	Ambient concentration of the air pollutant ($\mu g/m^3$)[1/]											
		1-hour average NO_2	1-year average NO_2[11/]	1-hour average SO_2	24-hour average SO_2	1-year average SO_2[11/]	8-hour average TSP[11/]	24-hour average TSP	1-year average TSP[11/]	24-hour average PM-10	1-year average PM-10[11/]	1-hour average CO	8-hour average CO[11/]
31. Village No.4, Ban Chak Manthed	4/	41.40	6.74	7.08	5.24	1.15	110.78	138.00	42.41	88.00	27.04	1,145.60	755.81

Remark:
- 1/ Pluak Daeng Power Plant Project site
- 2/ Village No. 2, Ban Noen Sawan
- 3/ Prasitharam Temple
- 4/ Ban Map Toei School
- 5/ the community in the west of the project site in Village No. 5, Map Yang Phon Sub-district
- 6/ Air Quality Monitoring Station at Pluak Daeng District Public Health Office
- 7/ Announcement of the National Environment Board No. 33 (2009) on nitrogen dioxide ambient concentration standard specification
- 8/ Announcement of the National Environment Board No. 21 (2001) on sulfur dioxide ambient concentration standard specification
- 9/ Announcement of the National Environment Board No. 10 (1995) and No. 24 (2004) on ambient air quality standard specification
- 10/ OSHA Standard, Part title: Safety and health regulations for construction, Subpart title: Occupational health and environmental controls, Standard number 1926.55 App A
- 11/ Calculation of 1-year average value of NO_2, 1-year average value of SO_2, 8-hour average value of TSP, 1-year average value of TSP, 1-year average value of PM-10, and 8-hour average value of CO is based on the details shown in Table 5.1.1-5.
- * In the case of the highest values in the monitoring by Air Quality Monitoring Station at Pluak Daeng District Public Health Office there are no data on the values of total suspended particulate (TSP) and carbon monoxide (CO), therefore the highest values in the monitoring by the monitoring point second closest to the receptor, which is the air quality monitoring station at Ban Map Toei School, are used instead.

- **Particulate Matter**

The expected impact during Construction Phase is only dust dispersion from excavation and open cut activities. The value of dust dispersion used in impact assessment during construction of the the project derived from US.EPA, Subject: Compilation of Emission Factor, AP-42,1995, is 1.2 ton/arce of construction area/month of construction activity. The project area covers approximately 492 rai or 787,200 square meters in Pluak Daeng Industrial Park, under the administration of Rojana Industrial Park Rayong 2 Co., Ltd.; is approved in the environmental impact assessment report on the Pluak Daeng Industrial Park Extension, Phase 1. According to the land sale and purchase agreement that the project enters into with Rojana Industrial Park Public Company Limited (the parent company of Rojana Industrial Park Rayong 2 Co., Ltd.), land levelling is the responsibility of Pluak Daeng Industrial Park in order that the execution of the project can be readily accommodated. In other words, Pluak Daeng Industrial Park is accountable for land levelling in the project by virtue of the said land sale and purchase agreement and is also obliged to comply with the measures for environmental impact prevention and reduction approved by the Office of Natural Resources and Environmental Policy and Planning. Consequently, the only construction activities potentially causing dust particle dispersion are excavation work for underpinning and construction ponds which will involve topsoil excavation covering the area of about 748,297 square meters, as shown in **Table 5.1.1-9**. The topsoil excavation is expected to take about 18 months (540 days), during which pipe rack foundations are laid, then steel sheets are assembled into pipe racks.

Welding of each part can be carried out alongside the construction of the power plant. In this way, during the construction phase of the project, topsoil excavation is expected to be at the rate of about 1,358.7 square meters per day and is to be executed only during daytime for 8 hours (8.00-17.00 hours). Therefore, impacts from dust particle dispersion potentially caused by topsoil excavation during the construction of pipe racks are incorporated into those incurred in the power plant's foundation and piling activities.

- **Amounts of pollutants released from the vehicles and machines used in the construction activities**

In the consulting team's assessment of the amounts of pollutants released from the vehicles and engines used in the construction activities, as such construction activities do not happen simultaneously, the assessment is carried out on the basis of each activity, namely piling, ground levelling, building, and transporting activities with reference to On-Road - EMFAC 2007 (v2.3) Emission Factors pursuant to California Environmental Quality Act (CEQA). The main pollutants, which are nitrogen dioxide (NO_2), carbon monoxide (CO), particulate matter 10 micrometers or less in diameter (PM-10), are investigated during the working period of eight hours (08.00-17.00 hours). The emission rates of pollutants from vehicles and engines used in the construction activities are shown in **Table 5.1.1-10** and the specifications are shown in **Table 5.1.1-11**.

TABLE 5.1.1-9
DETAILS OF THE AREAS IN PLUAK DAENG POWER PLANT PROJECT WHERE TOPSOIL EXCAVATION WORK IS TO BE EXECUTED

Different areas in the project	Approximate size (square meter.)
(1) Power Block Area	
– Power block	111,318
– Electricity transformer area	1,560
Total (1)	**112,878**
(2) Balance of Plant Area	
– Gas metering station	6,122
– Gas compressor area	2,400
– Diesel storage tank area	6,726
– Water treatment and wastewater treatment area	34,108
– Cooling water area	33,118
Total (2)	**82,474**
(3) Pond Area	
– Raw water pond	45,358
– Cooling water holding pond	20,221
– Wastewater holding pond	72
– Storm water pond	46,266
Total (3)	**111,917**
(4) Area of Buildings	
– Control building	1,000
– Workshop & warehouse building	1,200
– Administration building and security officer's booth	800
Total (4)	**3,000**
(5) Other areas such as for road, ditch, drainage pipeline, right of way in power transmission line, etc.	**438,028**
Grand Total	**748,297**

Source: Gulf PD Co., Ltd., 2016.

TABLE 5.1.1-10.
EMISSION RATES OF POLLUTANTS FROM THE VEHICLES AND ENGINES USED IN THE CONSTRUCTION ACTIVITIES

Pollutant source[2/]	Quantity	Emission factor (lb-hr)[1/]			Emission rate (gram/second)		
		NO_X	CO	PM-10	NO_X	CO	PM-10
1. Piling activities							
Pile driver	5	0.2666	0.3455	0.0334	1.333	1.728	0.167
Water tanker truck	2	0.1443	0.0741	0.0095	0.289	0.148	0.019
Total	**7**				**1.622**	**1.876**	**0.186**
2. Building activities							
Backhoe	10	0.1443	0.0741	0.0095	1.443	0.741	0.095
Crane	15	0.2666	0.3455	0.0334	3.999	5.183	0.501
Water tanker truck	2	0.1443	0.0741	0.0095	0.289	0.148	0.019
Total	**27**				**5.731**	**6.072**	**0.615**
3. Transporting activities							
Machinery transportation truck	10	0.1443	0.0741	0.0095	1.443	0.741	0.095
Equipment transportation truck	30	0.1443	0.0741	0.0095	4.329	2.223	0.285
Total	**40**				**5.772**	**2.964**	**0.380**

Source : 1/ Off-Road - OFFROAD Model Mobile Source Emission Factors, http://www.aqmd.gov – retrieved on 22th January 2016 (the horsepower rating of the engine is as proposed in the California Environmental Quality Act (CEQA))
2/ Generator Specifications, http://www.baifapower.com/products/10KVA-200KVA.html (retrieved on 21th July 2016)

TABLE 5.1.1-11
SPECIFICATIONS OF THE VEHICLES AND ENGINES USED IN THE CONSTRUCTION ACTIVITIES

Engine	Stack		Temperature[2/] (°C)	Air flow rate [2/] (m^3/s)
	Height[1/] (m)	Diameter[1/] (m)		
pile driver	3.56	0.15	482	0.297
backhoe	2.79	0.11	538	0.105
crane	3.56	0.15	482	0.297
water tanker truck	2.00	0.15	538	0.105
machinery transportation truck	2.00	0.15	538	0.105
equipment transportation truck	2.00	0.15	538	0.105

Source : 1/ Generator Specifications, http://www.baifapower.com/products/10KVA-200KVA.html (retrieved on 21th July 2016)
2/ Engine Horsepower, http://www.donaldsonexhaust.com (retrieved on 21th July 2016)

In estimating the concentration of nitrogen dioxide released from the engines during the construction phase, the consulting team choose the Plume Volume Molar Ratio Method (PVMRM) in determining the conversion factor of NO_2/NO_x, because the ozone concentration monitoring results of Pluak Daeng District Public Health Office's Air Quality Monitoring Station, Rayong Province, under the charge of the Pollution Control Department, are on an hourly basis. The data used are collected in 2015.

The equilibrium $NO_2/NO_{x\ r}$ ratio is 0.90. The in-stack NO_2/NO_x ratio is 0.11 for trucks and heavy engines powered by diesel fuel (reference - Truck/Cars, Diesel Heavy Duty : Modeling Compliance of The Federal 1-Hour NO_2 NAAQS, the California Air Pollution Control Officers Association (CAPCOA), 2011).

(1.3) Case study in the assessment of air quality impact during the construction phase

The case study in the assessment of air quality impact during the construction phase can be summarized as follows:

(a) Assessment of dust particle dispersion caused by topsoil excavation in the construction sites

- The case before the dust particle suppression measure is established
- The case when there is measure to suppress dust particle dispersion with water spray

(b) Amounts of pollutants released from the vehicles and machines used in the construction activities

- the case where the assessment is on the impact incurred by the piling activities
- the case where the assessment is on the impact incurred by the building activities
- the case where the assessment is on the impact incurred by the transporting activities

(1.4) Findings from the assessment in the construction phase

Findings from the assessment in the construction phase can be classified into 2 main cases, as mentioned in (1.3). For the assessment of dust particle dispersion caused by topsoil excavation in the construction sites, there are two cases - the case before the dust particle suppression measure is established and the case when there is measure to suppress dust particle dispersion with water spray twice a day. The parameters used in the assessment of the impact are the average total suspended particulate (TSP) over the period of 8 hours, 24 hours and 1 year. For the assessment of the impact caused by the vehicles and engines used in the construction activities, the parameters used are the average amount of nitrogen dioxide (NO_2) over the period of 1 hour, and 1 year; the average amount of carbon monoxide (CO) over the period of 1 hour, and 8 hours; and the average amount of particulate matter 10 micrometers or less in diameter (PM-10) over the period of 24 hours, and 1 year. The findings reveal that the air pollutant values in the study area and sensitive receptors are lower than the values stipulated in general ambient air quality standards. The details are as follows:

(a) Assessment of dust particle dispersion resulting from topsoil excavation in the construction sites

- **Average total suspended particulate (TSP) over the period of 8 hours**

The case before the dust particle suppression measure is established

The execution of the project causes the highest concentration level of the total suspended particulate (TSP) in the ambience over the period of 8 hours on average in the project site, the grid reference for which is 733628 E 1433214 N. The concentration level is 480.31 $\mu g/m^3$, accounting for 3.20% of that stipulated in the Occupational Safety and Health Administration (OSHA) standards, according to which the average TSP in the ambience over the period of 8 hours must not exceed 15,000 $\mu g/m^3$, as shown in **Table 5.1.1-12**.

When considered together with the existing monitoring results (the highest value in the existing monitoring of the average TSP over the period of 24 hours in the project area during 13th-20th February 2016, which is 132.04 $\mu g/m^3$), the highest concentration level of the average TSP in the ambience over the period of 8 hours on average is 612.35 micrograms/ cubic meter or 4.08% of that stipulated in the OSHA standards, as shown in **Table 5.1.1-12**.

The case when there is measure to suppress dust particle dispersion with water spray twice a day

In the case when there is measure to suppress dust particle dispersion with water spray twice a day, the highest concentration level of 8-hour average TSP in the ambience caused by the project's construction activities is registered in the project site, the grid reference for which is 733628 E 1433214 N, and is 240.16 $\mu g/m^3$ or 1.60% of that stipulated in the OSHA standards, as shown in **Table 5.1.1-12**. When considered together with the existing monitoring results (the highest value in the current monitoring of the average TSP over the period of 24 hours in the project precinct during 13th-20th February 2016, which is 132.04 $\mu g/m^3$), the highest concentration level of the average TSP in the ambience over the period of 8 hours is 372.20 $\mu g/m^3$ or 2.48% of that stipulated in the OSHA standards, as shown in **Table 5.1.1-12**.

TABLE 5.1.1-12
ESTIMATED VALUES OF 8-HOUR AVERAGE TOTAL SUSPENDED PARTICULATE (TSP) CAUSED BY THE PROJECT'S CONSTRUCTION ACTIVITIES

Details	Concentration levels of 8-hour average total suspended particulate (TSP) ($\mu g/m^3$)				
	Results of the assessment by using the AERMOD model		Concentration level according to existing monitoring data [2/]	Results of the assessment by using the AERMOD model and existing monitoring data	
	Before the mitigation measure is established	When there is dust suppression measure by using water spray twice a day[1/]		Before the mitigation measure is established	When there is dust suppression measure by using water spray twice a day[1/]
Highest concentration value	480.31	240.16	132.04	612.35	372.20
Grid reference	733628E, 1433214N				
Location	project site				
Direction and distance from the project site	-				
Type of land	industrial park				
Standard value[3/]	**15,000**				

Remark: 1/ Application of water spray to the construction sites twice a day can suppress dust particle dispersion by 50%.(Source: National Pollution Inventory (NPI), Emission Estimation Technique Manual for Mining,Version 3.1, National Pollutant Inventory, Canberra, Australia, January 2012 :Table 4)

2/ The calculation is based on the highest value in the current monitoring of the average TSP over the period of 24 hours in the project area during 13th-20th February 2016 and the equation applied in the calculation is $C_1/C_2 = (t_2/t_1)^n$ (reference - Air Pollution: Original and Control, 2nd Edition, Harper Collins Publisher, 1981)

where

C_1 and C_2 = concentration value at t_1 and t_2

n = constant, which is 0.17-0.20 (n =0.2)

t_1 and t_2 = a particular period (minute)

3/ OSHA Standard, Part title: Safety and health regulations for construction, Subpart title: Occupational health and environmental controls, Standard number 1926.55 App A

Source : Team Consulting Engineering and Management Co., Ltd., 2016

- **Average total suspended particulate (TSP) over the period of 24 hours**

The case before the dust particle suppression measure is established

The execution of the project causes the highest concentration level of the average TSP in the ambience over the period of 24 hours in the project site, the grid reference for which is 733628 E 1433214 N. The concentration level is 185.54 $\mu g/m^3$, accounting for 56.22% of national ambient air quality standards, according to which the average TSP in the ambience over the period of 24 hours must not exceed 330 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of the average TSP in the ambience over the period of 24 hours range between 0.55-8.99 $\mu g/m^3$ or 0.18-2.72% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-13**.

When considered together with the existing monitoring results, the highest concentration level of the average TSP in the ambience over the period of 24 hours is 291.54 $\mu g/m^3$, accounting for 88.35% of that stipulated in general ambient air quality standards, according to which the average TSP in the ambience over the period of 24 hours must not exceed 3300 $\mu g/m^3$. For the 31 sensitive receptors, the concentration levels of the average TSP in the ambience over the period of 24 hours range between 106.72-149.01 $\mu g/m^3$ or 32.34-45.15% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-13**.

The case when there is measure to suppress dust particle dispersion with water spray twice a day

In the case when there is measure to suppress dust particle dispersion with water spray twice a day, the highest concentration level of 24-hour average TSP in the ambience caused by the project's construction activities is registered in the project site, the grid reference for which is 733628 E 1433214 N, and is 92.77 $\mu g/m^3$, accounting for 28.11% of that stipulated in general ambient air quality standards, according to which the average TSP in the ambience over the period of 24 hours must not exceed 3,300 $\mu g/m^3$. For the 31 sensitive receptors, the average concentration levels of the TSP in the ambience over the period of 24 hours range between 0.29-4.50 $\mu g/m^3$ or 0.09-1.368% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-13**.

TABLE 5.1.1-13

ESTIMATED VALUES OF 24-HOUR AVERAGE TOTAL SUSPENDED PARTICULATE (TSP) CAUSED BY THE PROJECT'S CONSTRUCTION ACTIVITIES

Details	Concentration levels of 24-hour average total suspended particulate (TSP) ($\mu g/m^3$)				
	Results of the assessment by using the AERMOD model		Concentration level according to existing monitoring data [3/]	Results of the assessment by using the AERMOD model and existing monitoring data	
	Before the mitigation measure is established	When there is dust suppression measure by using water spray twice a day[1/]		Before the mitigation measure is established	When there is dust suppression measure by using water spray twice a day[1/]
Highest concentration value	185.54	92.77	106[2/]	291.54	198.77
Grid reference	733628E, 1433214N				
Location	project site				
Direction and distance from the project site	-				
Type of land	industrial park				
Sensitive receptor					
1. Map Yang Phon Sub-district Administrative Organization	5.57	2.78	138	143.57	140.78
2. Ban Map Toei School	6.49	3.25	138	144.49	141.25
3. Map Toei Temple	8.37	4.19	138	146.37	142.19
4. Nikhom Sang Ton Eng 9 School	2.82	1.41	128	130.82	129.41
5. Prasitharam Temple	3.07	1.53	128	131.07	129.53
6. Map Yang Phon Sub-district Health Promoting Hospital	1.71	0.85	144	145.71	144.85
7. Ban Map Yang Phon School	0.59	0.29	144	144.59	144.29
8. Map Yang Phon Temple	2.10	1.05	144	146.10	145.05
9. Pluak Daeng Sub-district Administrative Organization	0.82	0.41	138	138.82	138.41
10. Orawin Witthaya School	1.22	0.61	138	139.22	138.61
11. Pluak Daeng High Voltage Electricity Station	1.21	0.60	138	139.21	138.60
12. Wang Pradu Temple	2.02	1.01	138	140.02	139.01

TABLE 5.1.1-13

ESTIMATED VALUES OF 24-HOUR AVERAGE TOTAL SUSPENDED PARTICULATE (TSP) CAUSED BY THE PROJECT'S CONSTRUCTION ACTIVITIES (CONT'D)

Details	Concentration levels of 24-hour average total suspended particulate (TSP) ($\mu g/m^3$)				
	Results of the assessment by using the AERMOD model		Concentration level according to existing monitoring data 3/	Results of the assessment by using the AERMOD model and existing monitoring data	
	Before the mitigation measure is established	When there is dust suppression measure by using water spray twice a day 1/		Before the mitigation measure is established	When there is dust suppression measure by using water spray twice a day 1/
13. Wang Pradu School (closed down)	2.02	1.01	138	140.02	139.01
14. Village no.5, Ban Khlong Plu	2.05	1.02	128	130.05	129.02
15. Village no.7, Ban Wang Pla	4.67	2.33	128	132.67	130.33
16. Village no.8, Ban Soi 13	2.79	1.39	128	130.79	129.39
17. Village no.7, Ban Wang Pradu	1.68	0.84	138	139.68	138.84
18. Village no.4, Ban Khao Mapud	3.27	1.64	128	131.27	129.64
19. Village no.5, Ban Wang Tan Mon	8.99	4.50	106	114.99	110.50
20. Village no.1, Ban Map Toei	3.53	1.76	138	141.53	139.76
21. Village no.7, Ban Chak Oi	1.99	0.99	138	139.99	138.99
22. Village no.6, Ban Map Yang Mai	1.89	0.94	110	111.89	110.94
23. Village no.6, Ban Thab Tong	1.24	0.62	138	139.24	138.62
24. Village no.2, Ban Noen Sawan	5.01	2.50	144	149.01	146.50
25. Village no.4, Ban Wang Ta Phin	1.64	0.82	138	139.64	138.82
26. Village no.3, Ban Map Yang Phon	3.32	1.66	144	147.32	145.66
27. Village no.6, Ban Nong Rakam	0.72	0.36	106	106.72	106.36
28. Village no.5, Ban Khlong Phlu	1.30	0.65	106	107.30	106.65
29. Village no.7, Ban Wang Pla	2.84	1.42	128	130.84	129.42

TABLE 5.1.1-13
ESTIMATED VALUES OF 24-HOUR AVERAGE TOTAL SUSPENDED PARTICULATE (TSP) CAUSED BY THE PROJECT'S CONSTRUCTION ACTIVITIES (CONT'D)

Details	Concentration levels of 24-hour average total suspended particulate (TSP) ($\mu g/m^3$)				
	Results of the assessment by using the AERMOD model		Concentration level according to existing monitoring data 3/	Results of the assessment by using the AERMOD model and existing monitoring data	
	Before the mitigation measure is established	When there is dust suppression measure by using water spray twice a day 1/		Before the mitigation measure is established	When there is dust suppression measure by using water spray twice a day 1/
30. Village no.8, Ban Soi 13	1.53	0.77	128	129.53	128.77
31. Village no.4, Ban Chak Manthed	0.67	0.34	138	138.67	138.34
Standard value	330 4/				

Remark : 1/ Application of water spray to the construction sites twice a day can suppress dust particle dispersion by 50%.
(Source : National Pollution Inventory (NPI), Emission Estimation Technique Manual for Mining, Version 3.1, National Pollutant Inventory, Canberra, Australia, January 2012 : Table 4)

2/ When reference to Table 5.1.1-5 : Highest values in the existing data on the ambient air quality monitoring in the project's vicinity

3/ With reference to Table 5.1.1-8 : Highest values in the existing data on air quality monitoring which are used to represent each receptor's air pollutant concentration level

4/ Announcement of the National Environment Board No. 24 (2004) on ambient air quality standard specification

Source : Team Consulting Engineering and Management Co., Ltd., 2016

When considered together with the existing monitoring results, the highest concentration level of 24-hour average TSP in the ambience is 198.77 µg/m^3 or 60.23% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the concentration levels of the average TSP in the ambience over the period of 24 hours range between 106.36-146.50 µg/m^3 or 32.23-44.39% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-13**.

- **Average total suspended particulate (TSP) over the period of 1 year**

The case before the dust particle suppression measure is established

The execution of the project causes the highest concentration level of the total suspended particulate (TSP) in the ambience over the period of one year on average in the project site, the grid reference for which is 733728 E 1433214 N. The concentration level is 0.007 µg/m^3, accounting for 0.007% of that stipulated in general ambient air quality standards, according to which the average TSP in the ambience over the period of 1 year must not exceed 100 µg/m^3. For the 31 sensitive receptors, the average concentration levels of the TSP in the ambience over the period of one year range between 0.000001-0.000036 µg/m^3 or 0.000001-0.000036% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-14**.

When considered together with the existing monitoring results, the highest concentration level of 1-year average TSP in the ambience is 32.577 µg/m^3 or 32.577% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the concentration levels of the average TSP in the ambience over the period of one year range between 44.250026-32.570002 µg/m^3 or 44.250026-32.570002% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-14**.

The case when there is measure to suppress dust particle dispersion with water spray twice a day

In the case when there is measure to suppress dust particle dispersion with water spray twice a day, the highest concentration level of 1-year average TSP in the ambience caused by the project's construction activities is registered in the project site, the grid reference for which is 733728 E 1433214 N, and is 0.004 µg/m^3, accounting for 0.004% of that stipulated in general ambient air quality standards, according to which the average TSP in the ambience over the period of one year must not exceed 100 µg/m^3. For the 31 sensitive receptors, the average concentration levels of the TSP in the ambience over the period of one year range between 32.570001-44.250013 µg/m^3 or 32.570001-44.250013% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-14**.

TABLE 5.1.1-14

ESTIMATED VALUES OF 1-YEAR AVERAGE TOTAL SUSPENDED PARTICULATE (TSP) CAUSED BY THE PROJECT'S CONSTRUCTION ACTIVITIES

Details	Concentration levels of 1-year average total suspended particulate (TSP) ($\mu g/m^3$)				
	Results of the assessment by using the AERMOD model		Concentration level according to existing monitoring data[3/]	Results of the assessment by using the AERMOD model and existing monitoring data	
	Before the mitigation measure is established	When there is dust suppression measure by using water spray twice a day[1/]		Before the mitigation measure is established	When there is dust suppression measure by using water spray twice a day[1/]
Highest concentration value	0.007	0.004	32.57[2/]	32.577	32.574
Grid reference	733728E, 1433214N				
Location	project site				
Direction and distance from the project site	-				
Type of land	industrial park				
Sensitive receptor					
1. Map Yang Phon Sub-district Administrative Organization	0.000018	0.000009	42.41	42.410018	42.410009
2. Ban Map Toei School	0.000018	0.000009	42.41	42.410018	42.410009
3. Map Toei Temple	0.000018	0.000009	42.41	42.410018	42.410009
4. Nikhom Sang Ton Eng 9 School	0.000013	0.000007	39.33	39.330013	39.330007
5. Prasitharam Temple	0.000013	0.000007	39.33	39.330013	39.330007
6. Map Yang Phon Sub-district Health Promoting Hospital	0.000004	0.000002	44.25	44.250004	44.250002
7. Ban Map Yang Phon School	0.000002	0.000001	44.25	44.250002	44.250001
8. Map Yang Phon Temple	0.000008	0.000004	44.25	44.250008	44.250004
9. Pluak Daeng Sub-district Administrative Organization	0.000003	0.000001	42.41	42.410003	42.410001
10. Orawin Witthaya School	0.000003	0.000001	42.41	42.410003	42.410001
11. Pluak Daeng High Voltage Electricity Station	0.000003	0.000002	42.41	42.410003	42.410002
12. Wang Pradu Temple	0.000003	0.000002	42.41	42.410003	42.410002
13. Wang Pradu School (closed down)	0.000003	0.000002	42.41	42.410003	42.410002
14. Village no.5, Ban Khlong Plu	0.000007	0.000004	39.33	39.330007	39.330004
15. Village no.7, Ban Wang Pla	0.000015	0.000008	39.33	39.330015	39.330008
16. Village no.8, Ban Soi 13	0.000011	0.000005	39.33	39.330011	39.330005

TABLE 5.1.1-14

ESTIMATED VALUES OF 1-YEAR AVERAGE TOTAL SUSPENDED PARTICULATE (TSP) CAUSED BY THE PROJECT'S CONSTRUCTION ACTIVITIES (CONT'D)

Details	Concentration levels of 1-year average total suspended particulate (TSP) ($\mu g/m^3$)				
	Results of the assessment by using the AERMOD model		Concentration level according to existing monitoring data[3/]	Results of the assessment by using the AERMOD model and existing monitoring data	
	Before the mitigation measure is established	When there is dust suppression measure by using water spray twice a day[1/]		Before the mitigation measure is established	When there is dust suppression measure by using water spray twice a day[1/]
17. Village no.7, Ban Wang Pradu	0.000004	0.000002	42.41	42.410004	42.410002
18. Village no.4, Ban Khao Mapud	0.000013	0.000007	39.33	39.330013	39.330007
19. Village no.5, Ban Wang Tan Mon	0.000036	0.000018	32.57	32.570036	32.570018
20. Village no.1, Ban Map Toei	0.000015	0.000007	42.41	42.410015	42.410007
21. Village no.7, Ban Chak Oi	0.000006	0.000003	42.41	42.410006	42.410003
22. Village no.6, Ban Map Yang Mai	0.000009	0.000004	33.8	33.800009	33.800004
23. Village no.6, Ban Thab Tong	0.000006	0.000003	42.41	42.410006	42.410003
24. Village no.2, Ban Noen Sawan	0.000026	0.000013	44.25	44.250026	44.250013
25. Village no.4, Ban Wang Ta Phin	0.000006	0.000003	42.41	42.410006	42.410003
26. Village no.3, Ban Map Yang Phon	0.000014	0.000007	44.25	44.250014	44.250007
27. Village no.6, Ban Nong Rakam	0.000002	0.000001	32.57	32.570002	32.570001
28. Village no.5, Ban Khlong Phlu	0.000004	0.000002	32.57	32.570004	32.570002
29. Village no.7, Ban Wang Pla	0.000009	0.000004	39.33	39.330009	39.330004
30. Village no.8, Ban Soi 13	0.000006	0.000003	39.33	39.330006	39.330003
31. Village no.4, Ban Chak Manthed	0.000001	0.000001	42.41	42.410001	42.410001
Standard value	100[4/]				

Remark : [1/] Application of water spray to the construction sites twice a day can suppress dust particle dispersion by 50%.
(Source : National Pollution Inventory (NPI), Emission Estimation Technique Manual for Mining, Version 3.1, National Pollutant Inventory, Canberra, Australia, January 2012 : Table 4)
[2/] With reference to Table 5.1.1-5 : Highest values in the existing data on the ambient air quality monitoring in the project's vicinity
[3/] With reference to Table 5.1.1-8 : Highest values in the existing data on air quality monitoring which are used to represent each receptor's air pollutant concentration level
[4/] Announcement of the National Environment Board No. 24 (2004) on ambient air quality standard specification

Source : Team Consulting Engineering and Management Co., Ltd., 2016

(b) Amounts of pollutants released from the vehicles and engines used in the construction activities

The investigation of the pollutants released from the vehicles and engines used in the construction activities reveals that the activity that emits air pollutants most is building. Coming second and third are transporting and piling. Most of the effects of the pollutants caused by the said activities can be felt only in the project site and the air pollutant values in the study area and sensitive receptors are lower than the values stipulated in general ambient air quality standards, as shown in **Table 5.1.1-15** to **Table 5.1.1-17**, and **Appendix 5A-3**.

(2) Operation phase

During the operation phase, the main impact is caused by pollutants emitted from the stacks in the fuel burning process. The main pollutants released from the stacks of the heat recovery steam generator (HRSG) are total suspended particulate (TSP), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2). The details of the assessment of impacts resulting from the emission of pollutants in different cases are as follows:

(2.1) Selection of the model

The AERMOD mathematical model, version 9.1, which is the latest model, is used in assessing the air quality impact during the operation phase. The preparation of the input data to be used in the model are as already discussed in the part of the assessment of air quality impact during the construction phase.

(2.2) Emission source data

The main fuel to be used in generating electricity in Pluak Daeng Power Plant Project is natural gas, with diesel as reserved fuel. The pollutants from electricity generation process are to be released from the stacks of the heat recovery steam generator (HRSG), 4 in total, 60 meters high from the ground level and 8 meters in diameter. The main pollutant from electricity generation process is oxide of nitrogen (NO_x), the level of which must be regulated by the project in order to ensure that it will not exceed the established standard level. For this, Dry Low NOx (DLN) System is to be employed in the case that natural gas is used as fuel and Water Injection System in the case of diesel. The consulting team also take into consideration the emission of sulfur dioxide (SO_2) and total suspended particulate (TSP), which may spread to and negatively impact nearby communities. Emission source input data to be used in the model are as follows:

- Stack location
- Height of the stack (meter)
- Diameter of the stack (meter)
- Exit temperature (Kelvin temperature scale -°K)
- Exit velocity (meter/ second)
- Emission rate (gram/second)

TABLE 5.1.1-15

RESULTS OF THE PREDICTION OF AIR QUALITY BY USING THE AERMOD MODEL AND THE HIGHEST VALUES IN THE EXISTING MONITORING DATA IN THE CASE OF IMPACT FROM PILING ACTIVITIES

Details	Estimated highest concentration levels of air pollutants in the case of impact from piling activities ($\mu g/m^3$)																	
	1-hour average NO_2			1-year average NO^2			1-hour average CO			8-hour average CO			24-hour average PM-10			1-year average PM-10		
	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total
Highest concentration value	34.61	67.74[1/]	102.35	1.49	11.02[1/]	12.51	50.00	2,062.09[1/]	2112.09	34.77	1,360.47[1/]	1,395.24	1.37	88.00[1/]	89.37	0.17	27.04[1/]	27.21
Grid reference	733828E, 1433114N			733828E, 1433114N			733828E,1433114N			733628E, 1433114N			733628E, 1433114N			733828E, 1433114N		
Location	project site			project site			project site			project site			project site			project site		
Direction and distance from the project site	-			-			-			-			-			-		
Type of land	industrial park			industrial park			industrial park			industrial park			industrial park			industrial park		
Sensitive receptor																		
1. Map Yang Phon Sub-district Administrative Organization	11.13	41.4	52.53	0.10	6.74	6.84	14.49	1,145.60	1,160.09	4.84	755.81	760.65	0.19	88.00	88.19	0.013	27.04	15.98
2. Ban Map Toei School	10.99	41.4	52.39	0.11	6.74	6.85	14.70	1,145.60	1,160.30	4.71	755.81	760.52	0.20	88.00	88.20	0.013	27.04	15.06
3. Map Toei Temple	11.08	41.4	52.48	0.11	6.74	6.85	14.74	1,145.60	1,160.34	5.05	755.81	760.86	0.18	88.00	88.18	0.014	27.04	17.21
4. Nikhom Sang Ton Eng 9 School	6.44	34.44	40.88	0.05	5.6	5.65	8.13	1,145.60	1,153.73	2.88	755.81	758.69	0.11	88.00	88.11	0.006	27.04	17.53
5. Prasitharam Temple	6.36	34.44	40.80	0.05	5.6	5.65	8.09	1,145.60	1,153.69	2.97	755.81	758.78	0.11	88.00	88.11	0.006	27.04	17.21
6. Map Yang Phon Sub-district Health Promoting Hospital	6.75	57.96	64.71	0.04	9.43	9.47	8.66	2,062.09	2,070.75	1.90	1,360.47	1,362.37	0.09	78.00	78.09	0.005	23.97	15.06
7. Ban Map Yang Phon School	7.55	57.96	65.51	0.05	9.43	9.48	10.86	2,062.09	2,072.95	3.13	1,360.47	1,363.60	0.14	78.00	78.14	0.006	23.97	17.21
8. Map Yang Phon Temple	6.48	57.96	64.44	0.05	9.43	9.48	8.66	2,062.09	2,070.75	2.17	1,360.47	1,362.64	0.08	78.00	78.08	0.006	23.97	15.06
9. Pluak Daeng Sub-district Administrative Organization	3.42	67.74	71.16	0.02	11.02	11.04	4.45	1,145.60	1,150.05	1.51	755.81	757.32	0.05	86.50	86.55	0.003	26.58	17.21
10. Orawin Witthaya School	3.64	67.74	71.38	0.03	11.02	11.05	4.83	1,145.60	1,150.43	2.15	755.81	757.96	0.07	86.50	86.57	0.003	26.58	17.21
11. Pluak Daeng High Voltage Electricity Station	3.61	67.74	71.35	0.02	11.02	11.04	4.86	1,145.60	1,150.46	1.28	755.81	757.09	0.04	86.50	86.54	0.003	26.58	15.06
12. Wang Pradu Temple	5.60	41.4	47.00	0.01	6.74	6.75	7.18	1,145.60	1,152.78	1.19	755.81	757.00	0.06	88.00	88.06	0.002	27.04	15.06
13. Wang Pradu School (closed down)	5.46	41.4	46.86	0.01	6.74	6.75	7.67	1,145.60	1,153.27	1.29	755.81	757.10	0.05	88.00	88.05	0.002	27.04	15.06
14. Village no.5, Ban Khlong Plu	4.78	34.44	39.22	0.02	5.6	5.62	6.23	1,145.60	1,151.83	3.17	755.81	758.98	0.11	88.00	88.11	0.003	27.04	15.06
15. Village no.7, Ban Wang Pla	6.39	34.44	40.83	0.05	5.6	5.65	8.09	1,145.60	1,153.69	3.46	755.81	759.27	0.11	88.00	88.11	0.006	27.04	17.21
16. Village no.8, Ban Soi 13	5.59	34.44	40.03	0.04	5.6	5.64	7.25	1,145.60	1,152.85	2.88	755.81	758.69	0.10	88.00	88.10	0.005	27.04	17.21
17. Village no.7, Ban Wang Pradu	4.59	41.4	45.99	0.01	6.74	6.75	5.92	1,145.60	1,151.52	1.01	755.81	756.82	0.04	88.00	88.04	0.002	27.04	15.06
18. Village no.4, Ban Khao Mapud	5.49	34.44	39.93	0.04	5.6	5.64	7.27	1,145.60	1,152.87	1.53	755.81	757.34	0.05	88.00	88.05	0.004	27.04	17.21
19. Village no.5, Ban Wang Tan Mon	10.34	40.65	50.99	0.09	6.62	6.71	13.10	1,145.60	1,158.70	5.21	755.81	761.02	0.17	63.00	63.17	0.011	19.36	15.06
20. Village no.1, Ban Map Toei	9.45	41.4	50.85	0.07	6.74	6.81	12.39	1,145.60	1,157.99	2.57	755.81	758.38	0.13	88.00	88.13	0.008	27.04	15.06
21. Village no.7, Ban Chak Oi	6.08	41.4	47.48	0.04	6.74	6.78	7.90	1,145.60	1,153.50	2.26	755.81	758.07	0.07	88.00	88.07	0.005	27.04	15.06
22. Village no.6, Ban Map Yang Mai	6.02	48.36	54.38	0.02	7.87	7.89	7.97	916.48	924.45	2.13	604.65	606.78	0.07	65.00	65.07	0.003	19.97	15.06
23. Village no.6, Ban Thab Tong	4.75	41.4	46.15	0.03	6.74	6.77	6.38	1,145.60	1,151.98	1.63	755.81	757.44	0.06	88.00	88.06	0.004	27.04	15.06
24. Village no.2, Ban Noen Sawan	10.56	57.96	68.52	0.10	9.43	9.53	13.01	2,062.09	2,075.10	4.04	1,360.47	1,364.51	0.14	78.00	78.14	0.012	23.97	15.06
25. Village no.4, Ban Wang Ta Phin	4.53	41.4	45.93	0.03	6.74	6.77	5.84	1,145.60	1,151.44	1.65	755.81	757.46	0.05	88.00	88.05	0.004	27.04	15.06
26. Village no.3, Ban Map Yang Phon	6.51	57.96	64.47	0.04	9.43	9.47	8.37	2,062.09	2,070.46	2.43	1,360.47	1,362.90	0.08	78.00	78.08	0.005	23.97	15.06
27. Village no.6, Ban Nong Rakam	2.04	40.65	42.69	0.00	6.62	6.62	3.63	1,145.60	1,149.23	0.61	755.81	756.42	0.02	63.00	63.02	0.001	19.36	17.52
28. Village no.5, Ban Khlong Phlu	3.93	40.65	44.58	0.02	6.62	6.64	5.46	1,145.60	1,151.06	2.49	755.81	758.30	0.08	63.00	63.08	0.002	19.36	15.06
29. Village no.7, Ban Wang Pla	4.05	34.44	38.49	0.03	5.6	5.63	5.49	1,145.60	1,151.09	2.23	755.81	758.04	0.07	88.00	88.07	0.004	27.04	27.04

TABLE 5.1.1-15

RESULTS OF THE PREDICTION OF AIR QUALITY BY USING THE AERMOD MODEL AND THE HIGHEST VALUES IN THE EXISTING MONITORING DATA IN THE CASE OF IMPACT FROM PILING ACTIVITIES (CONT'D)

Details	Estimated highest concentration levels of air pollutants in the case of impact from piling activities ($\mu g/m^3$)																	
	1-hour average NO_2			1-year average NO_2			1-hour average CO			8-hour average CO			24-hour average PM-10			1-year average PM-10		
	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total
30. Village no.8, Ban Soi 13	5.17	34.44	39.61	0.03	5.6	5.63	6.84	1,145.60	1,152.44	2.20	755.81	758.01	0.07	88.00	88.07	0.004	27.04	27.04
31. Village no.4, Ban Chak Manthed	2.70	41.4	44.10	0.01	6.74	6.75	3.73	1,145.60	1,149.33	0.70	755.81	756.51	0.02	88.00	88.02	0.001	27.04	27.04
Standard value [3/]	320			57			34200			10260			120			50		
WHO [4/]	200			40			-			-			50			20		

Remark : [1/] With reference to Table 5.1.1-5 : Highest values in the existing data on the ambient air quality monitoring in the project's vicinity

[2/] With reference to Table 5.1.1-8 : Highest values in the existing data on air quality monitoring which are used to represent each receptor's air pollutant concentration level

[3/] With reference to the standards in :

- Announcement of the National Environment Board No. 10 (1995) and No. 24 (2004) on ambient air quality standard specification
- Announcement of the National Environment Board No. 33 (2009) on nitrogen dioxide ambient concentration standard specification

[4/] Referenced from WHO Ambient Air Quality Guidelines in Environmental, Health, and Safety (EHS) Guidelines for International Finance Corporation (2007)

Source : Team Consulting Engineering and Management Co., Ltd., 2016

TABLE 5.1.1-16

RESULTS OF THE PREDICTION OF AIR QUALITY BY USING THE AERMOD MODEL AND THE HIGHEST VALUES IN THE EXISTING MONITORING DATA IN THE CASE OF IMPACT FROM BUILDING ACTIVITIES

Details	Estimated highest concentration levels of air pollutants in the case of impact from building activities ($\mu g/m^3$)																	
	1-hour average NO_2			1-year average NO_2			1-hour average CO			8-hour average CO			24-hour average PM-10			1-year average PM-10		
	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total
Highest concentration value	115.19	67.74[1/]	182.93	6.58	11.02[1/]	17.6	133.27	2,062.09[1/]	2195.36	80.89	1,360.47[1/]	1,441.36	3.11	88.00[1/]	91.11	0.70	27.04[1/]	27.74
Grid reference	734028E, 1433014N			733928E, 1433114N			734028E, 1433114N			733728E, 1433014N			733728E, 1433014N			733928E, 1433114N		
Location	project site			project site			project site			project site			project site			project site		
Direction and distance from the project site	-			-			-			-			-			-		
Type of land	industrial park			industrial park			industrial park			industrial park			industrial park			industrial park		
Sensitive receptor																		
1. Map Yang Phon Sub-district Administrative Organization	43.87	41.4	85.27	0.40	6.74	7.14	49.50	1,145.60	1,195.10	16.00	755.81	771.81	0.60	88.00	88.60	0.045	27.04	27.08
2. Ban Map Toei School	45.43	41.4	86.83	0.42	6.74	7.16	50.57	1,145.60	1,196.17	18.53	755.81	774.34	0.68	88.00	88.68	0.048	27.04	27.09
3. Map Toei Temple	47.02	41.4	88.42	0.45	6.74	7.19	52.32	1,145.60	1,197.92	19.68	755.81	775.49	0.72	88.00	88.72	0.050	27.04	27.09
4. Nikhom Sang Ton Eng 9 School	25.72	34.44	60.16	0.18	5.6	5.78	28.52	1,145.60	1,174.12	9.77	755.81	765.58	0.38	88.00	88.38	0.021	27.04	27.06
5. Prasitharam Temple	24.79	34.44	59.23	0.18	5.6	5.78	27.41	1,145.60	1,173.01	9.68	755.81	765.49	0.41	88.00	88.41	0.020	27.04	27.06
6. Map Yang Phon Sub-district Health Promoting Hospital	26.10	57.96	84.06	0.15	9.43	9.58	29.49	2,062.09	2,091.58	7.07	1,360.47	1,367.54	0.36	78.00	78.36	0.018	23.97	23.99
7. Ban Map Yang Phon School	26.00	57.96	83.96	0.17	9.43	9.60	34.82	2,062.09	2,096.91	10.33	1,360.47	1,370.80	0.46	78.00	78.46	0.021	23.97	23.99
8. Map Yang Phon Temple	27.52	57.96	85.48	0.19	9.43	9.62	30.01	2,062.09	2,092.10	8.38	1,360.47	1,368.85	0.30	78.00	78.30	0.022	23.97	23.99
9. Pluak Daeng Sub-district Administrative Organization	12.12	67.74	79.86	0.09	11.02	11.11	14.30	1,145.60	1,159.90	4.47	755.81	760.28	0.16	86.50	86.66	0.010	26.58	26.59
10. Orawin Witthaya School	13.19	67.74	80.93	0.10	11.02	11.12	15.62	1,145.60	1,161.22	7.14	755.81	762.95	0.25	86.50	86.75	0.011	26.58	26.59
11. Pluak Daeng High Voltage Electricity Station	13.16	67.74	80.90	0.09	11.02	11.11	15.78	1,145.60	1,161.38	3.84	755.81	759.65	0.13	86.50	86.63	0.010	26.58	26.59
12. Wang Pradu Temple	21.52	41.4	62.92	0.05	6.74	6.79	25.13	1,145.60	1,170.73	4.24	755.81	760.05	0.19	88.00	88.19	0.006	27.04	27.05
13. Wang Pradu School (closed down)	20.65	41.4	62.05	0.06	6.74	6.80	26.07	1,145.60	1,171.67	4.39	755.81	760.20	0.17	88.00	88.17	0.006	27.04	27.05
14. Village no.5, Ban Khlong Plu	18.55	34.44	52.99	0.10	5.60	5.70	22.17	1,145.60	1,167.77	11.01	755.81	766.82	0.38	88.00	88.38	0.011	27.04	27.05
15. Village no.7, Ban Wang Pla	24.03	34.44	58.47	0.20	5.60	5.80	27.80	1,145.60	1,173.40	11.70	755.81	767.51	0.40	88.00	88.40	0.022	27.04	27.06
16. Village no.8, Ban Soi 13	20.90	34.44	55.34	0.16	5.60	5.76	24.60	1,145.60	1,170.20	9.90	755.81	765.71	0.34	88.00	88.34	0.018	27.04	27.06
17. Village no.7, Ban Wang Pradu	17.51	41.4	58.91	0.05	6.74	6.79	20.52	1,145.60	1,166.12	3.54	755.81	759.35	0.12	88.00	88.12	0.006	27.04	27.05
18. Village no.4, Ban Khao Mapud	20.51	34.44	54.95	0.14	5.6	5.74	23.90	1,145.60	1,169.50	5.20	755.81	761.01	0.18	88.00	88.18	0.015	27.04	27.06
19. Village no.5, Ban Wang Tan Mon	41.81	40.65	82.46	0.38	6.62	7.00	47.58	1,145.60	1,193.18	19.87	755.81	775.68	0.69	63.00	63.69	0.042	19.36	19.40
20. Village no.1, Ban Map Toei	38.04	41.4	79.44	0.28	6.74	7.02	43.06	1,145.60	1,188.66	8.20	755.81	764.01	0.46	88.00	88.46	0.031	27.04	27.07
21. Village no.7, Ban Chak Oi	23.21	41.4	64.61	0.16	6.74	6.90	26.61	1,145.60	1,172.21	7.87	755.81	763.68	0.27	88.00	88.27	0.019	27.04	27.06
22. Village no.6, Ban Map Yang Mai	21.51	48.36	69.87	0.10	7.87	7.97	26.27	916.48	942.75	5.90	604.65	610.55	0.20	65.00	65.20	0.011	19.97	19.98
23. Village no.6, Ban Thab Tong	18.25	41.4	59.65	0.12	6.74	6.86	20.81	1,145.60	1,166.41	5.64	755.81	761.45	0.23	88.00	88.23	0.014	27.04	27.05
24. Village no.2, Ban Noen Sawan	42.61	57.96	100.57	0.39	9.43	9.82	48.24	2,062.09	2,110.33	14.62	1,360.47	1,375.09	0.50	78.00	78.50	0.043	23.97	24.01
25. Village no.4, Ban Wang Ta Phin	17.35	41.4	58.75	0.13	6.74	6.87	19.90	1,145.60	1,165.50	5.67	755.81	761.48	0.19	88.00	88.19	0.014	27.04	27.05
26. Village no.3, Ban Map Yang Phon	25.02	57.96	82.98	0.17	9.43	9.60	29.07	2,062.09	2,091.16	8.14	1,360.47	1,368.61	0.28	78.00	78.28	0.019	23.97	23.99
27. Village no.6, Ban Nong Rakam	7.54	40.65	48.19	0.02	6.62	6.64	12.04	1,145.60	1,157.64	2.03	755.81	757.84	0.07	63.00	63.07	0.002	19.36	19.36

TABLE 5.1.1-16

RESULTS OF THE PREDICTION OF AIR QUALITY BY USING THE AERMOD MODEL AND THE HIGHEST VALUES IN THE EXISTING MONITORING DATA IN THE CASE OF IMPACT FROM BUILDING ACTIVITIES

Details	Estimated highest concentration levels of air pollutants in the case of impact from building activities ($\mu g/m^3$)																	
	1-hour average NO_2			1-year average NO_2			1-hour average CO			8-hour average CO			24-hour average PM-10			1-year average PM-10		
	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total
28. Village no.5, Ban Khlong Phlu	14.88	40.65	55.53	0.08	6.62	6.70	18.61	1,145.60	1,164.21	8.34	755.81	764.15	0.28	63.00	63.28	0.009	19.36	19.37
29. Village no.7, Ban Wang Pla	14.82	34.44	49.26	0.12	5.6	5.72	18.27	1,145.60	1,163.87	7.14	755.81	762.95	0.24	88.00	88.24	0.013	27.04	27.05
30. Village no.8, Ban Soi 13	19.22	34.44	53.66	0.12	5.6	5.72	22.87	1,145.60	1,168.47	7.11	755.81	762.92	0.24	88.00	88.24	0.014	27.04	27.05
31. Village no.4, Ban Chak Manthed	10.61	41.4	52.01	0.04	6.74	6.78	12.81	1,145.60	1,158.41	2.27	755.81	758.08	0.08	88.00	88.08	0.004	27.04	27.04
Standard value [3/]	320			57			34,200			10,260			120			50		
WHO [4/]	200			40			-			-			50			20		

Remark : [1/] With reference to Table 5.1.1-5 : Highest values in the existing data on the ambient air quality monitoring in the project's vicinity

[2/] With reference to Table 5.1.1-8 : Highest values in the existing data on air quality monitoring which are used to represent each receptor's air pollutant concentration level

[3/] With reference to the standards in :

- Announcement of the National Environment Board No. 10 (1995) and No. 24 (2004) on ambient air quality standard specification
- Announcement of the National Environment Board No. 33 (2009) on nitrogen dioxide ambient concentration standard specification

[4/] Referenced from WHO Ambient Air Quality Guidelines in Environmental, Health, and Safety (EHS) Guidelines for International Finance Corporation (2007)

Source : Team Consulting Engineering and Management Co., Ltd., 2016

TABLE 5.4-17

RESULTS OF THE PREDICTION OF AIR QUALITY BY USING THE AERMOD MODEL AND THE HIGHEST VALUES IN THE EXISTING MONITORING DATA IN THE CASE OF IMPACT FROM TRANSPORTING ACTIVITIES

Details	Estimated highest concentration levels of air pollutants in the case of impact from transporting activities ($\mu g/m^3$)																	
	1-hour average NO_2			1-year average NO_2			1-hour average CO			8-hour average CO			24-hour average PM-10			1-year average PM-10		
	Using the model	Using existing monitoring data [2/]	Total	using the model	using existing monitoring data [2]	total	using the model	using existing monitoring data [2]	total	using the model	using existing monitoring data [2]	total	using the model	using existing monitoring data [2]	total	using the model	using existing monitoring data [2]	total
Highest concentration value	87.33	67.74[1/]	155.07	6.82	11.02[1/]	17.84	50.15	2,062.09[1/]	2112.24	36.94	1,360.47[1/]	1,397.41	1.92	88.00[1/]	89.92	0.50	27.04[1/]	27.54
Grid reference	734128E, 1433114N			734028E, 1433214N			734128E, 1433114N			734028E,1433114N			734028E, 1433114N			734028E, 1433214N		
Location	project site			project site			project site			project site			project site			project site		
Direction and distance from the project site	-			-			-			-			-			-		
Type of land	industrial park			industrial park			industrial park			industrial park			industrial park			industrial park		
Sensitive receptor																		
1. Map Yang Phon Sub-district Administrative Organization	44.59	41.4	85.99	0.46	6.74	7.20	25.36	1,145.60	1,170.96	10.52	755.81	766.33	0.46	88.00	88.46	0.034	27.04	27.07
2. Ban Map Toei School	44.15	41.4	85.55	0.48	6.74	7.22	25.58	1,145.60	1,171.18	10.35	755.81	766.16	0.47	88.00	88.47	0.035	27.04	27.08
3. Map Toei Temple	44.23	41.4	85.63	0.50	6.74	7.24	25.26	1,145.60	1,170.86	10.34	755.81	766.15	0.49	88.00	88.49	0.036	27.04	27.08
4. Nikhom Sang Ton Eng 9 School	27.50	34.44	61.94	0.19	5.6	5.79	15.99	1,145.60	1,161.59	4.94	755.81	760.75	0.24	88.00	88.24	0.014	27.04	27.05
5. Prasitharam Temple	26.88	34.44	61.32	0.20	5.6	5.80	15.55	1,145.60	1,161.15	5.05	755.81	760.86	0.25	88.00	88.25	0.014	27.04	27.05
6. Map Yang Phon Sub-district Health Promoting Hospital	28.89	57.96	86.85	0.17	9.43	9.60	17.37	2,062.09	2,079.46	3.77	1,360.47	1,364.24	0.25	78.00	78.25	0.013	23.97	23.98
7. Ban Map Yang Phon School	25.02	57.96	82.98	0.18	9.43	9.61	16.35	2,062.09	2,078.44	5.32	1,360.47	1,365.79	0.32	78.00	78.32	0.014	23.97	23.98
8. Map Yang Phon Temple	27.97	57.96	85.93	0.21	9.43	9.64	18.41	2,062.09	2,080.50	4.78	1,360.47	1,365.25	0.21	78.00	78.21	0.016	23.97	23.99
9. Pluak Daeng Sub-district Administrative Organization	13.63	67.74	81.37	0.10	11.02	11.12	7.82	1,145.60	1,153.42	2.64	755.81	758.45	0.12	86.50	86.62	0.007	26.58	26.59
10. Orawin Witthaya School	14.88	67.74	82.62	0.10	11.02	11.12	8.73	1,145.60	1,154.33	3.77	755.81	759.58	0.17	86.50	86.67	0.008	26.58	26.59
11. Pluak Daeng High Voltage Electricity Station	14.17	67.74	81.91	0.09	11.02	11.11	8.72	1,145.60	1,154.32	2.20	755.81	758.01	0.09	86.50	86.59	0.007	26.58	26.59
12. Wang Pradu Temple	22.24	41.4	63.64	0.06	6.74	6.80	12.82	1,145.60	1,158.42	2.34	755.81	758.15	0.12	88.00	88.12	0.004	27.04	27.04
13. Wang Pradu School (closed down)	22.59	41.4	63.99	0.06	6.74	6.80	14.17	1,145.60	1,159.77	2.39	755.81	758.20	0.12	88.00	88.12	0.004	27.04	27.04
14. Village no.5, Ban Khlong Plu	19.26	34.44	53.70	0.11	5.60	5.71	12.61	1,145.60	1,158.21	5.93	755.81	761.74	0.26	88.00	88.26	0.008	27.04	27.05
15. Village no.7, Ban Wang Pla	25.91	34.44	60.35	0.20	5.60	5.80	14.97	1,145.60	1,160.57	6.01	755.81	761.82	0.26	88.00	88.26	0.015	27.04	27.06
16. Village no. 8, Ban Soi 13	22.19	34.44	56.63	0.17	5.60	5.77	13.05	1,145.60	1,158.65	5.33	755.81	761.14	0.23	88.00	88.23	0.013	27.04	27.05
17. Village no.7, Ban Wang Pradu	18.54	41.4	59.94	0.06	6.74	6.80	11.89	1,145.60	1,157.49	2.01	755.81	757.82	0.10	88.00	88.10	0.004	27.04	27.04
18. Village no.4, Ban Khao Mapud	22.63	34.44	57.07	0.15	5.60	5.75	13.95	1,145.60	1,159.55	2.43	755.81	758.24	0.10	88.00	88.10	0.011	27.04	27.05
19. Village no.5, Ban Wang Tan Mon	38.58	40.65	79.23	0.39	6.62	7.01	22.17	1,145.60	1,167.77	10.38	755.81	766.19	0.45	63.00	63.45	0.029	19.36	19.39
20. Village no.1, Ban Map Toei	36.96	41.4	78.36	0.28	6.74	7.02	21.10	1,145.60	1,166.70	6.00	755.81	761.81	0.26	88.00	88.26	0.021	27.04	27.06
21. Village no.7, Ban Chak Oi	23.91	41.4	65.31	0.17	6.74	6.91	15.45	1,145.60	1,161.05	3.61	755.81	759.42	0.16	88.00	88.16	0.012	27.04	27.05
22. Village no.6, Ban Map Yang Mai	23.88	48.36	72.24	0.10	7.87	7.97	14.54	916.48	931.02	4.18	604.65	608.83	0.18	65.00	65.18	0.008	19.97	19.98
23. Village no.6, Ban Thab Tong	19.80	41.4	61.20	0.14	6.74	6.88	11.99	1,145.60	1,157.59	2.80	755.81	758.61	0.14	88.00	88.14	0.010	27.04	27.05
24. Village no.2, Ban Noen Sawan	40.81	57.96	98.77	0.43	9.43	9.86	23.34	2,062.09	2,085.43	7.65	1,360.47	1,368.12	0.35	78.00	78.35	0.031	23.97	24.00
25. Village no.4, Ban Wang Ta Phin	18.97	41.4	60.37	0.14	6.74	6.88	11.49	1,145.60	1,157.09	2.94	755.81	758.75	0.13	88.00	88.13	0.010	27.04	27.05
26. Village no.3, Ban Map Yang Phon	25.19	57.96	83.15	0.20	9.43	9.63	14.73	2,062.09	2,076.82	3.89	1,360.47	1,364.36	0.17	78.00	78.17	0.014	23.97	23.98
27. Village no.6, Ban Nong Rakam	7.89	40.65	48.54	0.03	6.62	6.65	5.51	1,145.60	1,151.11	0.92	755.81	756.73	0.04	63.00	63.04	0.002	19.36	19.36

TABLE 5.4-17

RESULTS OF THE PREDICTION OF AIR QUALITY BY USING THE AERMOD MODEL AND THE HIGHEST VALUES IN THE EXISTING MONITORING DATA IN THE CASE OF IMPACT FROM TRANSPORTING ACTIVITIES (CONT'D)

Details	Estimated highest concentration levels of air pollutants in the case of impact from transporting activities (μg/m³)																	
	1-hour average NO_2			1-year average NO_2			1-hour average CO			8-hour average CO			24-hour average PM-10			1-year average PM-10		
	Using the model	Using existing monitoring data 2/	Total	using the model	using existing monitoring data 2	total	using the model	using existing monitoring data 2	total	using the model	using existing monitoring data 2	total	using the model	using existing monitoring data 2	total	using the model	using existing monitoring data 2	total
28. Village no.5, Ban Khlong Phlu	15.40	40.65	56.05	0.09	6.62	6.71	9.83	1,145.60	1,155.43	4.16	755.81	759.97	0.18	63.00	63.18	0.006	19.36	19.37
29. Village no.7, Ban Wang Pla	15.71	34.44	50.15	0.12	5.6	5.72	9.70	1,145.60	1,155.30	3.66	755.81	759.47	0.16	88.00	88.16	0.009	27.04	27.05
30. Village no.8, Ban Soi 13	20.54	34.44	54.98	0.13	5.6	5.73	12.31	1,145.60	1,157.91	3.73	755.81	759.54	0.16	88.00	88.16	0.010	27.04	27.05
31. Village no.4, Ban Chak Manthed	9.46	41.4	50.86	0.04	6.74	6.78	5.62	1,145.60	1,151.22	1.10	755.81	756.91	0.05	88.00	88.05	0.003	27.04	27.04
Standard value 3/	320			57			34,200			10,260			120			50		
WHO 4/	200			40			-			-			50			20		

Remark : 1/ With reference to Table 5.1.1-5 : Highest values in the existing data on the ambient air quality monitoring in the project's vicinity

2/ With reference to Table 5.1.1-8 : Highest values in the existing data on air quality monitoring which are used to represent each receptor's air pollutant concentration level

3/ With reference to the standards in :

- Announcement of the National Environment Board No. 10 (1995) and No. 24 (2004) on ambient air quality standard specification
- Announcement of the National Environment Board No. 33 (2009) on nitrogen dioxide ambient concentration standard specification

4/ Referenced from WHO Ambient Air Quality Guidelines in Environmental, Health, and Safety (EHS) Guidelines for International Finance Corporation (2007)

Source : Team Consulting Engineering and Management Co., Ltd., 2016

The application of the said mathematical model is to be used in conjunction with the highest values in existing data on ambient air quality monitoring by the station or the monitoring point at the receptor as prescribed by the project. For a sensitive receptor where no monitoring result is available, the project will consider using existing data on ambient air quality monitoring from the station or the monitoring point near that receptor (as shown in **Table 5.1.1-8**). There are 6 cases based on the 100% load operation and minimum load operation fired by the two fuels in question. Plant operation will be between minimum generation and 100% load (full load). Plant load will be dependable on EGAT's dispatch instruction which in any case will be between minimum generation and full load. From past experience of IPP, plant will be operated near full load approximately for half of the time, and near minimum generation load approximately for half of the time. However, the future EGAT's dispatch can be either similar or different from the past experience. Therefore, the assessment was based on the highest capacity at 100 % load and the minimum operation. Details are as follows:

- Case 1: Impacts caused by Pluak Daeng Power Plant Project in the event of natural gas-fired operation at 100% load are assessed in conjunction with results of ambient air quality monitoring.
- Case 2: Impacts caused by Pluak Daeng Power Plant Project in the event of natural gas-fired operation at minimum load are assessed in conjunction with results of ambient air quality monitoring.
- Case 3: Impacts caused by Pluak Daeng Power Plant Project in the event of natural gas-fired operation at 100% load; plus the existing impacts caused by other industrial plants as specified in the environmental impact assessment report though there is not yet air pollutant emission within the radius of 15 kilometers from the project location; are assessed in conjunction with results of ambient air quality monitoring.
- Case 4: Impacts caused by Pluak Daeng Power Plant Project in the event of diesel-fired operation at 100% load are assessed in conjunction with results of ambient air quality monitoring.
- Case 5: Impacts caused by Pluak Daeng Power Plant Project in the event of diesel-fired operation at minimum load are assessed in conjunction with results of ambient air quality monitoring.
- Case 6: Impacts caused by Pluak Daeng Power Plant Project in the event of diesel-fired operation at 100% load; plus the existing impacts caused by other industrial plants as specified in the environmental impact assessment report though there is not yet air pollutant emission within the radius of 15 kilometers from the project location; are assessed in conjunction with results of ambient air quality monitoring.

All the nine sources of air pollutants emitted from other industrial plants in the study area to be used in the assessment of the potential air quality impact after the development of the project as specified in the environmental impact assessment report are power plant projects. 6 are Gulf Group's power plant projects and other 3 are Glow Group's power plant project, the natural gas power plant projects of Amata B.Grimm Power (Rayong) 3 Co., Ltd. and Amata B.Grimm Power (Rayong) 4 Co., Ltd. The details about the stacks, installed capacity, fuel used, as well as the air quality status of each project are shown in **Table 5.1.1-18.**

According to Glow Hemaraj Power Co., Ltd. data on air pollutant emission, which refers to the data in the document certifying the air pollutant emission rates of Glow Hemaraj Power Co., Ltd. cogeneration plant project in Hemaraj Eastern Seaboard Industrial Estate (Rayong), dated 5 November 2014, and the environmental impact assessment report (the complete edition) of Glow Hemaraj Power Co., Ltd. cogeneration plant project in Eastern Seaboard Industrial Estate (Rayong), in Pluak Daeng District, Rayong Province, 2007; in the event of natural gas being used as fuel, only the details about nitrogen dioxide emission is provided. For the case of diesel being used as fuel, the details about the emission of nitrogen dioxide, sulfur dioxide, and total suspended particulates are shown in **Appendix 5A-4**.

Having considered the assessment of the impact caused by particulate matter 10 micrometers or less in diameter (PM-10) during the operation phase of the project, both in the case when natural gas and the case when diesel is used as fuel in conjunction with the existing impacts caused by other industrial plants as specified in the environmental impact assessment report though there is not yet air pollutant emission within the radius of 15 kilometers from the project location, which are 9 natural gas-fired power plant projects in total; the consulting team formulate the hypothesis to be used with the model consisting of two parts as follows:

- For emission of dust particles from natural gas-fired power plant, the hypothesized ratio of PM-10/TSP is 1.00.
- For emission of dust particles from diesel-fired power plant, the hypothesized ratio of PM-10/TSP is 0.82 (reference - AP-42: Chapter 3.4, Large Stationary Diesel and All Stationary Dual-fuel Engines)

The details about the stacks and the emission rates in each case are shown in **Table 5.1.1-18** to **Table 5.1.1-19** and **Figure 5.1.1-13**.

TABLE 5.1.1-18

DETAILS ABOUT THE STACKS AND THE AIR QUALITY STATUS OF THE INDUSTRIAL PLANTS SPECIFIED IN THE ENVIRONMENTAL IMPACT ASSESSMENT REPORT THOUGH THERE IS NOT YET AIR POLLUTANT EMISSION WITHIN THE RADIUS OF 15 KILOMETERS FROM THE PROJECT LOCATION

Industrial plant	Installed capacity (MW)	Fuel used	Location	Stack		Exit temperature (^{o}K)	Exit velocity (m/s)	Emission rate			
				Height (m)	Diameter (m)			NO_2 (g/s)	SO_2 (g/s)	TSP (g/s)	PM-10 (g/s)
1. Sri Racha Power Plant[1/]	2,650	natural gas	HRSG 1	60	7.01	355.55	23.5	20	6.17	7.86	7.86
			HRSG 2	60	7.01	355.55	23.5	20	6.17	7.86	7.86
			HRSG 3	60	7.01	355.55	23.5	20	6.17	7.86	7.86
			HRSG 4	60	7.01	355.55	23.5	20	6.17	7.86	7.86
		diesel	HRSG 1	60	7.01	421.15	27.5	20	18.95	11.6	9.51
			HRSG 2	60	7.01	421.15	27.5	20	18.95	11.6	9.51
			HRSG 3	60	7.01	421.15	27.5	20	18.95	11.6	9.51
			HRSG 4	60	7.01	421.15	27.5	20	18.95	11.6	9.51
2. Ta Sit Power Plant 1[2/]	137	natural gas	HRSG 1	40	3.00	373	19.6	7.4	1.0	1.8	1.8
			HRSG 2	40	3.00	373	19.6	7.4	1.0	1.8	1.8
3. Ta Sit Power Plant 2[2/]	137	natural gas	HRSG 1	40	3.00	373	19.6	7.4	1.0	1.8	1.8
			HRSG 2	40	3.00	373	19.6	7.4	1.0	1.8	1.8
4. Ta Sit Power Plant 3[3/]	137	natural gas	HRSG 1	40	3.00	373	19.6	7.4	1.0	1.8	1.8
			HRSG 2	40	3.00	373	19.6	7.4	1.0	1.8	1.8
5. Ta Sit Power Plant 4[3/]	137	natural gas	HRSG 1	40	3.00	373	19.6	7.4	1.0	1.8	1.8
			HRSG 2	40	3.00	373	19.6	7.4	1.0	1.8	1.8
6. Vang Ta Phin Power Plant [2/]	137	natural gas	HRSG 1	40	3.00	373	19.6	7.4	1.0	1.8	1.8
			HRSG 2	40	3.00	373	19.6	7.4	1.0	1.8	1.8
7. Glow Hemaraj Power Co., Ltd.	1,126	natural gas [4/,5/]	HRSG 1	50	6.5	373	22.61	74.4	-	-	-
			HRSG 2	50	6.5	373	22.61	74.4	-	-	-
			HRSG 3	50	6.5	373	22.61	74.4	-	-	-

TABLE 5.1.1-18

DETAILS ABOUT THE STACKS AND THE AIR QUALITY STATUS OF THE INDUSTRIAL PLANTS SPECIFIED IN THE ENVIRONMENTAL IMPACT ASSESSMENT REPORT THOUGH THERE IS NOT YET AIR POLLUTANT EMISSION WITHIN THE RADIUS OF 15 KILOMETERS FROM THE PROJECT LOCATION (CONT'D)

Industrial plant	Installed capacity (MW)	Fuel used	Location	Stack		Exit temperature (^{o}K)	Exit velocity (m/s)	Emission rate			
				Height (m)	Diameter (m)			NO_2 (g/s)	SO_2 (g/s)	TSP (g/s)	PM-10 (g/s)
		diesel 5/	HRSG 1	50	6.5	413	15.56	113.5	365.7	60.4	-
			HRSG 2	50	6.5	413	15.56	113.5	365.7	60.4	-
			HRSG 3	50	6.5	413	15.56	113.5	365.7	60.4	-
8. Natural Gas Power Plant of Amata B.Grimm Power (Rayong) 3 Co., Ltd.6/	142.1	natural gas	HRSG 1	45	3.03	376.15	19.40	7.33	1.70	1.30	1.30
			HRSG 2	45	3.03	376.15	19.40	7.33	1.70	1.30	1.30
9. Amata B.Grimm Power (Rayong) 4 Co., Ltd.7/	142.1	natural gas	HRSG 1	45	3.03	376.15	19.40	7.33	1.70	1.30	1.30
			HRSG 2	45	3.03	376.15	19.40	7.33	1.70	1.30	1.30

Remark : No data available in the environmental impact assessment report

Source :
1/ Environmental Impact Assessment Report of Sri Racha Power Plant, Gulf SRC Co., Ltd., 2016
2/ Changes in the Project Details in the Environmental Impact Assessment report of Eastern Seaboard Industrial Estate Project (Rayong), Eastern Seaboard Industrial Estate (Rayong) Co., Ltd., 2015
3/ Changes in the Project Details in the Environmental Impact Assessment report of Hemaraj Eastern Seaboard Industrial Estate Project (Rayong), Hemaraj Eastern Seaboard Industrial Estate (Rayong) Co., Ltd., 2015
4/ Document certifying the air pollutant emission rates of Glow Hemaraj Power Co., Ltd. cogeneration plant project in Hemaraj Eastern Seaboard Industrial Estate (Rayong), dated 5th November 2014
5/ Environmental Impact Assessment Report (Complete Edition) of Eastern Seaboard Industrial Estate's Cogeneration Plant Project (Rayong), Pluak Daeng District, Rayong Province (2007)
6/ Environmental Impact Assessment Report (Complete Edition) of Amata B.Grimm Power (Rayong) 3 Co., Ltd. Power Plant Project (2014)
7/ Environmental Impact Assessment Report (Complete Edition) of Amata B.Grimm Power (Rayong) 4 Co., Ltd. Power Plant Project (2014)

TABLE 5.1.1-19
PLUAK DAENG POWER PLANT'S POLLUTANT EMISSION RATES

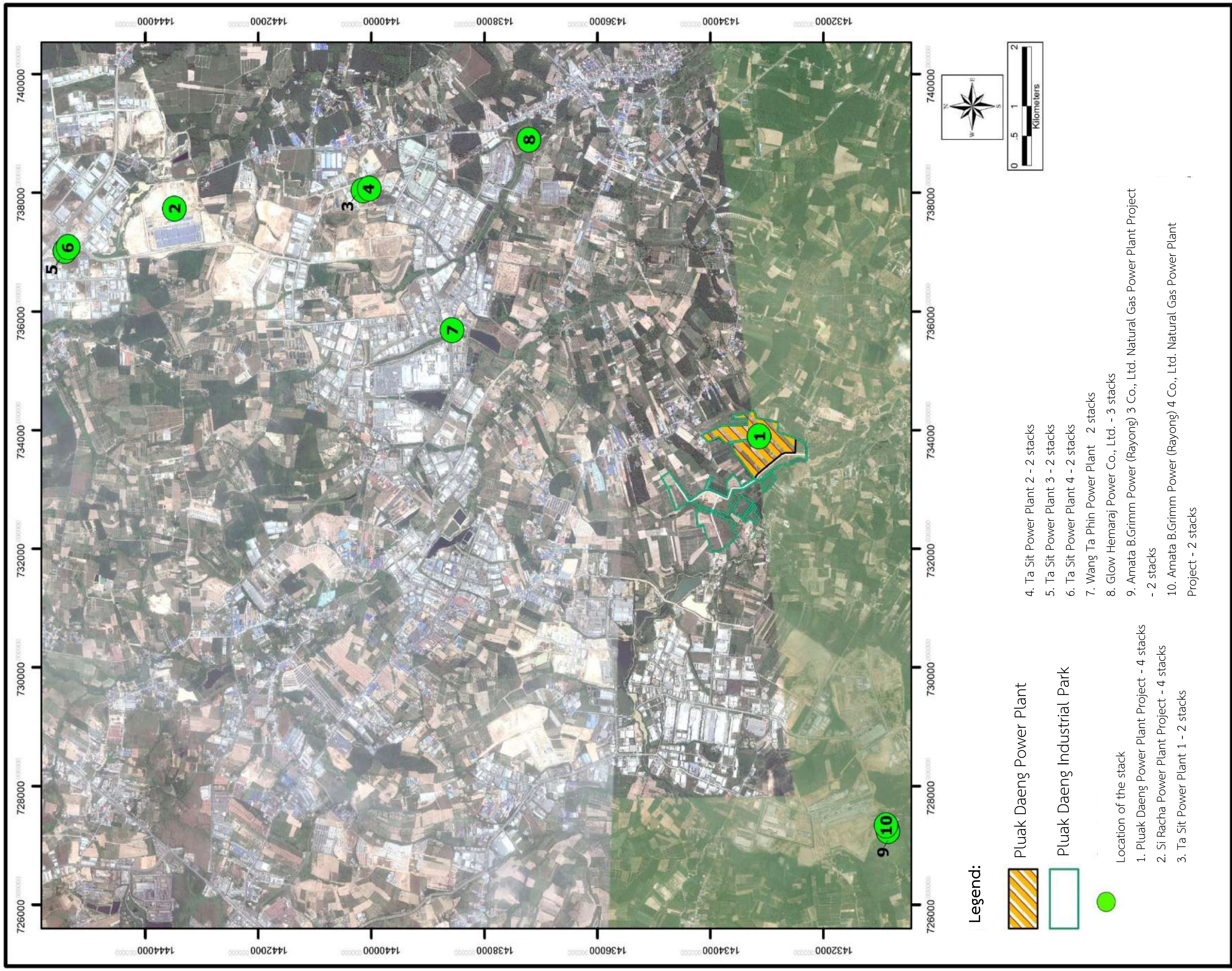
Details	Unit	Natural gas		Diesel		Standard values(1),(2)		Stipulated limit 3)	
		100% load	Minimum load	100% load	Minimum load	Natural gas	Diesel	Natural gas	Diesel
Installed capacity	MW	700	375	500	375				
Number of stacks	Stack	4	4	4	4				
Stack height	m	60	60	60	60				
Stack diameter(internal)	m	8	8	8	8				
Exit temperature	°C	83	76	96	82				
Exit velocity	m/s	23.1	15.8	20.8	17.2				
Excess O_2 (on a dry basis)	Vol %	7	7	7	7				
flow rate of the air at the exit (on a dry basis)	Nm^3/s	786	554	693	640				
Pollutant concentration									
- NO_x as NO_2 @ 7%O_2	ppmvd	59	59	99	99	120	180	80	110
- SO_x as SO_2 @ 7%O_2	ppmvd	10	10	20	20	20	260	14	28
- TSP @ 7%O_2	mg/m^3	20	20	35	35	60	120	32	44
Emission rate/stack									
- NO_2	g/s	58.6	35.4	74.0	61.2			66.36	75.00
- SO_2	g/s	13.9	8.4	21.0	17.6			15.79	25.79
- TSP	g/s	9.7	5.9	12.9	10.6			12.35	14.22
Air pollutant control system		Dry Low NO_x Combustion		Water Injection System					

Remark : (1) Standard values of air pollutant emission with reference to the Ministry of Natural Resources and Environment's Announcement on Regulatory Standards Established to Control Air Pollutant Emission from New Power Plants, issued on 20th December, 2009

(2) Standard values of air pollutant emission with reference to the Ministry of Industry's Regulations on the Establishment of Limits on the Level of Air Impurities Emitted from Electricity Producers or Distributors, issued on 20th December, 2009

(3) Regulations on air pollutant emission from independent power producers, as stipulated in the environmental impact assessment report on the Pluak Daeng Industrial Park, Expansion Phase 1, 2016 (as shown in **Appendix 3T**)

Source : Gulf PD Co., Ltd., 2016



TEAM

FIGURE 5.1.1-13 : LOCATIONS OF THE STACKS OF THE POWER PLANTS IN THE STUDY AREA

10P2809/Damrongsak.B/18-07-59/P2809-036.mxd

In addition, the presence of buildings can affect plume rise and the initial dispersion of pollutants within the atmosphere. Turbulent wake zones can be created around buildings that force pollutants to the ground instead of allowing them to rise freely within the atmosphere. Building downwash occurs as the wind flows over and around buildings and impacts the dispersion of pollution from nearby stacks, refer to **Figure 5.1.1-14**, entitled “Simplified Building Downwash Depiction.” According to Section 123 of the Clean Air Act, GEP is defined as “the height necessary to insure that emissions from a stack do not result in excessive concentrations of any air pollutant in the immediate vicinity of the source as a result of atmospheric downwash, eddies or wakes which may be created by the source itself, nearby structures or nearby terrain obstacles.”

In order to avoid excessive downwind concentrations due to building downwash effects, the height of the stack must be tall enough to allow the emissions plume to escape the cavity region that is created on the downwind side of a building complex, a height that is referred to as good engineering practice (GEP) stack height.

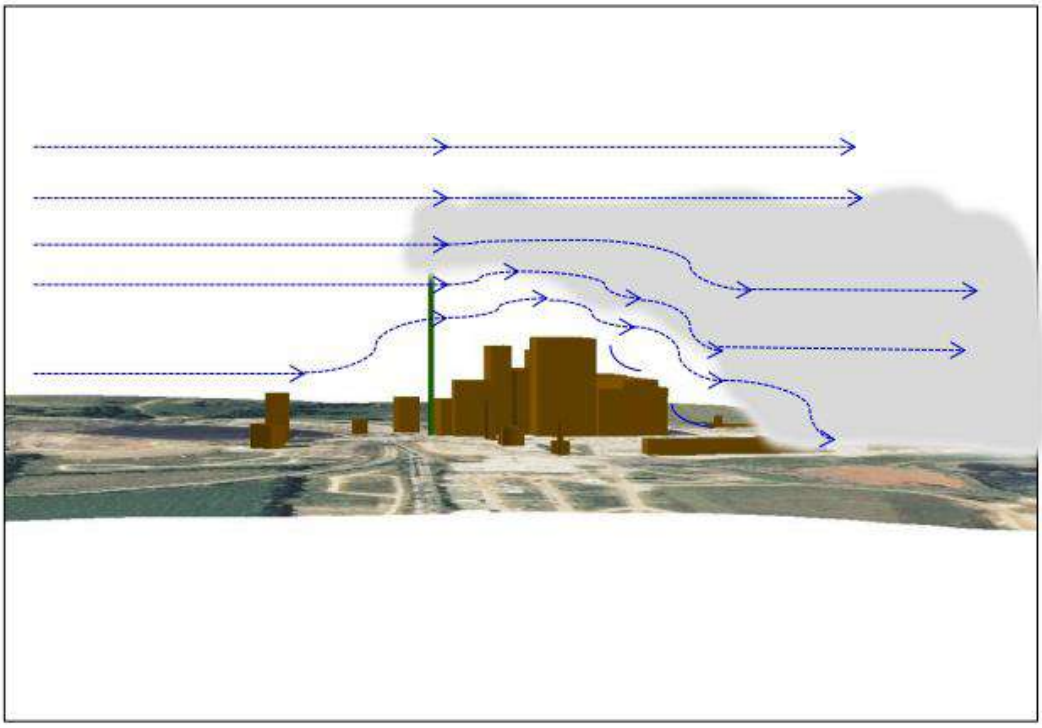


FIGURE 5.1.1-14 : SIMPLIFIED BUILDING DOWNWASH DEPICTION

Therefore, the consulting team also take into consideration the Good Engineering Practice (GEP) with reference to the Guideline for Determination of Good Practice Stack Height [Technical Support Document for the Stack Height Regulations (Revised) U.S.EPA (1985)]. The equation used is as follows:

$$Hg = H + 1.5L \quad (1)$$

where Hg = good engineering practice stack height (meter)
H = height of nearby structure(s) (meter)
L = least dimension between the height and width of nearby structure(s) (meter)

From the stacks of the heat recovery steam generator (HRSG) in the project, the nearby structure is HRSG Building, which is about 28 meters tall and 25.12 meters wide. When Equation 1 is applied, the result is as follows:

$$Hg = 28\text{ m} + (1.5 \times 25.12\text{ m})$$
$$= 65.68\text{ m}$$

From the result of the calculation above, the project's stack height (60 meters) is not in accordance with the Good Engineering Practice (GEP). As a result, the consulting team deem that the air pollutant emission impacts caused by the execution of the project in the aforementioned six cases should also be assessed in conjunction with the downwash effect. In this way, the case study in the assessment of air quality impact caused by the project can be summarized as follows:

1) The assessment under normal condition (without downwash effect)

- Case 1: Impacts caused by Pluak Daeng Power Plant Project in the event of natural gas-fired operation at 100% load are assessed in conjunction with results of ambient air quality monitoring.
- Case 2: Impacts caused by Pluak Daeng Power Plant Project in the event of natural gas-fired operation at minimum load are assessed in conjunction with results of ambient air quality monitoring.
- Case 3: Impacts caused by Pluak Daeng Power Plant Project in the event of natural gas-fired operation at 100% load; plus the existing impacts caused by other industrial plants as specified in the environmental impact assessment report though there is not yet air pollutant emission within the radius of 15 kilometers from the project location; are assessed in conjunction with results of ambient air quality monitoring.
- Case 4: Impacts caused by Pluak Daeng Power Plant Project in the event of diesel-fired operation at 100% load are assessed in conjunction with results of ambient air quality monitoring.
- Case 5: Impacts caused by Pluak Daeng Power Plant Project in the event of diesel-fired operation at minimum load are assessed in conjunction with results of ambient air quality monitoring.

- Case 6: Impacts caused by Pluak Daeng Power Plant Project in the event of diesel-fired operation at 100% load; plus the existing impacts caused by other industrial plants as specified in the environmental impact assessment report though there is not yet air pollutant emission within the radius of 15 kilometers from the project location; are assessed in conjunction with results of ambient air quality monitoring.

2) The assessment under the effect of downwash condition

- Case 1: Impacts caused by Pluak Daeng Power Plant Project in the event of natural gas-fired operation at 100% load are assessed in conjunction with results of ambient air quality monitoring.
- Case 2: Impacts caused by Pluak Daeng Power Plant Project in the event of natural gas-fired operation at minimum load are assessed in conjunction with results of ambient air quality monitoring.
- Case 3: Impacts caused by Pluak Daeng Power Plant Project in the event of natural gas-fired operation at 100% load; plus the existing impacts caused by other industrial plants as specified in the environmental impact assessment report though there is not yet air pollutant emission within the radius of 15 kilometers from the project location; are assessed in conjunction with results of ambient air quality monitoring.
- Case 4: Impacts caused by Pluak Daeng Power Plant Project in the event of diesel-fired operation at 100% load are assessed in conjunction with results of ambient air quality monitoring.
- Case 5: Impacts caused by Pluak Daeng Power Plant Project in the event of diesel-fired operation at minimum load are assessed in conjunction with results of ambient air quality monitoring.
- Case 6: Impacts caused by Pluak Daeng Power Plant Project in the event of diesel-fired operation at 100% load; plus the existing impacts caused by other industrial plants as specified in the environmental impact assessment report though there is not yet air pollutant emission within the radius of 15 kilometers from the project location; are assessed in conjunction with results of ambient air quality monitoring.

(2.3) Air Quality Assessment Results

In estimating the concentration of nitrogen dioxide in the ambient air caused by the development of the project and the operation of other plants in the study area, the consulting team choose the Plume Volume Molar Ratio Method (PVMRM) in determining the conversion factor of NO_2/NO_x. For this, the ozone concentration data on an hourly basis collected in 2015 by of Pluak Daeng District Public Health Office's Air Quality Monitoring Station, Rayong Province, under the charge of the Pollution Control Department, are used.

The equilibrium $NO_2/NO_{x\,r}$ ratio is 0.90. The in-stack NO_2/NO_x ratio is 0.11 for the natural gas-fired power plant projects (reference - Gas Turbine: Modeling Compliance of The Federal 1-Hour NO_2 NAAQS, the California Air Pollution Control Officers Association (CAPCOA), 2011)[1]. For the diesel-fired power plant projects the NO_2/NO_x ratio is 0.50 (the default value is according to the Guideline Manual on the Use of Models to Assess Air Pollutant Dispersion).

To be in line with the ambient air quality standards, the parameters used in the assessment of air quality impact with the AERMOD mathematical model are the average concentration of nitrogen dioxide (NO_2) over the period of 1 hour, and 1 year; the average concentration of sulfur dioxide (SO_2) over the period of 24 hours, and 1 year; the average concentration of total suspended particulate (TSP) over the period of 24 hours, and 1 year; and the average concentration of particulate matter 10 micrometers or less in diameter (PM-10) over the period of 24 hours, and 1 year. The findings reveal that the air pollutant values in the study area and sensitive receptors are lower than the values stipulated in general ambient air quality standards. The details are as follows:

(2.3.1) The assessment in normal condition (without downwash effect)

(a) Case 1: Impacts caused by Pluak Daeng Power Plant Project in the event of natural gas-fired operation at 100% load are assessed in conjunction with results of ambient air quality monitoring.

- **Average concentration of nitrogen dioxide (NO_2) over the period of 1 hour, and 1 year**

The nitrogen dioxide (NO_2) released into the ambience during the operation phase of the project results in the highest concentration level of NO_2 in the study area over the period of 1 hour on average in the area of Jom Hae Mountain (grid reference - 728828 E 1419614 N), which is about 14.04 kilometers away from the project location to the south - southwest (SSW). The concentration level is 123.69 $\mu g/m^3$, accounting for 38.65% of that stipulated in general ambient air quality standards, according to which the average NO_2 in the ambience over the period of 1 hour must not exceed 320 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of NO_2 in the ambience over the period of 1 hour on average range between 0.06-4.84 $\mu g/m^3$ or 0.02-1.51% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-20** and **Appendix 5A-5**.

[1] Petrochemical Section, the Office of Natural Resources and Environmental Policy and Planning, 2014, “Data on the In-stack NO_2/NO_x Ratio for Emission from Industrial Plants in Map Ta Phut Area, Mueang Rayong District, Rayong Province, for Air Modeling”

TABLE 5.1.1-20

RESULTS OF THE PREDICTION OF AIR QUALITY BY USING THE AERMOD MODEL IN NORMAL CONDITION (WITHOUT DOWNWASH EFFECT), CASE 1: IMPACTS CAUSED BY PLUAK DAENG POWER PLANT PROJECT IN THE EVENT OF NATURAL GAS-FIRED OPERATION AT 100% LOAD ARE ASSESSED IN CONJUNCTION WITH RESULTS OF AMBIENT AIR QUALITY MONITORING

Study Area	Estimated highest concentration levels of air pollutants in the case of impact from transporting activities ($\mu g/m^3$)																										
	1-hour average NO_2			1-year average NO_2			1-hour average SO_2			24-hour average SO_2			1-year average SO_2			24-hour average TSP			1-year average TSP			24-hour average PM-10			1-year average PM-10		
	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model
Grid reference	123.69	67.74[1/]	191.43	1.94	11.02[1/]	12.96	80.44	39.83[1/]	120.27	14.78	47.17[1/]	61.95	1.42	6.48[1/]	7.90	10.32	144.00[1/]	154.32	0.99	44.25[1/]	45.24	10.32	88.00[1/]	98.32	0.99	27.04[1/]	28.03
Location	728828E, 1419614N			728828E, 1419614N			729328E, 1419114N			728828E, 1419614N			728828E, 1419114N			728828E, 1419614N			728828E, 1419114N			728828E, 1419614N			728828E, 1419114N		
Direction and distance from the project site	Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain		
	SSW 14.04 km			SSW 14.04 km			SSW 14.71 km			SSW 14.04 km			SSW 14.88 km			SSW 14.39 km			SSW 14.88 km			SSW 14.39 km			SSW 14.88 km		
Grid reference	mountain			mountain			mountain			mountain			mountain			mountain			mountain			mountain			mountain		
Sensitive Area																											
1. Map Yang Phon Sub-district Administrative Organization	0.25	41.40	41.65	0.003	6.74	6.743	0.16	7.08	7.24	0.03	5.24	5.27	0.002	1.15	1.152	0.018	138	138.02	0.0013	42.41	42.411	0.018	88.00	88.02	0.0013	27.04	27.041
2. Ban Map Toei School	0.24	41.40	41.64	0.003	6.74	6.743	0.16	7.08	7.24	0.03	5.24	5.27	0.002	1.15	1.152	0.019	138	138.02	0.0014	42.41	42.411	0.019	88.00	88.02	0.0014	27.04	27.041
3. Map Toei Temple	0.25	41.40	41.65	0.003	6.74	6.743	0.16	7.08	7.24	0.03	5.24	5.27	0.002	1.15	1.152	0.020	138	138.02	0.0016	42.41	42.412	0.020	88.00	88.02	0.0016	27.04	27.042
4. Nikhom Sang Ton Eng 9 School	2.48	34.44	36.92	0.007	5.60	5.607	1.33	6.55	7.88	0.17	5.24	5.41	0.003	1.07	1.073	0.121	128	128.12	0.0022	39.33	39.332	0.121	88.00	88.12	0.0022	27.04	27.042
5. Prasitharam Temple	1.90	34.44	36.34	0.006	5.60	5.606	1.02	6.55	7.57	0.13	5.24	5.37	0.003	1.07	1.073	0.087	128	128.09	0.0022	39.33	39.332	0.087	88.00	88.09	0.0022	27.04	27.042
6. Map Yang Phon Sub-district Health Promoting Hospital	0.33	57.96	58.29	0.003	9.43	9.433	0.37	11.79	12.16	0.05	47.17	47.22	0.002	1.92	1.922	0.032	144	144.03	0.0015	44.25	44.251	0.032	78.00	78.03	0.0015	23.97	23.971
7. Ban Map Yang Phon School	0.34	57.96	58.30	0.004	9.43	9.434	0.36	11.79	12.15	0.05	47.17	47.22	0.003	1.92	1.923	0.036	144	144.04	0.0019	44.25	44.252	0.036	78.00	78.04	0.0019	23.97	23.972
8. Map Yang Phon Temple	0.22	57.96	58.18	0.003	9.43	9.433	0.21	11.79	12.00	0.02	47.17	47.19	0.002	1.92	1.922	0.017	144	144.02	0.0015	44.25	44.252	0.017	78.00	78.02	0.0015	23.97	23.972
9. Pluak Daeng Sub-district Administrative Organization	1.58	67.74	69.32	0.004	11.02	11.024	0.83	39.83	40.66	0.06	7.88	7.94	0.001	6.48	6.481	0.040	138	138.04	0.0010	42.41	42.411	0.040	86.50	86.54	0.0010	26.58	26.581
10. Orawin Witthaya School	1.29	67.74	69.03	0.004	11.02	11.024	0.48	39.83	40.31	0.05	7.88	7.93	0.002	6.48	6.482	0.033	138	138.03	0.0011	42.41	42.411	0.033	86.50	86.53	0.0011	26.58	26.581
11. Pluak Daeng High Voltage Electricity Station	0.66	67.74	68.40	0.002	11.02	11.022	0.49	39.83	40.32	0.06	7.88	7.94	0.001	6.48	6.481	0.039	138	138.04	0.0009	42.41	42.411	0.039	86.50	86.54	0.0009	26.58	26.581
12. Wang Pradu Temple	1.80	41.40	43.20	0.004	6.74	6.744	2.81	7.08	9.89	0.35	5.24	5.59	0.002	1.15	1.152	0.241	138	138.24	0.0017	42.41	42.412	0.241	88.00	88.24	0.0017	27.04	27.042
13. Wang Pradu School (closed down)	1.90	41.40	43.30	0.004	6.74	6.744	2.69	7.08	9.77	0.35	5.24	5.59	0.002	1.15	1.152	0.247	138	138.25	0.0016	42.41	42.412	0.247	88.00	88.25	0.0016	27.04	27.042
14. Village no.5, Ban Khlong Plu	0.25	34.44	34.69	0.002	5.60	5.602	0.13	6.55	6.68	0.01	5.24	5.25	0.001	1.07	1.071	0.009	128	128.01	0.0009	39.33	39.331	0.009	88.00	88.01	0.0009	27.04	27.041
15. Village no.7, Ban Wang Pla	1.29	34.44	35.73	0.005	5.60	5.605	0.59	6.55	7.14	0.06	5.24	5.30	0.003	1.07	1.073	0.039	128	128.04	0.0019	39.33	39.332	0.039	88.00	88.04	0.0019	27.04	27.042
16. Village no.8 , Ban Soi 13	2.47	34.44	36.91	0.005	5.60	5.605	1.72	6.55	8.27	0.17	5.24	5.41	0.002	1.07	1.072	0.115	128	128.12	0.0017	39.33	39.332	0.115	88.00	88.12	0.0017	27.04	27.042
17. Village no.7, Ban Wang Pradu	1.70	41.40	43.10	0.003	6.74	6.743	2.08	7.08	9.16	0.26	5.24	5.50	0.002	1.15	1.152	0.183	138	138.18	0.0012	42.41	42.411	0.183	88.00	88.18	0.0012	27.04	27.041
18. Village no.4, Ban Khao Mapud	1.18	34.44	35.62	0.004	5.60	5.604	0.36	6.55	6.91	0.04	5.24	5.28	0.002	1.07	1.072	0.028	128	128.03	0.0015	39.33	39.331	0.028	88.00	88.03	0.0015	27.04	27.041
19. Village no.5, Ban Wang Tan Mon	0.61	40.65	41.26	0.006	6.62	6.626	0.33	11.01	11.34	0.04	6.03	6.07	0.004	1.79	1.794	0.027	106	106.03	0.0026	32.57	32.573	0.027	63.00	63.03	0.0026	19.36	19.363
20. Village no.1, Ban Map Toei	0.44	41.40	41.84	0.003	6.74	6.743	0.67	7.08	7.75	0.06	5.24	5.30	0.002	1.15	1.152	0.045	138	138.05	0.0013	42.41	42.411	0.045	88.00	88.05	0.0013	27.04	27.041
21. Village no.7, Ban Chak Oi	0.59	41.40	41.99	0.003	6.74	6.743	0.43	7.08	7.51	0.03	5.24	5.27	0.002	1.15	1.152	0.024	138	138.02	0.0011	42.41	42.411	0.024	88.00	88.02	0.0011	27.04	27.041
22. Village no.6, Ban Map Yang Mai	0.14	48.36	48.50	0.002	7.87	7.872	0.09	10.74	10.83	0.01	5.5	5.51	0.002	1.75	1.752	0.009	110	110.01	0.0011	33.80	33.801	0.009	65.00	65.01	0.0011	19.97	19.971
23. Village no.6, Ban Thab Tong	0.98	41.40	42.38	0.002	6.74	6.742	0.79	7.08	7.87	0.05	5.24	5.29	0.001	1.15	1.151	0.032	138	138.03	0.0008	42.41	42.411	0.032	88.00	88.03	0.0008	27.04	27.041
24. Village no.2, Ban Noen Sawan	0.23	57.96	58.19	0.005	9.43	9.435	0.15	11.79	11.94	0.02	47.17	47.19	0.003	1.92	1.923	0.014	144	144.01	0.0024	44.25	44.252	0.014	78.00	78.01	0.0024	23.97	23.972
25. Village no.4, Ban Wang Ta Phin	0.30	41.40	41.70	0.002	6.74	6.742	0.17	7.08	7.25	0.02	5.24	5.26	0.001	1.15	1.151	0.014	138	138.01	0.0008	42.41	42.411	0.014	88.00	88.01	0.0008	27.04	27.041
26. Village no.3, Ban Map Yang Phon	0.18	57.96	58.14	0.003	9.43	9.433	0.15	11.79	11.94	0.02	47.17	47.19	0.002	1.92	1.922	0.014	144	144.01	0.0013	44.25	44.251	0.014	78.00	78.01	0.0013	23.97	23.971
27. Village no.6, Ban Nong Rakam	0.06	40.65	40.71	0.001	6.62	6.621	0.04	11.01	11.05	0.01	6.03	6.04	0.001	1.79	1.791	0.004	106	106.00	0.0004	32.57	32.570	0.004	63.00	63.00	0.0004	19.36	19.360

TABLE 5.1.1-20

RESULTS OF THE PREDICTION OF AIR QUALITY BY USING THE AERMOD MODEL IN NORMAL CONDITION (WITHOUT DOWNWASH EFFECT),

CASE 1: IMPACTS CAUSED BY PLUAK DAENG POWER PLANT PROJECT IN THE EVENT OF NATURAL GAS-FIRED OPERATION AT 100% LOAD ARE ASSESSED IN CONJUNCTION WITH RESULTS OF AMBIENT AIR QUALITY MONITORING (CONT'D)

Study Area	Estimated highest concentration levels of air pollutants in the case of impact from transporting activities (μg/m^3)																										
	1-hour average NO_2			1-year average NO_2			1-hour average SO_2			24-hour average SO_2			1-year average SO_2			24-hour average TSP			1-year average TSP			24-hour average PM-10			1-year average PM-10		
	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model	Using the model
28. Village no.5, Ban Khlong Phlu	0.64	40.65	41.29	0.002	6.62	6.622	0.35	11.01	11.36	0.03	6.03	6.06	0.001	1.79	1.791	0.020	106	106.02	0.0009	32.57	32.571	0.020	63.00	63.02	0.0009	19.36	19.361
29. Village no.7, Ban Wang Pla	2.46	34.44	36.90	0.006	5.60	5.606	1.03	6.55	7.58	0.11	5.24	5.35	0.002	1.07	1.072	0.074	128	128.07	0.0017	39.33	39.332	0.074	88.00	88.07	0.0017	27.04	27.042
30. Village no.8 , Ban Soi 13	4.84	34.44	39.28	0.009	5.60	5.609	3.81	6.55	10.36	0.46	5.24	5.70	0.004	1.07	1.074	0.318	128	128.32	0.0028	39.33	39.333	0.318	88.00	88.32	0.0028	27.04	27.043
31. Village no.4, Ban Chak Manthed	2.83	41.40	44.23	0.005	6.74	6.745	2.49	7.08	9.57	0.29	5.24	5.53	0.003	1.15	1.153	0.202	138	138.20	0.0019	42.41	42.412	0.202	88.00	88.20	0.0019	27.04	27.042
Standard value 3/	320			57			780			300			100			330			100			120			50		
WHO 4/	200			40			-			-			20			-			-			50			20		

Remark : 1/ With reference to Table 5.1.1-5 : Highest values in the existing data on the ambient air quality monitoring in the project's vicinity

2/ With reference to Table 5.1.1-8 : Highest values in the existing data on air quality monitoring which are used to represent each receptor's air pollutant concentration level

3/ With reference to the standards in :

- Announcement of the National Environment Board No.10 (1995) and No.24 (2004) on ambient air quality standard specification
- Announcement of the National Environment Board No.21 (2001) on sulfur dioxide ambient concentration standard specification
- Announcement of the National Environment Board No.33 (2009) on nitrogen dioxide ambient concentration standard specification

4/ Referenced from WHO Ambient Air Quality Guidelines in Environmental, Health, and Safety (EHS) Guidelines for International Finance Corporation (2007)

Source : Team Consulting Engineering and Management Co., Ltd., 2016

When considered together with the existing monitoring results, the highest concentration level of NO_2 in the ambience over the period of 1 hour on average is 191.43 μg/m^3, or 59.82% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of NO_2 in the ambience over the period of 1 hour on average range between 34.69-69.32 μg/m^3 or 10.84-21.66% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-20.**

The NO_2 released into the ambience during the operation phase of the project results in the highest concentration level of NO_2 in the study area over the period of 1 year on average in the area of Jom Hae Mountain (grid reference - 728828 E 1419614 N), which is about 14.04 kilometers away from the project location to the south-southwest (SSW). The concentration level is 1.94 μg/m^3, accounting for 3.40% of that stipulated in general ambient air quality standards, according to which the average NO_2 in the ambience over the period of 1 year must not exceed 57 μg/m^3. For the 31 sensitive receptors, the highest concentration levels of NO_2 in the ambience over the period of 1 year on average range between 0.001-0.009 μg/m^3 or 0.001-0.016% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-20** and **Appendix 5A-5.**

When considered together with the existing monitoring results, the highest concentration level of NO_2 in the ambience over the period of 1 year on average is 12.96 μg/m^3, or 22.74% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of NO_2 in the ambience over the period of 1 year on average range between 5.602-11.024 μg/m^3 or 9.828-19.340% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-20**.

- **Average concentration of sulfur dioxide (SO_2) over the period of 1 hour, 24 hours, and 1 year**

The sulfur dioxide (SO_2) released into the ambience during the operation phase of the project results in the highest concentration level of SO_2 in the study area over the period of 1 hour on average in the area of Jom Hae Mountain (grid reference - 729328 E 1419114 N), which is about 14.71 kilometers away from the project location to the south-southwest (SSW). The concentration level is 80.44 μg/m^3, accounting for 10.31% of that stipulated in general ambient air quality standards, according to which the average SO_2 in the ambience over the period of 1 hour must not exceed 780 μg/m^3. For the 31 sensitive receptors, the highest concentration levels of SO_2 in the ambience over the period of 1 hour on average range between 0.04-3.81 micrograms/ cubic meter or 0.01-0.49% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-20** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of SO_2 in the ambience over the period of 1 hour on average is 120.27 $\mu g/m^3$, or 15.42% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of SO_2 in the ambience over the period of 1 hour on average range between 6.68-40.66 $\mu g/m^3$ or 0.86-5.21% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-20**.

The SO_2 released into the ambience during the operation phase of the project results in the highest concentration level of SO_2 in the study area over the period of 24 hours on average in the area of Jom Hae Mountain (grid reference - 728828 E 1419614 N), which is about 14.04 kilometers away from the project location to the south - southwest (SSW). The concentration level is 14.78 $\mu g/m^3$, accounting for 4.93% of that stipulated in general ambient air quality standards, according to which the average SO_2 in the ambience over the period of 24 hours must not exceed 300 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of SO_2 in the ambience over the period of 24 hours on average range between 0.01-0.46 $\mu g/m^3$ or 0.003-0.153% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-20** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of SO_2 in the ambience over the period of 24 hours on average is 61.95 $\mu g/m^3$, or 20.65% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of SO_2 in the ambience over the period of 24 hours on average range between 5.25-47.22 $\mu g/m^3$ or 1.75-15.74% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-20**.

The SO_2 released into the ambience during the operation phase of the project results in the highest concentration level of SO_2in the study area over the period of 1 year on average in the area of Jom Hae Mountain (grid reference - 728828 E 1419114 N), which is about 14.88 kilometers away from the project location to the south-southwest (SSW). The concentration level is 1.42 $\mu g/m^3$, accounting for 1.42% of that stipulated in general ambient air quality standards, according to which the average SO_2 in the ambience over the period of 1 year must not exceed 100 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of SO_2 in the ambience over the period of 1 year on average range between 0.001-0.004 $\mu g/m^3$ or 0.001-0.004% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-20** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of SO_2 in the ambience over the period of 1 year on average is 7.90 μg/m^3, or 7.90% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of SO_2 in the ambience over the period of 1 year on average range between 1.071-6.482 μg/m^3 or 1.071-6.482% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-20**.

- **Average total suspended particulate (TSP) over the period of 24 hours and 1 year**

The execution of the project causes the highest concentration level of the average TSP in the ambience over the period of 24 hours in the area of Jom Hae Mountain (grid reference - 728828 E 1419614 N), which is about 14.39 kilometers away from the project location to the south - southwest (SSW). The concentration level is 10.32 μg/m^3, accounting for 3.13% of that stipulated in general ambient air quality standards, according to which the average TSP in the ambience over the period of 24 hours must not exceed 330 μg/m^3. For the 31 sensitive receptors, the highest concentration levels of TSP in the ambience over the period of 24 hours on average range between 0.004-0.318 μg/m^3 or 0.001-0.096% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-20** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of TSP in the ambience over the period of 24 hours on average is 154.32 μg/m^3, or 46.76% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of TSP in the ambience over the period of 24 hours on average range between 106.00-144.04 μg/m^3 or 32.12-43.65% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-20**.

The execution of the project causes the highest concentration level of the average TSP in the ambience over the period of 1 year in the area of Jom Hae Mountain (grid reference - 728828 E 1419114 N), which is about 14.88 kilometers away from the project location to the south- southwest (SSW). The concentration level is 0.99 μg/m^3, accounting for 0.99% of that stipulated in general ambient air quality standards, according to which the average TSP in the ambience over the period of 1 year must not exceed 100 μg/m^3. For the 31 sensitive receptors, the highest concentration levels of TSP in the ambience over the period of 1 year on average range between 0.0004-0.0028 μg/m^3 or 0.0004-0.0028% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-20** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of TSP in the ambience over the period of 1 year on average is 45.24 $\mu g/m^3$, or 45.24% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of TSP in the ambience over the period of 1 year on average range between 32.570-44.252 $\mu g/m^3$ or 32.570-44.252% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-20**.

- **Average amount of particulate matter 10 micrometers or less in diameter (PM-10) over the period of 24 hours, and 1 year**

The execution of the project causes the highest concentration level of PM-10 in the ambience over the period of 24 hours on average in the area of Jom Hae Mountain (grid reference - 728828 E 1419614 N), which is about 14.39 kilometers away from the project location to the south - southwest (SSW). The concentration level is 10.32 $\mu g/m^3$, accounting for 8.60% of that stipulated in general ambient air quality standards, according to which the average PM-10 in the ambience over the period of 24 hours must not exceed 120 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of PM-10 in the ambience over the period of 24 hours on average range between 0.004-0.318 $\mu g/m^3$ or 0.003-0.265% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-20** and **Appendix 5A-5.**

When considered together with the existing monitoring results, the highest concentration level of PM-10 in the ambience over the period of 24 hours on average is 98.32 $\mu g/m^3$, or 81.93% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of PM-10 in the ambience over the period of 24 hours on average range between 19.360-27.043 $\mu g/m^3$ or 38.720-54.086% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-20**.

The execution of the project causes the highest concentration level of PM-10 in the ambience over the period of 1 year on average in the area of Jom Hae Mountain (grid reference - 728828 E 1419114 N), which is about 14.88 kilometers away from the project location to the south-southwest (SSW). The concentration level is 0.99 $\mu g/m^3$, accounting for 1.98% of that stipulated in general ambient air quality standards, according to which the average PM-10 in the ambience over the period of 1 year must not exceed 50 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of PM-10 in the ambience over the period of 1 year on average range between 0.0004-0.028 $\mu g/m^3$ or 0.0008-0.0056% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-20** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of PM-10 in the ambience over the period of 1 year on average is 28.03 $\mu g/m^3$, or 56.06% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of PM-10 in the ambience over the period of 1 year on average range between 19.360-27.043 $\mu g/m^3$ or 38.720-54.086% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-20**.

(b) Case 2: Impacts caused by Pluak Daeng Power Plant Project in the event of natural gas-fired operation at minimum load are assessed in conjunction with results of ambient air quality monitoring.

- **Average concentration of nitrogen dioxide (NO_2) over the period of 1 hour, and 1 year**

The nitrogen dioxide (NO_2) released into the ambience during the operation phase of the project results in the highest concentration level NO_2 in the study area over the period of 1 hour on average in the area of Jom Hae Mountain (grid reference - 729828 E 1419614 N), which is about 14.39 kilometers away from the project location to the south - southwest (SSW). The concentration level is 111.15 $\mu g/m^3$, accounting for 34.73% of that stipulated in general ambient air quality standards, according to which the average NO_2 in the ambience over the period of 1 hour must not exceed 320 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of NO_2 in the ambience over the period of 1 hour on average range between 0.05-7.28 micrograms/ cubic meter or 0.01-2.28% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-21** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of NO_2 in the ambience over the period of 1 hour on average is 178.89 $\mu g/m^3$, or 55.90% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of NO_2 in the ambience over the period of 1 hour on average range between 35.01-71.39 $\mu g/m^3$ or 10.94-22.31% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-21**.

The NO_2 released into the ambience during the operation phase of the project results in the highest concentration level of NO_2 in the study area over the period of 1 year on average in the area of Jom Hae Mountain (grid reference - 728828 E 1419114 N), which is about 14.88 kilometers away from the project location to the south - southwest (SSW). The concentration level is 1.43 $\mu g/m^3$, accounting for 2.51% of that stipulated in general ambient air quality standards, according to which the average NO_2 in the ambience over the period of 1 year must not exceed 57 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of NO_2 in the ambience over the period of 1 year on average range between 0.0005-0.0013 $\mu g/m^3$ or 0.001-0.02% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-21** and **Appendix 5A-5**.

TABLE 5.1.1-21

RESULTS OF THE PREDICTION OF AIR QUALITY BY USING THE AERMOD MODEL IN NORMAL CONDITION (WITHOUT EOWNWASH EFFECT), CASE 2: IMPACTS CAUSED BY PLUAK DAENG POWER PLANT PROJECT IN THE EVENT OF NATURAL GAS-FIRED OPERATION AT MINIMUM LOAD ARE ASSESSED IN CONJUNCTION WITH RESULTS OF AMBIENT AIR QUALITY MONITORING

Details	Estimated highest concentration levels of air pollutants in case 2 ($\mu g/m^3$)																										
	1-hour average NO_2			1-year average NO_2			1-hour average SO_2			24-hour average SO_2			1-year average SO_2			24-hour average TSP			1-year average TSP			24-hour average PM-10			1-year average PM-10		
	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	using the model	using existing monitoring data [2/]	total
Highest concentration value	111.15	67.74[1/]	178.89	1.43	11.02[1/]	12.45	81.32	39.83[1/]	121.15	15.85	47.17[1/]	63.02	1.11	6.48[1/]	7.59	11.13	144[1/]	155.13	0.78	44.25[1/]	45.03	11.13	88.00[1/]	99.13	0.78	27.04	27.82
Grid reference	729828E, 1419614N			728828E, 1419114N			729828E, 1419614N			729828E, 1419614N			728828E, 1419114N			728828E, 1419614N			728828E, 1419114N			728828E, 1419614N			728828E, 1419114N		
Location	Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain		
Direction and distance from the project site	SSW 14.39 km			SSW 14.88 km			SSW 14.39 km			SSW 14.39 km			SSW 14.88 km			SSW 14.39 km			SSW 14.88 km			SSW 14.39 km			SSW 14.88 km		
Type of land	mountain			mountain			mountain			mountain			mountain			mountain			mountain			mountain			mountain		
Sensitive receptor																											
1. Map Yang Phon Sub-district Administrative Organization	0.52	41.40	41.92	0.001	6.74	6.741	0.17	7.08	7.25	0.01	5.24	5.25	0.001	1.15	1.151	0.007	138	138.01	0.0006	42.41	42.411	0.007	88.00	88.01	0.0006	27.04	27.041
2. Ban Map Toei School	0.26	41.40	41.66	0.001	6.74	6.741	0.09	7.08	7.17	0.01	5.24	5.25	0.001	1.15	1.151	0.008	138	138.01	0.0006	42.41	42.411	0.008	88.00	88.01	0.0006	27.04	27.041
3. Map Toei Temple	0.21	41.40	41.61	0.002	6.74	6.742	0.09	7.08	7.17	0.01	5.24	5.25	0.001	1.15	1.151	0.008	138	138.01	0.0007	42.41	42.411	0.008	88.00	88.01	0.0007	27.04	27.041
4. Nikhom Sang Ton Eng 9 School	4.78	34.44	39.22	0.008	5.60	5.608	2.72	6.55	9.27	0.35	5.24	5.59	0.003	1.07	1.073	0.246	128	128.25	0.0019	39.33	39.332	0.246	88.00	88.25	0.0019	27.04	27.042
5. Prasitharam Temple	4.15	34.44	38.59	0.007	5.60	5.607	2.71	6.55	9.26	0.26	5.24	5.50	0.003	1.07	1.073	0.186	128	128.19	0.0018	39.33	39.332	0.186	88.00	88.19	0.0018	27.04	27.042
6. Map Yang Phon Sub-district Health Promoting Hospital	0.55	57.96	58.51	0.002	9.43	9.432	0.78	11.79	12.57	0.09	47.17	47.26	0.001	1.92	1.921	0.065	144	144.07	0.0008	44.25	44.251	0.065	78.00	78.07	0.0008	23.97	23.971
7. Ban Map Yang Phon School	0.58	57.96	58.54	0.002	9.43	9.432	0.78	11.79	12.57	0.10	47.17	47.27	0.002	1.92	1.922	0.067	144	144.07	0.0011	44.25	44.251	0.067	78.00	78.07	0.0011	23.97	23.971
8. Map Yang Phon Temple	0.34	57.96	58.30	0.002	9.43	9.432	0.42	11.79	12.21	0.04	47.17	47.21	0.001	1.92	1.921	0.031	144	144.03	0.0007	44.25	44.251	0.031	78.00	78.03	0.0007	23.97	23.971
9. Pluak Daeng Sub-district Administrative Organization	3.65	67.74	71.39	0.005	11.02	11.025	2.00	39.83	41.83	0.11	7.88	7.99	0.002	6.48	6.482	0.080	138	138.08	0.0012	42.41	42.411	0.080	86.50	86.58	0.0012	26.58	26.581
10. Orawin Witthaya School	2.40	67.74	70.14	0.005	11.02	11.025	1.13	39.83	40.96	0.08	7.88	7.96	0.002	6.48	6.482	0.057	138	138.06	0.0012	42.41	42.411	0.057	86.50	86.56	0.0012	26.58	26.581
11. Pluak Daeng High Voltage Electricity Station	1.43	67.74	69.17	0.003	11.02	11.023	1.05	39.83	40.88	0.12	7.88	8.00	0.001	6.48	6.481	0.082	138	138.08	0.0009	42.41	42.411	0.082	86.50	86.58	0.0009	26.58	26.581
12. Wang Pradu Temple	3.52	41.40	44.92	0.006	6.74	6.746	4.88	7.08	11.96	0.62	5.24	5.86	0.003	1.15	1.153	0.434	138	138.43	0.0023	42.41	42.412	0.434	88.00	88.43	0.0023	27.04	27.042
13. Wang Pradu School (closed down)	3.47	41.40	44.87	0.005	6.74	6.745	4.74	7.08	11.82	0.63	5.24	5.87	0.003	1.15	1.153	0.442	138	138.44	0.0022	42.41	42.412	0.442	88.00	88.44	0.0022	27.04	27.042
14. Village No.5, Ban Khlong Plu	0.57	34.44	35.01	0.001	5.60	5.601	0.41	6.55	6.96	0.02	5.24	5.26	0.001	1.07	1.071	0.017	128	128.02	0.0004	39.33	39.330	0.017	88.00	88.02	0.0004	27.04	27.040
15. Village No.7, Ban Wang Pla	3.25	34.44	37.69	0.005	5.60	5.605	1.70	6.55	8.25	0.12	5.24	5.36	0.002	1.07	1.072	0.086	128	128.09	0.0013	39.33	39.331	0.086	88.00	88.09	0.0013	27.04	27.041
16. Village No.8 , Ban Soi 13	4.69	34.44	39.13	0.005	5.60	5.605	3.04	6.55	9.59	0.32	5.24	5.56	0.002	1.07	1.072	0.225	128	128.22	0.0014	39.33	39.331	0.225	88.00	88.22	0.0014	27.04	27.041
17. Village No.7, Ban Wang Pradu	2.97	41.40	44.37	0.004	6.74	6.744	3.62	7.08	10.70	0.51	5.24	5.75	0.002	1.15	1.152	0.356	138	138.36	0.0016	42.41	42.412	0.356	88.00	88.36	0.0016	27.04	27.042
18. Village No.4, Ban Khao Mapud	2.96	34.44	37.40	0.004	5.60	5.604	0.88	6.55	7.43	0.09	5.24	5.33	0.001	1.07	1.071	0.065	128	128.06	0.0010	39.33	39.331	0.065	88.00	88.06	0.0010	27.04	27.041
19. Village No.5, Ban Wang Tan Mon	1.20	40.65	41.85	0.003	6.62	6.623	0.73	11.01	11.74	0.08	6.03	6.11	0.002	1.79	1.792	0.055	106	106.06	0.0012	32.57	32.571	0.055	63.00	63.06	0.0012	19.36	19.361
20. Village No.1, Ban Map Toei	1.35	41.40	42.75	0.002	6.74	6.742	2.51	7.08	9.59	0.21	5.24	5.45	0.001	1.15	1.151	0.150	138	138.15	0.0008	42.41	42.411	0.150	88.00	88.15	0.0008	27.04	27.041
21. Village No.7, Ban Chak Oi	1.29	41.40	42.69	0.002	6.74	6.742	0.99	7.08	8.07	0.06	5.24	5.30	0.001	1.15	1.151	0.040	138	138.04	0.0009	42.41	42.411	0.040	88.00	88.04	0.0009	27.04	27.041
22. Village No.6, Ban Map Yang Mai	0.08	48.36	48.44	0.001	7.87	7.871	0.05	10.74	10.79	0.01	5.5	5.51	0.001	1.75	1.751	0.004	110	110.00	0.0005	33.80	33.800	0.004	65.00	65.00	0.0005	19.97	19.970
23. Village No.6, Ban Thab Tong	2.51	41.40	43.91	0.002	6.74	6.742	2.17	7.08	9.25	0.12	5.24	5.36	0.001	1.15	1.151	0.085	138	138.09	0.0007	42.41	42.411	0.085	88.00	88.09	0.0007	27.04	27.041
24. Village No.2, Ban Noen Sawan	0.15	57.96	58.11	0.002	9.43	9.432	0.09	11.79	11.88	0.01	47.17	47.18	0.001	1.92	1.921	0.007	144	144.01	0.0010	44.25	44.251	0.007	78.00	78.01	0.0010	23.97	23.971
25. Village No.4, Ban Wang Ta Phin	0.69	41.40	42.09	0.001	6.74	6.741	0.36	7.08	7.44	0.04	5.24	5.28	0.001	1.15	1.151	0.027	138	138.03	0.0005	42.41	42.410	0.027	88.00	88.03	0.0005	27.04	27.040
26. Village No.3, Ban Map Yang Phon	0.28	57.96	58.24	0.002	9.43	9.432	0.30	11.79	12.09	0.04	47.17	47.21	0.001	1.92	1.921	0.026	144	144.03	0.0009	44.25	44.251	0.026	78.00	78.03	0.0009	23.97	23.971

TABLE 5.1.1-21

RESULTS OF THE PREDICTION OF AIR QUALITY BY USING THE AERMOD MODEL IN NORMAL CONDITION (WITHOUT EOWNWASH EFFECT),

CASE 2: IMPACTS CAUSED BY PLUAK DAENG POWER PLANT PROJECT IN THE EVENT OF NATURAL GAS-FIRED OPERATION AT MINIMUM LOAD ARE ASSESSED IN CONJUNCTION WITH RESULTS OF AMBIENT AIR QUALITY MONITORING (CONT'D)

Details	Estimated highest concentration levels of air pollutants in case 2 ($\mu g/m^3$)																										
	1-hour average NO_2			1-year average NO_2			1-hour average SO_2			24-hour average SO_2			1-year average SO_2			24-hour average TSP			1-year average TSP			24-hour average PM-10			1-year average PM-10		
	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	using the model	using existing monitoring data [2/]	total
27. Village No.6, Ban Nong Rakam	0.05	40.65	40.70	0.0005	6.62	6.620	0.02	11.01	11.03	0.002	6.03	6.03	0.0003	1.79	1.790	0.002	106	106.00	0.0002	32.57	32.570	0.002	63.00	63.00	0.0002	19.36	19.360
28. Village No.5, Ban Khlong Phlu	1.42	40.65	42.07	0.002	6.62	6.622	1.18	11.01	12.19	0.07	6.03	6.10	0.001	1.79	1.791	0.051	106	106.05	0.0006	32.57	32.571	0.051	63.00	63.05	0.0006	19.36	19.361
29. Village No.7, Ban Wang Pla	5.69	34.44	40.13	0.008	5.60	5.608	2.60	6.55	9.15	0.20	5.24	5.44	0.002	1.07	1.072	0.142	128	128.14	0.0017	39.33	39.332	0.142	88.00	88.14	0.0017	27.04	27.042
30. Village No.8, Ban Soi 13	7.28	34.44	41.72	0.013	5.60	5.613	4.59	6.55	11.14	0.67	5.24	5.91	0.004	1.07	1.074	0.472	128	128.47	0.0030	39.33	39.333	0.472	88.00	88.47	0.0030	27.04	27.043
31. Village No.4, Ban Chak Manthed	3.54	41.40	44.94	0.007	6.74	6.747	3.48	7.08	10.56	0.40	5.24	5.64	0.004	1.15	1.154	0.280	138	138.28	0.0027	42.41	42.413	0.280	88.00	88.28	0.0027	27.04	27.043
Standard value[3/]	320			57			780			300			100			330			100			120			50		
WHO [4/]	200			40			-			20			-			-			-			50			20		

Remark :
[1/] With reference to Table 5.1.1-5 : Highest values in the existing data on the ambient air quality monitoring in the project's vicinity
[2/] With reference to Table 5.1.1-8 : Highest values in the existing data on air quality monitoring which are used to represent each receptor's air pollutant concentration level
[3/] With reference to the standards in :
- Announcement of the National Environment Board No. 10 (1995) and No. 24 (2004) on ambient air quality standard specification
- Announcement of the National Environment Board No. 21 (2001) on sulfur dioxide ambient concentration standard specification
- Announcement of the National Environment Board No. 33 (2009) on nitrogen dioxide ambient concentration standard specification

[4/] Referenced from WHO Ambient Air Quality Guidelines in Environmental, Health, and Safety (EHS) Guidelines for International Finance Corporation (2007)

Source : Team Consulting Engineering and Management Co., Ltd., 2016

When considered together with the existing monitoring results, the highest concentration level of NO_2 in the ambience over the period of 1 year on average is 12.45 $\mu g/m^3$, or 21.84% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of NO_2 in the ambience over the period of 1 year on average range between 5.601-11.025 $\mu g/m^3$ or 9.827-19.343% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-21**.

- **Average concentration of sulfur dioxide (SO_2) over the period of 1 hour, 24 hours, and 1 year**

The sulfur dioxide (SO_2) released into the ambience during the operation phase of the project results in the highest concentration level of SO_2 in the study area over the period of 1 hour on average in the area of Jom Hae Mountain (grid reference - 729828 E 1419614 N), which is about 14.39 kilometers away from the project location to the south - southwest (SSW). The concentration level is 81.32 $\mu g/m^3$, accounting for 10.43% of that stipulated in general ambient air quality standards, according to which the average SO_2 in the ambience over the period of 1 hour must not exceed 780 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of SO_2 in the ambience over the period of 1 hour on average range between 0.02-4.88 $\mu g/m^3$ or 0.003-0.63% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-21** and **Appendix 5A-5.**

When considered together with the existing monitoring results, the highest concentration level of SO_2 in the ambience over the period of 1 hour on average is 121.15 $\mu g/m^3$, or 15.53% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of SO_2 in the ambience over the period of 1 hour on average range between 6.96-41.83 $\mu g/m^3$ or 0.89-5.36% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-21**.

The SO_2 released into the ambience during the operation phase of the project results in the highest concentration level of SO_2 in the study area over the period of 24 hours on average in the area of Jom Hae Mountain (grid reference - 729828 E 1419614 N), which is about 14.39 kilometers away from the project location to the south - southwest (SSW). The concentration level is 15.85 $\mu g/m^3$, accounting for 5.28% of that stipulated in general ambient air quality standards, according to which the average SO_2 in the ambience over the period of 24 hours must not exceed 300 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of SO_2 in the ambience over the period of 24 hours on average range between 0.002-067 $\mu g/m^3$ or 0.001-0.22% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-21** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of SO_2 in the ambience over the period of 24 hours on average is 63.02 µg/m^3, or 21.01% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of SO_2 in the ambience over the period of 24 hours on average range between 5.25-47.27 µg/m^3 or 1.75-15.76% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-21**.

The SO_2 released into the ambience during the operation phase of the project results in the highest concentration level of SO_2 in the study area over the period of 1 year on average in the area of Jom Hae Mountain (grid reference - 728828 E 1419114 N), which is about 14.88 kilometers away from the project location to the south - southwest (SSW). The concentration level is 1.11 µg/m^3, accounting for 1.11% of that stipulated in general ambient air quality standards, according to which the average SO_2 in the ambience over the period of 1 year must not exceed 100 µg/m^3. For the 31 sensitive receptors, the highest concentration levels of SO_2 in the ambience over the period of 1 year on average range between 0.003-0.004 µg/m^3 or 0.003-0.004% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-21** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of SO_2 in the ambience over the period of 1 year on average is 7.59 µg/m^3, or 7.59% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of SO_2 in the ambience over the period of 1 year on average range between 1.071-6.482 µg/m^3 or 1.071-6.482% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-21**.

- **Average total suspended particulate (TSP) over the period of 24 hours and 1 year**

The execution of the project causes the highest concentration level of the average TSP in the ambience over the period of 24 hours in the area of Jom Hae Mountain (grid reference - 728828 E 1419614 N), which is about 14.39 kilometers away from the project location to the south - southwest (SSW). The concentration level is 11.13 µg/m^3, accounting for 3.37% of that stipulated in general ambient air quality standards, according to which the average TSP in the ambience over the period of 24 hours must not exceed 330 µg/m^3. For the 31 sensitive receptors, the highest concentration levels of TSP in the ambience over the period of 24 hours on average range between 0.002-0.472 µg/m^3 or 0.0006-0.14% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-21** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of TSP in the ambience over the period of 24 hours on average is 155.13 μg/m³, or 47.01% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of TSP in the ambience over the period of 24 hours on average range between 106.00-144.07 μg/m³ or 32.12-43.66% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-21**.

The execution of the project causes the highest concentration level of the average TSP in the ambience over the period of 1 year in the area of Jom Hae Mountain (grid reference - 728828 E 1419114 N), which is about 14.88 kilometers away from the project location to the south - southwest (SSW). The concentration level is 0.78 μg/m³, accounting for 0.78% of that stipulated in general ambient air quality standards, according to which the average TSP in the ambience over the period of 1 year must not exceed 100 μg/m³. For the 31 sensitive receptors, the highest concentration levels of TSP in the ambience over the period of 1 year on average range between 0.0002-0.0030 μg/m³ or 0.0002-0.0030% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-21** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of TSP in the ambience over the period of 1 year on average is 45.03 μg/m³, or 45.03% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of TSP in the ambience over the period of 1 year on average range between 32.570-44.251 μg/m³ or 32.570-44.251% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-21**.

- **Average amount of particulate matter 10 micrometers or less in diameter (PM-10) over the period of 24 hours, and 1 year**

The execution of the project causes the highest concentration level of PM-10 in the ambience over the period of 24 hours on average in the area of Jom Hae Mountain (grid reference - 728828 E 1419614 N), which is about 14.39 kilometers away from the project location to the south - southwest (SSW). The concentration level is 11.13 μg/m³, accounting for 9.28% of that stipulated in general ambient air quality standards, according to which the average PM-10 in the ambience over the period of 24 hours must not exceed 120 μg/m³. For the 31 sensitive receptors, the highest concentration levels of PM-10 in the ambience over the period of 24 hours on average range between 0.002-0.472 μg/m³ meter or 0.001-0.393% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-21** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of PM-10 in the ambience over the period of 24 hours on average is 99.13 μg/m^3, or 82.61% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of PM-10 in the ambience over the period of 24 hours on average range between 63.00-88.47 μg/m^3 or 52.50-73.73% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-21**.

The execution of the project causes the highest concentration level of PM-10 in the ambience over the period of 1 year on average in the area of Jom Hae Mountain (grid reference - 728828 E 1419114 N), which is about 14.88 kilometers away from the project location to the south - southwest (SSW). The concentration level is 0.78 μg/m^3, accounting for 1.56% of that stipulated in general ambient air quality standards, according to which the average PM-10 in the ambience over the period of 1 year must not exceed 50 μg/m^3. For the 31 sensitive receptors, the highest concentration levels of PM-10 in the ambience over the period of 1 year on average range between 0.0002-0.0030 μg/m^3 or 0.0004-0.0061% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-21** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of PM-10 in the ambience over the period of 1 year on average is 27.82 μg/m^3, or 55.64% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of PM-10 in the ambience over the period of 1 year on average range between 19.360-27.043 μg/m^3 or 38.720-54.086% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-21**.

(c) Case 3: Impacts caused by Pluak Daeng Power Plant Project in the event of natural gas-fired operation at 100% load; plus the proposed emission from other non-operated factories as specified in their environmental impact assessment report within 15-kilometer radius from the project location; are assessed in conjunction with results of ambient air quality measurement

- **Average concentration of nitrogen dioxide (NO_2) over the period of 1 hour, and 1 year**

The nitrogen dioxide (NO_2) released into the ambience during the operation phase of the project results in the highest concentration level NO_2in the study area over the period of 1 hour on average in the area of Song Phi Nong Mountain (grid reference - 722328 E 1438114 N), which is about 12.52 kilometers away from the project location to the north - west (NW). The concentration level is 236.89 μg/m^3, accounting for 74.03% of that stipulated in general ambient air quality standards, according to which the average NO_2 in the ambience over the period of 1 hour must not exceed 320 μg/m^3. For the 31 sensitive receptors, the highest concentration levels of NO_2 in the ambience over the period of 1 hour on average range between 5.57-16.44 μg/m^3 or 1.74-5.14%, as shown in **Table 5.1.1-22** and **Appendix 5A-5**.

TABLE 5.1.1-22

RESULTS OF THE PREDICTION OF AIR QUALITY BY USING THE AERMOD MODEL IN NORMAL CONDITION (WITHOUT DOWNWASH EFFECT),
CASE 3: IMPACTS CAUSED BY PLUAK DAENG POWER PLANT PROJECT IN THE EVENT OF NATURAL GAS-FIRED OPERATION AT 100% LOAD; PLUS THE EXISTING IMPACTS CAUSED BY OTHER INDUSTRIAL PLANTS AS SPECIFIED IN THE ENVIRONMENTAL IMPACT ASSESSMENT REPORT THOUGH THERE IS NOT YET AIR POLLUTANT EMISSION WITHIN THE RADIUS OF 15 KILOMETERS FROM THE PROJECT LOCATION; ARE ASSESSED IN CONJUNCTION WITH RESULTS OF AMBIENT AIR QUALITY MONITORING

Details	Estimated highest concentration levels of air pollutants in case 3 ($\mu g/m^3$)																										
	1-hour average NO_2			1-year average NO_2			1-hour average SO_2			24-hour average SO_2			1-year average SO_2			24-hour average TSP			1-year average TSP			24-hour average PM-10			1-year average PM-10		
	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total
Highest concentration value	236.89	67.74[1/]	304.63	6.55	11.02[1/]	17.57	100.16	39.83[1/]	139.99	20.92	47.17[1/]	68.09	2.63	6.48[1/]	9.11	18.14	144[1/]	162.14	2.99	44.25[1/]	47.24	18.14	88.00[1/]	106.14	2.99	27.04[1/]	30.03
Grid reference	722328E, 1438114N			722328E, 1438614N			729328E, 1419114N			728828E, 1419614N			729328E, 1419114N			728828E, 1419614N			722328E, 1439114N			728828E, 1419614N			722328E, 1439114N		
Location	Song Phi Nong Mountain			Song Phi Nong Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			a cassava plantation			Jom Hae Mountain			a cassava plantation		
Direction and distance from the project site	NW 12.52 km			NW 12.75 km			SSW 14.71 km			SSW 14.04 km			SSW 14.71 km			SSW 14.04 km			SW 18.07 km			SSW 14.04 km			SW 18.07 km		
Type of land	mountain			mountain			mountain			mountain			mountain			mountain			agricultural			mountain			agricultural		
Sensitive receptor																											
1. Map Yang Phon Sub-district Administrative Organization	13.08	41.40	54.48	0.12	6.74	6.86	2.12	7.08	9.20	0.42	5.24	5.66	0.02	1.15	1.17	0.70	138	138.70	0.02	42.41	42.43	0.70	88.00	88.70	0.02	27.04	27.06
2. Ban Map Toey School	13.12	41.40	54.52	0.12	6.74	6.86	2.14	7.08	9.22	0.43	5.24	5.67	0.02	1.15	1.17	0.71	138	138.71	0.02	42.41	42.43	0.71	88.00	88.71	0.02	27.04	27.06
3. Map Toey Temple	13.38	41.40	54.78	0.13	6.74	6.87	2.17	7.08	9.25	0.43	5.24	5.67	0.02	1.15	1.17	0.72	138	138.72	0.03	42.41	42.44	0.72	88.00	88.72	0.03	27.04	27.07
4. Nikhom Sang Ton Eng 9 School	14.91	34.44	49.35	0.24	5.60	5.84	2.78	6.55	9.33	0.82	5.24	6.06	0.04	1.07	1.11	1.22	128	129.22	0.05	39.33	39.38	1.22	88.00	89.22	0.05	27.04	27.09
5. Prasitharam Temple	14.72	34.44	49.16	0.25	5.60	5.85	2.81	6.55	9.36	0.83	5.24	6.07	0.04	1.07	1.11	1.23	128	129.23	0.05	39.33	39.38	1.23	88.00	89.23	0.05	27.04	27.09
6. Map Yang Phon Sub-district Health Promoting Hospital	12.20	57.96	70.16	0.28	9.43	9.71	2.11	11.79	13.90	0.72	47.17	47.89	0.05	1.92	1.97	1.29	144	145.29	0.07	44.25	44.32	1.29	78.00	79.29	0.07	23.97	24.04
7. Ban Map Yang Phon School	12.80	57.96	70.76	0.27	9.43	9.70	2.29	11.79	14.08	0.56	47.17	47.73	0.05	1.92	1.97	1.01	144	145.01	0.07	44.25	44.32	1.01	78.00	79.01	0.07	23.97	24.04
8. Map Yang Phon Temple	14.42	57.96	72.38	0.21	9.43	9.64	2.33	11.79	14.12	0.54	47.17	47.71	0.04	1.92	1.96	0.86	144	144.86	0.05	44.25	44.30	0.86	78.00	78.86	0.05	23.97	24.02
9. Pluak Daeng Sub-district Administrative Organization	5.59	67.74	73.33	0.07	11.02	11.09	1.48	39.83	41.31	0.30	7.88	8.18	0.02	6.48	6.50	0.33	138	138.33	0.01	42.41	42.42	0.33	86.50	86.83	0.01	26.58	26.59
10. Orawin Witthaya School	5.57	67.74	73.31	0.06	11.02	11.08	1.46	39.83	41.29	0.28	7.88	8.16	0.02	6.48	6.50	0.27	138	138.27	0.01	42.41	42.42	0.27	86.50	86.77	0.01	26.58	26.59
11. Pluak Daeng High Voltage Electricity Station	8.44	67.74	76.18	0.07	11.02	11.09	1.71	39.83	41.54	0.30	7.88	8.18	0.01	6.48	6.49	0.53	138	138.53	0.01	42.41	42.42	0.53	86.50	87.03	0.01	26.58	26.59
12. Wang Pradu Temple	8.49	41.40	49.89	0.09	6.74	6.83	2.81	7.08	9.89	0.35	5.24	5.59	0.02	1.15	1.17	0.44	138	138.44	0.02	42.41	42.43	0.44	88.00	88.44	0.02	27.04	27.06
13. Wang Pradu School (closed down)	8.30	41.40	49.70	0.08	6.74	6.82	2.70	7.08	9.78	0.36	5.24	5.60	0.02	1.15	1.17	0.43	138	138.43	0.02	42.41	42.43	0.43	88.00	88.43	0.02	27.04	27.06
14. Village No.5, Ban Khlong Plu	16.26	34.44	50.70	0.20	5.60	5.80	2.83	6.55	9.38	0.64	5.24	5.88	0.03	1.07	1.10	1.01	128	129.01	0.03	39.33	39.36	1.01	88.00	89.01	0.03	27.04	27.07
15. Village No.7, Ban Wang Pla	14.37	34.44	48.81	0.23	5.60	5.83	2.87	6.55	9.42	0.84	5.24	6.08	0.04	1.07	1.11	1.27	128	129.27	0.05	39.33	39.38	1.27	88.00	89.27	0.05	27.04	27.09
16. Village No.8, Ban Soi 13	12.93	34.44	47.37	0.22	5.60	5.82	2.59	6.55	9.14	0.70	5.24	5.94	0.04	1.07	1.11	1.19	128	129.19	0.05	39.33	39.38	1.19	88.00	89.19	0.05	27.04	27.09
17. Village No.7, Ban Wang Pradu	7.63	41.40	49.03	0.08	6.74	6.82	2.09	7.08	9.17	0.30	5.24	5.54	0.02	1.15	1.17	0.43	138	138.43	0.02	42.41	42.43	0.43	88.00	88.43	0.02	27.04	27.06
18. Village No.4, Ban Khao Mapud	12.00	34.44	46.44	0.23	5.60	5.83	2.55	6.55	9.10	0.86	5.24	6.10	0.04	1.07	1.11	1.43	128	129.43	0.05	39.33	39.38	1.43	88.00	89.43	0.05	27.04	27.09
19. Village No.5, Ban Wang Tan Mon	11.70	40.65	52.35	0.20	6.62	6.82	2.71	11.01	13.72	0.78	6.03	6.81	0.03	1.79	1.82	1.21	106	107.21	0.05	32.57	32.62	1.21	63.00	64.21	0.05	19.36	19.41
20. Village No 1, Ban Map Toey	12.80	41.40	54.20	0.11	6.74	6.85	2.13	7.08	9.21	0.37	5.24	5.61	0.02	1.15	1.17	0.62	138	138.62	0.02	42.41	42.43	0.62	88.00	88.62	0.02	27.04	27.06
21. Village No.7, Ban Chak Oi	8.00	41.40	49.40	0.07	6.74	6.81	2.10	7.08	9.18	0.29	5.24	5.53	0.02	1.15	1.17	0.42	138	138.42	0.01	42.41	42.42	0.42	88.00	88.42	0.01	27.04	27.05
22. Village No.6 , Ban Map Yang Mai	11.62	48.36	59.98	0.21	7.87	8.08	2.36	10.74	13.10	0.65	5.5	6.15	0.03	1.75	1.78	1.03	110	111.03	0.05	33.80	33.85	1.03	65.00	66.03	0.05	19.97	20.02
23. Village No.6, Ban Thab Tong	7.88	41.40	49.28	0.07	6.74	6.81	1.92	7.08	9.00	0.34	5.24	5.58	0.01	1.15	1.16	0.44	138	138.44	0.01	42.41	42.42	0.44	88.00	88.44	0.01	27.04	27.05
24. Village No.2, Ban Noen Sawan	12.33	57.96	70.29	0.20	9.43	9.63	2.85	11.79	14.64	0.59	47.17	47.76	0.03	1.92	1.95	0.99	144	144.99	0.05	44.25	44.30	0.99	78.00	78.99	0.05	23.97	24.02
25. Village No.4, Ban Wang Ta Phin	8.70	41.40	50.10	0.07	6.74	6.81	1.81	7.08	8.89	0.32	5.24	5.56	0.01	1.15	1.16	0.45	138	138.45	0.02	42.41	42.43	0.45	88.00	88.45	0.02	27.04	27.06
26. Village No.3, Ban Map Yang Phon	10.37	57.96	68.33	0.15	9.43	9.58	2.35	11.79	14.14	0.52	47.17	47.69	0.03	1.92	1.95	0.82	144	144.82	0.04	44.25	44.29	0.82	78.00	78.82	0.04	23.97	24.01

TABLE 5.1.1-22

RESULTS OF THE PREDICTION OF AIR QUALITY BY USING THE AERMOD MODEL IN NORMAL CONDITION (WITHOUT DOWNWASH EFFECT), CASE 3: IMPACTS CAUSED BY PLUAK DAENG POWER PLANT PROJECT IN THE EVENT OF NATURAL GAS-FIRED OPERATION AT 100% LOAD; PLUS THE EXISTING IMPACTS CAUSED BY OTHER INDUSTRIAL PLANTS AS SPECIFIED IN THE ENVIRONMENTAL IMPACT ASSESSMENT REPORT THOUGH THERE IS NOT YET AIR POLLUTANT EMISSION WITHIN THE RADIUS OF 15 KILOMETERS FROM THE PROJECT LOCATION; ARE ASSESSED IN CONJUNCTION WITH RESULTS OF AMBIENT AIR QUALITY MONITORING (CONT'D)

Details	Estimated highest concentration levels of air pollutants in case 3 ($\mu g/m^3$)																										
	1-hour average NO_2			1-year average NO_2			1-hour average SO_2			24-hour average SO_2			1-year average SO_2			24-hour average TSP			1-year average TSP			24-hour average PM-10			1-year average PM-10		
	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total
27. Village No.6, Ban Nong Rakam	13.78	40.65	54.43	0.12	6.62	6.74	2.29	11.01	13.30	0.36	6.03	6.39	0.02	1.79	1.81	0.56	106	106.56	0.02	32.57	32.59	0.56	63.00	63.56	0.02	19.36	19.38
28. Village No.5, Ban Khlong Phlu	15.65	40.65	56.30	0.20	6.62	6.82	3.07	11.01	14.08	0.68	6.03	6.71	0.03	1.79	1.82	1.08	106	107.08	0.03	32.57	32.60	1.08	63.00	64.08	0.03	19.36	19.39
29. Village No.7, Ban Wang Pla	16.44	34.44	50.88	0.24	5.60	5.84	2.82	6.55	9.37	0.84	5.24	6.08	0.03	1.07	1.10	1.23	128	129.23	0.05	39.33	39.38	1.23	88.00	89.23	0.05	27.04	27.09
30. Village No.8 , Ban Soi 13	14.91	34.44	49.35	0.26	5.60	5.86	4.15	6.55	10.70	0.87	5.24	6.11	0.04	1.07	1.11	1.29	128	129.29	0.06	39.33	39.39	1.29	88.00	89.29	0.06	27.04	27.10
31. Village No.4, Ban Chak Manthed	6.00	41.40	47.40	0.06	6.74	6.80	2.52	7.08	9.60	0.29	5.24	5.53	0.02	1.15	1.17	0.23	138	138.23	0.01	42.41	42.42	0.23	88.00	88.23	0.01	27.04	27.05
Standard values [3/]	320			57			780			300			100			330			100			120			50		
WHO [4/]	200			40			-			20			-			-			-			50			20		

Remark : 1/ With reference to Table 5.1.1-5 : Highest values in the existing data on the ambient air quality monitoring in the project's vicinity

2/ With reference to Table 5.1.1-8 : Highest values in the existing data on air quality monitoring which are used to represent each receptor's air pollutant concentration level

3/ With reference to the standards in :

- Announcement of the National Environment Board No. 10 (1995) and No. 24 (2004) on ambient air quality standard specification
- Announcement of the National Environment Board No. 21 (2001) on sulfur dioxide ambient concentration standard specification
- Announcement of the National Environment Board No. 33 (2009) on nitrogen dioxide ambient concentration standard specification

4/ Referenced from WHO Ambient Air Quality Guidelines in Environmental, Health, and Safety (EHS) Guidelines for International Finance Corporation (2007)

Source : Team Consulting Engineering and Management Co., Ltd., 2016

When considered together with the existing monitoring results, the highest concentration level of NO_2 in the ambience over the period of 1 hour on average is 304.63 μg/m^3, or 95.20% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of NO_2 in the ambience over the period of 1 hour on average range between 46.44-76.18 μg/m^3 or 14.51-23.81% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-22**.

The NO_2 released into the ambience during the operation phase of the project results in the highest concentration level of NO_2 in the study area over the period of 1 year on average in the area of Song Phi Nong Mountain (grid reference - 722328 E 1438114 N), which is about 12.75 kilometers away from the project location to the northwest (NW). The concentration level is 6.55 μg/m^3, accounting for 11.49% of that stipulated in general ambient air quality standards, according to which the average NO_2 in the ambience over the period of 1 year must not exceed 57 μg/m^3. For the 31 sensitive receptors, the highest concentration levels of NO_2 in the ambience over the period of 1 year on average range between 0.06-0.28 μg/m^3 or 0.11-0.49% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-22** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of NO_2 in the ambience over the period of 1 year on average is 17.57 μg/m^3, or 30.82% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of NO_2 in the ambience over the period of 1 year on average range between 5.80-11.09 μg/m^3 or 10.17-19.45% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-22**.

- **Average concentration of sulfur dioxide (SO_2) over the period of 1 hour, 24 hours, and 1 year**

The sulfur dioxide (SO_2) released into the ambience during the operation phase of the project results in the highest concentration level of SO_2 in the study area over the period of 1 hour on average in the area of Jom Hae Mountain (grid reference - 729328 E 1419114 N), which is about 14.71 kilometers away from the project location to the south - southwest (SSW). The concentration level is 100.16 μg/m^3, accounting for 12.84% of that stipulated in general ambient air quality standards, according to which the average SO_2 in the ambience over the period of 1 hour must not exceed 780 μg/m^3. For the 31 sensitive receptors, the highest concentration levels of SO_2 in the ambience over the period of 1 hour on average range between 1.46-4.15 μg/m^3 or 0.19-0.53% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-22** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of SO_2 in the ambience over the period of 1 hour on average is 139.99 μg/m^3, or 17.95% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of SO_2 in the ambience over the period of 1 hour on average range between 8.89-41.54 μg/m^3 or 1.14-5.33% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-22**.

The SO_2 released into the ambience during the operation phase of the project results in the highest concentration level of SO_2 in the study area over the period of 24 hours on average at the area of Jom Hae Mountain (grid reference - 728828 E 1419614 N), which is about 14.04 kilometers away from the project location to the south - southwest (SSW). The concentration level is 20.92 μg/m^3, accounting for 6.97% of that stipulated in general ambient air quality standards, according to which the average SO_2 in the ambience over the period of 24 hours must not exceed 300 μg/m^3. For the 31 sensitive receptors, the highest concentration levels of SO_2 in the ambience over the period of 24 hours on average range between 0.28-0.87 μg/m^3 or 0.09-0.29% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-22** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of SO_2 in the ambience over the period of 24 hours on average is 68.09 μg/m^3, or 22.70% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of SO_2 in the ambience over the period of 24 hours on average range between 5.53-47.89 μg/m^3 or 1.84-15.96% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-22**.

The SO_2 released into the ambience during the operation phase of the project results in the highest concentration level of SO_2 in the study area over the period of 1 year on average in the area of Jom Hae Mountain (grid reference - 729328 E 1419114 N), which is about 14.71 kilometers away from the project location to the south - southwest (SSW). The concentration level is 2.63 micrograms/ cubic meter, accounting for 2.63% of that stipulated in general ambient air quality standards, according to which the average SO_2 in the ambience over the period of 1 year must not exceed 100 μg/m^3. For the 31 sensitive receptors, the highest concentration levels of SO_2 in the ambience over the period of 1 year on average range between 0.01-0.05 μg/m^3 or 0.01-0.05% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-22** and **Appendix 5A-5.**

When considered together with the existing monitoring results, the highest concentration level of SO_2 in the ambience over the period of 1 year on average is 9.11 $\mu g/m^3$, or 9.11% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of SO_2 in the ambience over the period of 1 year on average range between 1.10-6.50 $\mu g/m^3$ or 1.10-6.50% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-22**.

- **Average total suspended particulate (TSP) over the period of 24 hours and 1 year**

The execution of the project causes the highest concentration level of the average TSP in the ambience over the period of 24 hours in the area of Jom Hae Mountain (grid reference - 728828 E 1419614 N), which is about 14.04 kilometers away from the project location to the south- southwest (SSW). The concentration level is 18.14 $\mu g/m^3$, accounting for 5.50% of that stipulated in general ambient air quality standards, according to which the average TSP in the ambience over the period of 24 hours must not exceed 330 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of TSP in the ambience over the period of 24 hours on average range between 0.23-1.43 $\mu g/m^3$or 0.07-0.43% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-22** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of TSP in the ambience over the period of 24 hours on average is 162.14 $\mu g/m^3$, or 49.13% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of TSP in the ambience over the period of 24 hours on average range between 106.56-145.29 $\mu g/m^3$ or 32.29-44.03% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-22**.

The execution of the project causes the highest concentration level of the average TSP in the ambience over the period of 1 year in the area of a cassava plantation (grid reference - 722328 E 1439114 N), which is about 18.07 kilometers away from the project location to the southwest (SW). The concentration level is 2.99 $\mu g/m^3$, accounting for 2.99% of that stipulated in general ambient air quality standards, according to which the average TSP in the ambience over the period of 1 year must not exceed 100 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of TSP in the ambience over the period of 1 year on average range between 0.01-0.07 $\mu g/m^3$ or 0.01-0.07% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-22** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of TSP in the ambience over the period of 1 year on average is 47.24 $\mu g/m^3$, or 47.24% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of TSP in the ambience over the period of 1 year on average range between 32.59-44.32 $\mu g/m^3$ or 32.59-44.32% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-22**.

- **Average amount of particulate matter 10 micrometers or less in diameter (PM-10) over the period of 24 hours, and 1 year**

The execution of the project causes the highest concentration level of PM-10 in the ambience over the period of 24 hours on average in the area of Jom Hae Mountain (grid reference - 728828 E 1419614 N), which is about 14.04 kilometers away from the project location to the south - southwest (SSW). The concentration level is 18.14 $\mu g/m^3$, accounting for 15.12% of that stipulated in general ambient air quality standards, according to which the average PM-10 in the ambience over the period of 24 hours must not exceed 120 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of PM-10 in the ambience over the period of 24 hours on average range between 0.23-1.43 $\mu g/m^3$ or 0.19-1.19 of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-22** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of PM-10 in the ambience over the period of 24 hours on average is 106.14 $\mu g/m^3$, or 88.45% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of PM-10 in the ambience over the period of 24 hours on average range between 63.56-89.43 $\mu g/m^3$ or 52.97-74.52% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-22**.

The execution of the project causes the highest concentration level of PM-10 in the ambience over the period of 1 year on average in the area of a cassava plantation (grid reference - 722328 E 1439114 N), which is about 18.07 kilometers away from the project location to the southwest (SW). The concentration level is 2.99 $\mu g/m^3$, accounting for 5.98% of that stipulated in general ambient air quality standards, according to which the average PM-10 in the ambience over the period of 1 year must not exceed 50 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of PM-10 in the ambience over the period of 1 year on average range between 0.01-0.07 $\mu g/m^3$ or 0.02-0.14% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-22** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of PM-10 in the ambience over the period of 1 year on average is 30.03 μg/m^3, or 60.06% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of PM-10 in the ambience over the period of 1 year on average range between 19.38-27.10 μg/m^3 or 38.76-54.20% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-22**.

- **Average amount of particulate matter 10 micrometers or less in diameter (PM-10) over the period of 24 hours, and 1 year**

The execution of the project causes the highest concentration level of PM-10 in the ambience over the period of 24 hours on average in the area of Jom Hae Mountain (grid reference - 728828 E 1419614 N), which is about 14.04 kilometers away from the project location to the south - southwest (SSW). The concentration level is 18.14 μg/m^3, accounting for 15.12% of that stipulated in general ambient air quality standards, according to which the average PM-10 in the ambience over the period of 24 hours must not exceed 120 μg/m^3. For the 31 sensitive receptors, the highest concentration levels of PM-10 in the ambience over the period of 24 hours on average range between 0.23-1.43 μg/m^3 or 0.19-1.19 of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-22** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of PM-10 in the ambience over the period of 24 hours on average is 106.14 μg/m^3, or 88.45% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of PM-10 in the ambience over the period of 24 hours on average range between 63.56-89.43 μg/m^3 or 52.97-74.52% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-22**.

The execution of the project causes the highest concentration level of PM-10 in the ambience over the period of 1 year on average in the area of a cassava plantation (grid reference - 722328 E 1439114 N), which is about 18.07 kilometers away from the project location to the southwest (SW). The concentration level is 2.99 μg/m^3, accounting for 5.98% of that stipulated in general ambient air quality standards, according to which the average PM-10 in the ambience over the period of 1 year must not exceed 50 μg/m^3. For the 31 sensitive receptors, the highest concentration levels of PM-10 in the ambience over the period of 1 year on average range between 0.01-0.07 μg/m^3 or 0.02-0.14% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-22** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of PM-10 in the ambience over the period of 1 year on average is 30.03 $\mu g/m^3$, or 60.06% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of PM-10 in the ambience over the period of 1 year on average range between 19.38-27.10 $\mu g/m^3$ or 38.76-54.20% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-22**.

(d) Case 4: Impacts caused by Pluak Daeng Power Plant Project in the event of diesel-fuelled operation at 100% load are assessed in conjunction with results of ambient air quality measurement

- **Average concentration of nitrogen dioxide (NO_2) over the period of 1 hour, and 1 year**

The nitrogen dioxide (NO_2) released into the ambience during the operation phase of the project results in the highest concentration level NO_2 in the study area over the period of 1 hour on average in the area of Jom Hae Mountain (grid reference - 729828 E 1419614 N), which is about 14.39 kilometers away from the project location to the south - southwest (SSW). The concentration level is 154.73 $\mu g/m^3$, accounting for 48.35% of that stipulated in general ambient air quality standards, according to which the average NO_2 in the ambience over the period of 1 hour must not exceed 320 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of NO_2 in the ambience over the period of 1 hour on average range between 0.08-6.20 $\mu g/m^3$ or 0.03-1.94% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-23** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of NO_2 in the ambience over the period of 1 hour on average is 222.47 $\mu g/m^3$, or 69.52% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of NO_2 in the ambience over the period of 1 hour on average range between 34.75-69.65 $\mu g/m^3$ or 10.86-21.77% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-23**.

The NO_2 released into the ambience during the operation phase of the project results in the highest concentration level of NO_2 in the study area over the period of 1 year on average in the area of Jom Hae Mountain (grid reference - 728828 E 1419114 N), which is about 14.88 kilometers away from the project location to the south - southwest (SSW). The concentration level is 2.43 $\mu g/m^3$, accounting for 4.26% of that stipulated in general ambient air quality standards, according to which the average NO_2 in the ambience over the period of 1 year must not exceed 57 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of NO_2 in the ambience over the period of 1 year on average range between 0.001-0.012 $\mu g/m^3$ or 0.002-0.021% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-23** and **Appendix 5A-5**.

TABLE 5.1.1-23

RESULTS OF THE PREDICTION OF AIR QUALITY BY USING THE AERMOD MODEL IN NORMAL CONDITION (WITHOUT DOWNWASH EFFECT), CASE 4: IMPACTS CAUSED BY PLUAK DAENG POWER PLANT PROJECT IN THE EVENT OF DIESEL-FIRED OPERATION AT 100% LOAD ARE ASSESSED IN CONJUNCTION WITH RESULTS OF AMBIENT AIR QUALITY MONITORING

Details	Estimated highest concentration levels of air pollutants in case 4 ($\mu g/m^3$)																										
	1-hour average NO_2			1-year average NO_2			1-hour average SO_2			24-hour average SO_2			1-year average SO_2			24-hour average TSP			1-year average TSP			24-hour average PM-10			1-year average PM-10		
	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total
Highest concentration value	154.73	67.74[1/]	222.47	2.43	11.02[1/]	13.45	119.72	39.83[1/]	159.55	21.70	47.17[1/]	68.87	2.12	6.48[1/]	8.60	13.33	144[1/]	157.33	1.31	44.25[1/]	45.56	10.94	88.00[1/]	98.94	1.07	27.04[1/]	28.11
Grid reference	729828E, 1419614N			728828E, 1419114N			729328E, 1419114N			728828E, 1419114N			728828E, 1419114N			728828E, 1419114N			728828E, 1419114N			728828E, 1419114N			728828E, 1419114N		
Location	Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain		
Direction and distance from the project site	SSW 14.39 km			SSW 14.88 km			SSW 14.71 km			SSW 14.88 km			SSW 14.88 km			SSW 14.88 km			SSW 14.88 km			SSW 14.88 km			SSW 14.88 km		
Type of land	mountain			mountain			mountain			mountain			mountain			mountain			mountain			mountain			mountain		
Sensitive receptor																											
1. Map Yang Phon Sub-district Administrative Organization	0.31	41.40	41.71	0.004	6.74	6.744	0.24	7.08	7.32	0.04	5.24	5.28	0.003	1.15	1.153	0.02	138	138.02	0.002	42.41	42.412	0.019	88.00	88.02	0.0015	27.04	27.041
2. Ban Map Toey School	0.30	41.40	41.70	0.004	6.74	6.744	0.25	7.08	7.33	0.04	5.24	5.28	0.003	1.15	1.153	0.03	138	138.03	0.002	42.41	42.412	0.021	88.00	88.02	0.0016	27.04	27.042
3. Map Toey Temple	0.31	41.40	41.71	0.004	6.74	6.744	0.24	7.08	7.32	0.04	5.24	5.28	0.003	1.15	1.153	0.03	138	138.03	0.002	42.41	42.412	0.022	88.00	88.02	0.0017	27.04	27.042
4. Nikhom Sang Ton Eng 9 School	3.18	34.44	37.62	0.009	5.60	5.609	2.07	6.55	8.62	0.27	5.24	5.51	0.005	1.07	1.075	0.16	128	128.16	0.003	39.33	39.333	0.135	88.00	88.13	0.0025	27.04	27.042
5. Prasitharam Temple	2.44	34.44	36.88	0.008	5.60	5.608	1.53	6.55	8.08	0.19	5.24	5.43	0.005	1.07	1.075	0.12	128	128.12	0.003	39.33	39.333	0.097	88.00	88.10	0.0024	27.04	27.042
6. Map Yang Phon Sub-district Health Promoting Hospital	0.42	57.96	58.38	0.004	9.43	9.434	0.57	11.79	12.36	0.07	47.17	47.24	0.003	1.92	1.923	0.04	144	144.04	0.002	44.25	44.252	0.036	78.00	78.04	0.0017	23.97	23.972
7. Ban Map Yang Phon School	0.43	57.96	58.39	0.005	9.43	9.435	0.54	11.79	12.33	0.08	47.17	47.25	0.004	1.92	1.924	0.05	144	144.05	0.003	44.25	44.253	0.039	78.00	78.04	0.0021	23.97	23.972
8. Map Yang Phon Temple	0.28	57.96	58.24	0.004	9.43	9.434	0.31	11.79	12.10	0.04	47.17	47.21	0.003	1.92	1.923	0.02	144	144.02	0.002	44.25	44.252	0.019	78.00	78.02	0.0017	23.97	23.972
9. Pluak Daeng Sub-district Administrative Organization	1.91	67.74	69.65	0.005	11.02	11.025	1.20	39.83	41.03	0.08	7.88	7.96	0.002	6.48	6.482	0.05	138	138.05	0.001	42.41	42.411	0.042	86.50	86.54	0.0011	26.58	26.581
10. Orawin Witthaya School	1.55	67.74	69.29	0.005	11.02	11.025	0.71	39.83	40.54	0.07	7.88	7.95	0.002	6.48	6.482	0.04	138	138.04	0.001	42.41	42.411	0.034	86.50	86.53	0.0011	26.58	26.581
11. Pluak Daeng High Voltage Electricity Station	0.82	67.74	68.56	0.003	11.02	11.023	0.71	39.83	40.54	0.08	7.88	7.96	0.002	6.48	6.482	0.05	138	138.05	0.001	42.41	42.411	0.042	86.50	86.54	0.0009	26.58	26.581
12. Wang Pradu Temple	2.26	41.40	43.66	0.005	6.74	6.745	4.26	7.08	11.34	0.53	5.24	5.77	0.004	1.15	1.154	0.32	138	138.32	0.002	42.41	42.412	0.265	88.00	88.26	0.0018	27.04	27.042
13. Wang Pradu School (closed down)	2.39	41.40	43.79	0.005	6.74	6.745	4.08	7.08	11.16	0.54	5.24	5.78	0.004	1.15	1.154	0.33	138	138.33	0.002	42.41	42.412	0.271	88.00	88.27	0.0018	27.04	27.042
14. Village No.5, Ban Khlong Plu	0.31	34.44	34.75	0.003	5.60	5.603	0.19	6.55	6.74	0.02	5.24	5.26	0.002	1.07	1.072	0.01	128	128.01	0.001	39.33	39.331	0.009	88.00	88.01	0.0010	27.04	27.041
15. Village No.7, Ban Wang Pla	1.64	34.44	36.08	0.006	5.60	5.606	0.88	6.55	7.43	0.08	5.24	5.32	0.004	1.07	1.074	0.05	128	128.05	0.003	39.33	39.333	0.043	88.00	88.04	0.0021	27.04	27.042
16. Village No.8, Ban Soi 13	3.18	34.44	37.62	0.006	5.60	5.606	2.67	6.55	9.22	0.25	5.24	5.49	0.004	1.07	1.074	0.16	128	128.16	0.002	39.33	39.332	0.128	88.00	88.13	0.0019	27.04	27.042
17. Village No.7, Ban Wang Pradu	2.14	41.40	43.54	0.003	6.74	6.743	3.16	7.08	10.24	0.40	5.24	5.64	0.003	1.15	1.153	0.25	138	138.25	0.002	42.41	42.412	0.201	88.00	88.20	0.0013	27.04	27.041
18. Village No.4, Ban Khao Mapud	1.49	34.44	35.93	0.005	5.60	5.605	0.53	6.55	7.08	0.06	5.24	5.30	0.003	1.07	1.073	0.04	128	128.04	0.002	39.33	39.332	0.031	88.00	88.03	0.0016	27.04	27.042
19. Village No.5, Ban Wang Tan Mon	0.78	40.65	41.43	0.008	6.62	6.628	0.52	11.01	11.53	0.06	6.03	6.09	0.006	1.79	1.796	0.04	106	106.04	0.004	32.57	32.574	0.030	63.00	63.03	0.0029	19.36	19.363
20. Village No.1, Ban Map Toey	0.52	41.40	41.92	0.003	6.74	6.743	0.93	7.08	8.01	0.09	5.24	5.33	0.003	1.15	1.153	0.06	138	138.06	0.002	42.41	42.412	0.046	88.00	88.05	0.0014	27.04	27.041
21. Village No.7, Ban Chak Oi	0.72	41.40	42.12	0.003	6.74	6.743	0.63	7.08	7.71	0.05	5.24	5.29	0.002	1.15	1.152	0.03	138	138.03	0.001	42.41	42.411	0.026	88.00	88.03	0.0012	27.04	27.041
22. Village No.6, Ban Map Yang Mai	0.18	48.36	48.54	0.003	7.87	7.873	0.13	10.74	10.87	0.02	5.5	5.52	0.003	1.75	1.753	0.01	110	110.01	0.002	33.80	33.802	0.010	65.00	65.01	0.0013	19.97	19.971
23. Village No.6, Ban Thab Tong	1.18	41.40	42.58	0.003	6.74	6.743	1.14	7.08	8.22	0.07	5.24	5.31	0.002	1.15	1.152	0.04	138	138.04	0.001	42.41	42.411	0.033	88.00	88.03	0.0009	27.04	27.041
24. Village No.2, Ban Noen Sawan	0.29	57.96	58.25	0.006	9.43	9.436	0.23	11.79	12.02	0.03	47.17	47.20	0.005	1.92	1.925	0.02	144	144.02	0.003	44.25	44.253	0.015	78.00	78.02	0.0026	23.97	23.973
25. Village No.4, Ban Wang Ta Phin	0.37	41.40	41.77	0.002	6.74	6.742	0.25	7.08	7.33	0.03	5.24	5.27	0.002	1.15	1.152	0.02	138	138.02	0.001	42.41	42.411	0.016	88.00	88.02	0.0008	27.04	27.041
26. Village No.3, Ban Map Yang Phon	0.22	57.96	58.18	0.004	9.43	9.434	0.23	11.79	12.02	0.03	47.17	47.20	0.003	1.92	1.923	0.02	144	144.02	0.002	44.25	44.252	0.015	78.00	78.01	0.0015	23.97	23.971

TABLE 5.1.1-23

RESULTS OF THE PREDICTION OF AIR QUALITY BY USING THE AERMOD MODEL IN NORMAL CONDITION (WITHOUT DOWNWASH EFFECT), CASE 4: IMPACTS CAUSED BY PLUAK DAENG POWER PLANT PROJECT IN THE EVENT OF DIESEL-FIRED OPERATION AT 100% LOAD ARE ASSESSED IN CONJUNCTION WITH RESULTS OF AMBIENT AIR QUALITY MONITORING (CONT'D)

Details	Estimated highest concentration levels of air pollutants in case 4 ($\mu g/m^3$)																										
	1-hour average NO_2			1-year average NO_2			1-hour average SO_2			24-hour average SO_2			1-year average SO_2			24-hour average TSP			1-year average TSP			24-hour average PM-10			1-year average PM-10		
	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total
27. Village No.6, Ban Nong Rakam	0.08	40.65	40.73	0.001	6.62	6.621	0.07	11.01	11.08	0.01	6.03	6.04	0.001	1.79	1.791	0.01	106	106.01	0.001	32.57	32.571	0.004	63.00	63.00	0.0005	19.36	19.360
28. Village No.5, Ban Khlong Phlu	0.78	40.65	41.43	0.003	6.62	6.623	0.51	11.01	11.52	0.04	6.03	6.07	0.002	1.79	1.792	0.03	106	106.03	0.001	32.57	32.571	0.021	63.00	63.02	0.0010	19.36	19.361
29. Village No.7, Ban Wang Pla	3.10	34.44	37.54	0.007	5.60	5.607	1.54	6.55	8.09	0.16	5.24	5.40	0.004	1.07	1.074	0.10	128	128.10	0.002	39.33	39.332	0.081	88.00	88.08	0.0019	27.04	27.042
30. Village No.8, Ban Soi 13	6.20	34.44	40.64	0.012	5.60	5.612	5.87	6.55	12.42	0.70	5.24	5.94	0.006	1.07	1.076	0.43	128	128.43	0.004	39.33	39.334	0.351	88.00	88.35	0.0030	27.04	27.043
31. Village No.4, Ban Chak Manthed	3.53	41.40	44.93	0.006	6.74	6.746	3.75	7.08	10.83	0.44	5.24	5.68	0.004	1.15	1.154	0.27	138	138.27	0.003	42.41	42.413	0.222	88.00	88.22	0.0021	27.04	27.042
Standard value [3/]	320			57			780			300			100			330			100			120			50		
WHO [4/]	200			40			-			20			-			-			-			50			20		

Remark :
[1/] With reference to Table 5.1.1-5 : Highest values in the existing data on the ambient air quality monitoring in the project's vicinity
[2/] With reference to Table 5.1.1-8 : Highest values in the existing data on air quality monitoring which are used to represent each receptor's air pollutant concentration level
[3/] With reference to the standards in :
- Announcement of the National Environment Board No. 10 (1995) and No. 24 (2004) on ambient air quality standard specification
- Announcement of the National Environment Board No. 21 (2001) on sulfur dioxide ambient concentration standard specification
- Announcement of the National Environment Board No. 33 (2009) on nitrogen dioxide ambient concentration standard specification

[4/] Referenced from WHO Ambient Air Quality Guidelines in Environmental, Health, and Safety (EHS) Guidelines for International Finance Corporation (2007)

Source : Team Consulting Engineering and Management Co., Ltd., 2016

When considered together with the existing monitoring results, the highest concentration level of NO_2 in the ambience over the period of 1 year on average is 13.45 $\mu g/m^3$, or 23.60% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of NO_2 in the ambience over the period of 1 hour on average range between 5.603-11.025 $\mu g/m^3$ or 9.829-19.342% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-23**.

- **Average concentration of sulfur dioxide (SO_2) over the period of 1 hour, 24 hours, and 1 year**

The sulfur dioxide (SO_2) released into the ambience during the operation phase of the project results in the highest concentration level of SO_2 in the study area over the period of 1 hour on average in the area of Jom Hae Mountain (grid reference - 729328 E 1419114 N), which is about 14.71 kilometers away from the project location to the south - southwest (SSW). The concentration level is 119.72 $\mu g/m^3$, accounting for 15.35% of that stipulated in general ambient air quality standards, according to which the average SO_2 in the ambience over the period of 1 hour must not exceed 780 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of SO_2 in the ambience over the period of 1 hour on average range between 0.07-5.87 $\mu g/m^3$ or 0.01-0.75 % of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-23** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of SO_2 in the ambience over the period of 1 hour on average is 159.55 $\mu g/m^3$, or 20.46% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of SO_2 in the ambience over the period of 1 hour on average range between 6.74-41.03 $\mu g/m^3$ or 0.86-5.26% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-23**.

The SO_2 released into the ambience during the operation phase of the project results in the highest concentration level of SO_2 in the study area over the period of 24 hours on average in the area of Jom Hae Mountain (grid reference - 728828 E 1419114 N), which is about 14.88 kilometers away from the project location to the south - southwest (SSW). The concentration level is 21.70 $\mu g/m^3$, accounting for 7.23% of that stipulated in general ambient air quality standards, according to which the average SO_2 in the ambience over the period of 24 hours must not exceed 300 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of SO_2 in the ambience over the period of 24 hours on average range between 0.01-0.46 $\mu g/m^3$ or 0.003-0.23% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-23** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of SO_2 in the ambience over the period of 24 hours on average is 68.87 $\mu g/m^3$, or 22.96% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of SO_2 in the ambience over the period of 24 hours on average range between 5.26-47.25 $\mu g/m^3$ or 1.75-15.75% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-23**.

The SO_2 released into the ambience during the operation phase of the project results in the highest concentration level of SO_2 in the study area over the period of 1 year on average in the area of Jom Hae Mountain (grid reference - 728828 E 1419114 N), which is about 14.88 kilometers away from the project location to the south - southwest (SSW). The concentration level is 2.12 $\mu g/m^3$, accounting for 2.12% of that stipulated in general ambient air quality standards, according to which the average SO_2 in the ambience over the period of 1 year must not exceed 100 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of SO_2 in the ambience over the period of 1 year on average range between 0.001-0.010 $\mu g/m^3$ or 0.001-0.010% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-23** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of SO_2 in the ambience over the period of 1 year on average is 8.60 $\mu g/m^3$, or 8.60% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of SO_2 in the ambience over the period of 1 year on average range between 1.072-6.482 $\mu g/m^3$ or 1.072-6.482% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-23**.

- **Average total suspended particulate (TSP) over the period of 24 hours and 1 year**

The execution of the project causes the highest concentration level of the average TSP in the ambience over the period of 24 hours in the area of Jom Hae Mountain (grid reference - 728828 E 1419114 N), which is about 14.88 kilometers away from the project location to the south - southwest (SSW). The concentration level is 13.33 $\mu g/m^3$, accounting for 4.04% of that stipulated in general ambient air quality standards, according to which the average TSP in the ambience over the period of 24 hours must not exceed 330 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of TSP in the ambience over the period of 24 hours on average range between 0.01-0.43 $\mu g/m^3$ or 0.003-0.130% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-23** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of TSP in the ambience over the period of 24 hours on average is 157.33 μg/m^3, or 47.68% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of TSP in the ambience over the period of 24 hours on average range between 106.01-144.05 μg/m^3 or 32.12-43.65% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-23**.

The execution of the project causes the highest concentration level of the average TSP in the ambience over the period of 1 year in the area of Jom Hae Mountain (grid reference - 728828 E 1419114 N), which is about 14.88 kilometers away from the project location to the south - southwest (SSW). The concentration level is 1.31 μg/m^3, accounting for 1.31% of that stipulated in general ambient air quality standards, according to which the average TSP in the ambience over the period of 1 year must not exceed 100 μg/m^3. For the 31 sensitive receptors, the highest concentration levels of TSP in the ambience over the period of 1 year on average range between 0.001-0.004 μg/m^3 or 0.001-0.004% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-23** and **Appendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of TSP in the ambience over the period of 1 year on average is 45.56 μg/m^3, or 45.56% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of TSP in the ambience over the period of 1 year on average range between 32.571-44.253 μg/m^3 or 32.571-44.253% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-23**.

- **Average amount of particulate matter 10 micrometers or less in diameter (PM-10) over the period of 24 hours, and 1 year**

The execution of the project causes the highest concentration level of PM-10 in the ambience over the period of 24 hours on average in the area of Jom Hae Mountain (grid reference - 728828 E 1419114 N), which is about 14.88 kilometers away from the project location to the south - southwest (SSW). The concentration level is 10.94 μg/m^3, accounting for 9.12% of that stipulated in general ambient air quality standards, according to which the average PM-10 in the ambience over the period of 24 hours must not exceed 120 μg/m^3. For the 31 sensitive receptors, the highest concentration levels of PM-10 in the ambience over the period of 24 hours on average range between 0.004-0.351 μg/m^3 or 0.003-0.292% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-23** and **Appendix 5A-5.**

When considered together with the existing monitoring results, the highest concentration level of PM-10 in the ambience over the period of 24 hours on average is 98.94 $\mu g/m^3$, or 82.45% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of PM-10 in the ambience over the period of 24 hours on average range between 63.00-88.35 $\mu g/m^3$ or 52.50-73.63% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-23**.

The execution of the project causes the highest concentration level of PM-10 in the ambience over the period of 1 year on average in the area of Jom Hae Mountain (grid reference - 728828 E 1419114 N), which is about 14.88 kilometers away from the project location to the south - southwest (SSW). The concentration level is 1.07 $\mu g/m^3$, accounting for 2.14%of that stipulated in general ambient air quality standards, according to which the average PM-10 in the ambience over the period of 1 year must not exceed 50 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of PM-10 in the ambience over the period of 1 year on average range between 0.0005-0.0030 $\mu g/m^3$ or 0.0010-0.0060% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-23** and **Appendix 5A-5.**

When considered together with the existing monitoring results, the highest concentration level of PM-10 in the ambience over the period of 1 year on average is 28.11 $\mu g/m^3$, or 56.22% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of PM-10 in the ambience over the period of 1 year on average range between 19.360-27.043 $\mu g/m^3$ or 38.720-54.086% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-23**.

(e) Case 5: Impacts caused by Pluak Daeng Power Plant Project in the event of diesel-fulled operation at minimum load are assessed in conjunction with results of ambient air quality measurement

- **Average concentration of nitrogen dioxide (NO_2) over the period of 1 hour, and 1 year**

The nitrogen dioxide (NO_2) released into the ambience during the operation phase of the project results in the highest concentration level NO_2in the study area over the period of 1 hour on average in the area of Jom Hae Mountain (grid reference - 729828 E 141961N), which is about 14.39 kilometers away from the project location to the south - southwest (SSW). The concentration level is 153.82 $\mu g/m^3$, accounting for 48.07% of that stipulated in general ambient air quality standards, according to which the average NO_2 in the ambience over the period of 1 hour must not exceed 320 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of NO_2 in the ambience over the period of 1 hour on average range between 0.06-9.30 $\mu g/m^3$ or 0.02-2.91% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-24** and **Appendix 5A-5.**

TABLE 5.1.1-24

RESULTS OF THE PREDICTION OF AIR QUALITY BY USING THE AERMOD MODEL IN NORMAL CONDITION (WITHOUT DOWNWASH EFFECT)

CASE 5: IMPACTS CAUSED BY PLUAK DAENG POWER PLANT PROJECT IN THE EVENT OF DIESEL-FIRED OPERATION AT MINIMUM LOAD ARE ASSESSED IN CONJUNCTION WITH RESULTS OF AMBIENT AIR QUALITY MONITORING

Details	Estimated highest concentration levels of air pollutants in case 5 (µg/m³)																										
	1-hour average NO_2			1-year average NO_2			1-hour average SO_2			24-hour average SO_2			1-year average SO_2			24-hour average TSP			1-year average TSP			24-hour average PM-10			1-year average PM-10		
	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total
Highest concentration value	153.82	67.74[1/]	221.56	2.30	11.02[1/]	13.32	136.39	39.83[1/]	176.22	27.35	47.17[1/]	74.52	2.12	6.48[1/]	8.60	16.47	144[1/]	160.47	1.28	44.25[1/]	45.53	13.51	88.00[1/]	101.51	1.05	27.04[1/]	28.09
Grid reference	729828E, 1419614N			728828E, 1419114N			729828E, 1419614N			728828E, 1419614N			728828E, 1419114N			728828E, 1419614N			728828E, 1419114N			728828E, 1419614N			728828E, 1419114N		
Location	Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain		
Direction and distance from the project site	SSW			SSW			SSW			SSW			SSW			SSW			SSW			SSW			SSW		
	14.39 km			14.88 km			14.39 km			14.04 km			14.88 km			14.04 km			14.88 km			14.04 km			14.88 km		
Type of land	mountain			mountain			mountain			mountain			mountain			mountain			mountain			mountain			mountain		
Sensitive receptor																											
1. Map Yang Phon Sub-district Administrative Organization	0.53	41.40	41.93	0.003	6.74	6.743	0.20	7.08	7.28	0.03	5.24	5.27	0.002	1.15	1.152	0.016	138	138.02	0.0012	42.41	42.411	0.013	88.00	88.01	0.0010	27.04	27.041
2. Ban Map Toey School	0.30	41.40	41.70	0.003	6.74	6.743	0.20	7.08	7.28	0.03	5.24	5.27	0.002	1.15	1.152	0.017	138	138.02	0.0013	42.41	42.411	0.014	88.00	88.01	0.0010	27.04	27.041
3. Map Toey Temple	0.30	41.40	41.70	0.003	6.74	6.743	0.20	7.08	7.28	0.03	5.24	5.27	0.002	1.15	1.152	0.018	138	138.02	0.0014	42.41	42.411	0.015	88.00	88.01	0.0011	27.04	27.041
4. Nikhom Sang Ton Eng 9 School	5.55	34.44	39.99	0.010	5.60	5.610	3.61	6.55	10.16	0.49	5.24	5.73	0.005	1.07	1.075	0.293	128	128.29	0.0029	39.33	39.333	0.240	88.00	88.24	0.0023	27.04	27.042
5. Prasitharam Temple	4.60	34.44	39.04	0.009	5.60	5.609	3.43	6.55	9.98	0.36	5.24	5.60	0.005	1.07	1.075	0.217	128	128.22	0.0027	39.33	39.333	0.178	88.00	88.18	0.0023	27.04	27.042
6. Map Yang Phon Sub-district Health Promoting Hospital	0.64	57.96	58.60	0.003	9.43	9.433	1.04	11.79	12.83	0.12	47.17	47.29	0.002	1.92	1.922	0.074	144	144.07	0.0015	44.25	44.252	0.061	78.00	78.06	0.0012	23.97	23.971
7. Ban Map Yang Phon School	0.66	57.96	58.62	0.004	9.43	9.434	1.01	11.79	12.80	0.13	47.17	47.30	0.003	1.92	1.923	0.076	144	144.08	0.0019	44.25	44.252	0.062	78.00	78.06	0.0016	23.97	23.972
8. Map Yang Phon Temple	0.39	57.96	58.35	0.003	9.43	9.433	0.54	11.79	12.33	0.06	47.17	47.23	0.002	1.92	1.922	0.035	144	144.03	0.0014	44.25	44.251	0.029	78.00	78.03	0.0012	23.97	23.971
9. Pluak Daeng Sub-district Administrative Organization	4.03	67.74	71.77	0.006	11.02	11.026	2.71	39.83	42.54	0.16	7.88	8.04	0.003	6.48	6.483	0.094	138	138.09	0.0016	42.41	42.412	0.077	86.50	86.58	0.0013	26.58	26.581
10. Orawin Witthaya School	2.58	67.74	70.32	0.006	11.02	11.026	1.43	39.83	41.26	0.11	7.88	7.99	0.003	6.48	6.483	0.066	138	138.07	0.0016	42.41	42.412	0.054	86.50	86.55	0.0013	26.58	26.581
11. Pluak Daeng High Voltage Electricity Station	1.52	67.74	69.26	0.003	11.02	11.023	1.34	39.83	41.17	0.15	7.88	8.03	0.002	6.48	6.482	0.092	138	138.09	0.0012	42.41	42.411	0.075	86.50	86.58	0.0010	26.58	26.581
12. Wang Pradu Temple	3.89	41.40	45.29	0.007	6.74	6.747	6.85	7.08	13.93	0.89	5.24	6.13	0.005	1.15	1.155	0.534	138	138.53	0.0029	42.41	42.413	0.438	88.00	88.44	0.0024	27.04	27.042
13. Wang Pradu School (closed down)	3.85	41.40	45.25	0.006	6.74	6.746	6.62	7.08	13.70	0.91	5.24	6.15	0.005	1.15	1.155	0.546	138	138.55	0.0028	42.41	42.413	0.448	88.00	88.45	0.0023	27.04	27.042
14. Village No.5, Ban Khlong Plu	0.53	34.44	34.97	0.002	5.60	5.602	0.43	6.55	6.98	0.03	5.24	5.27	0.001	1.07	1.071	0.017	128	128.02	0.0009	39.33	39.331	0.014	88.00	88.01	0.0007	27.04	27.041
15. Village No.7, Ban Wang Pla	3.38	34.44	37.82	0.007	5.60	5.607	2.07	6.55	8.62	0.16	5.24	5.40	0.003	1.07	1.073	0.097	128	128.10	0.0021	39.33	39.332	0.080	88.00	88.08	0.0017	27.04	27.042
16. Village No.8 , Ban Soi 13	5.50	34.44	39.94	0.007	5.60	5.607	4.50	6.55	11.05	0.45	5.24	5.69	0.003	1.07	1.073	0.271	128	128.27	0.0021	39.33	39.332	0.222	88.00	88.22	0.0017	27.04	27.042
17. Village No.7, Ban Wang Pradu	3.55	41.40	44.95	0.005	6.74	6.745	5.35	7.08	12.43	0.70	5.24	5.94	0.003	1.15	1.153	0.423	138	138.42	0.0020	42.41	42.412	0.347	88.00	88.35	0.0016	27.04	27.042
18. Village No.4, Ban Khao Mapud	3.03	34.44	37.47	0.005	5.60	5.605	1.03	6.55	7.58	0.12	5.24	5.36	0.003	1.07	1.073	0.071	128	128.07	0.0016	39.33	39.332	0.058	88.00	88.06	0.0013	27.04	27.041
19. Village No.5, Ban Wang Tan Mon	1.33	40.65	41.98	0.006	6.62	6.626	0.97	11.01	11.98	0.10	6.03	6.13	0.004	1.79	1.794	0.063	106	106.06	0.0024	32.57	32.572	0.052	63.00	63.05	0.0019	19.36	19.362
20. Village No.1, Ban Map Toey	1.26	41.40	42.66	0.003	6.74	6.743	2.75	7.08	9.83	0.24	5.24	5.48	0.002	1.15	1.152	0.144	138	138.14	0.0013	42.41	42.411	0.118	88.00	88.12	0.0011	27.04	27.041
21. Village No.7, Ban Chak Oi	1.26	41.40	42.66	0.003	6.74	6.743	1.11	7.08	8.19	0.07	5.24	5.31	0.002	1.15	1.152	0.043	138	138.04	0.0013	42.41	42.411	0.035	88.00	88.04	0.0011	27.04	27.041
22. Village No.6 , Ban Map Yang Mai	0.14	48.36	48.50	0.002	7.87	7.872	0.10	10.74	10.84	0.01	5.5	5.51	0.002	1.75	1.752	0.009	110	110.01	0.0010	33.80	33.801	0.007	65.00	65.01	0.0008	19.97	19.971
23. Village No.6, Ban Thab Tong	2.56	41.40	43.96	0.003	6.74	6.743	2.65	7.08	9.73	0.15	5.24	5.39	0.002	1.15	1.152	0.089	138	138.09	0.0010	42.41	42.411	0.073	88.00	88.07	0.0008	27.04	27.041
24. Village No.2, Ban Noen Sawan	0.22	57.96	58.18	0.004	9.43	9.434	0.18	11.79	11.97	0.02	47.17	47.19	0.003	1.92	1.923	0.013	144	144.01	0.0021	44.25	44.252	0.011	78.00	78.01	0.0017	23.97	23.972
25. Village No.4, Ban Wang Ta Phin	0.71	41.40	42.11	0.002	6.74	6.742	0.44	7.08	7.52	0.05	5.24	5.29	0.001	1.15	1.151	0.031	138	138.03	0.0008	42.41	42.411	0.025	88.00	88.03	0.0007	27.04	27.041
26. Village No. 3, Ban Map Yang Phon	0.31	57.96	58.27	0.003	9.43	9.433	0.39	11.79	12.18	0.05	47.17	47.22	0.002	1.92	1.922	0.029	144	144.03	0.0014	44.25	44.251	0.024	78.00	78.02	0.0012	23.97	23.971

TABLE 5.1.1-24

RESULTS OF THE PREDICTION OF AIR QUALITY BY USING THE AERMOD MODEL IN NORMAL CONDITION (WITHOUT DOWNWASH EFFECT)

CASE 5: IMPACTS CAUSED BY PLUAK DAENG POWER PLANT PROJECT IN THE EVENT OF DIESEL-FIRED OPERATION AT MINIMUM LOAD ARE ASSESSED IN CONJUNCTION WITH RESULTS OF AMBIENT AIR QUALITY MONITORING (CONT'D)

Details	Estimated highest concentration levels of air pollutants in case 5 ($\mu g/m^3$)																										
	1-hour average NO_2			1-year average NO_2			1-hour average SO_2			24-hour average SO_2			1-year average SO_2			24-hour average TSP			1-year average TSP			24-hour average PM-10			1-year average PM-10		
	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total
27. Village No.6, Ban Nong Rakam	0.06	40.65	40.71	0.001	6.62	6.621	0.05	11.01	11.06	0.01	6.03	6.04	0.001	1.79	1.791	0.003	106	106.00	0.0004	32.57	32.570	0.003	63.00	63.00	0.0003	19.36	19.360
28. Village No.5, Ban Khlong Phlu	1.35	40.65	42.00	0.003	6.62	6.623	1.27	11.01	12.28	0.08	6.03	6.11	0.002	1.79	1.792	0.049	106	106.05	0.0010	32.57	32.571	0.040	63.00	63.04	0.0008	19.36	19.361
29. Village No.7, Ban Wang Pla	6.20	34.44	40.64	0.010	5.60	5.610	3.39	6.55	9.94	0.29	5.24	5.53	0.004	1.07	1.074	0.173	128	128.17	0.0024	39.33	39.332	0.142	88.00	88.14	0.0020	27.04	27.042
30. Village No.8 , Ban Soi 13	9.30	34.44	43.74	0.016	5.60	5.616	7.91	6.55	14.46	1.05	5.24	6.29	0.007	1.07	1.077	0.632	128	128.63	0.0043	39.33	39.334	0.518	88.00	88.52	0.0035	27.04	27.043
31. Village No.4, Ban Chak Manthed	4.72	41.40	46.12	0.008	6.74	6.748	5.46	7.08	12.54	0.65	5.24	5.89	0.006	1.15	1.156	0.389	138	138.39	0.0034	42.41	42.413	0.319	88.00	88.32	0.0028	27.04	27.043
Standard value [3/]	320			57			780			300			100			330			100			120			50		
WHO [4/]	200			40			-			20			-			-			-			50			20		

Remark :

[1/] With reference to Table 5.1.1-5 : Highest values in the existing data on the ambient air quality monitoring in the project's vicinity

[2/] With reference to Table 5.1.1-8 : Highest values in the existing data on air quality monitoring which are used to represent each receptor's air pollutant concentration level

[3/] With reference to the standards in :

- Announcement of the National Environment Board No. 10 (1995) and No. 24 (2004) on ambient air quality standard specification
- Announcement of the National Environment Board No. 21 (2001) on sulfur dioxide ambient concentration standard specification
- Announcement of the National Environment Board No. 33 (2009) on nitrogen dioxide ambient concentration standard specification

[4/] Referenced from WHO Ambient Air Quality Guidelines in Environmental, Health, and Safety (EHS) Guidelines for International Finance Corporation (2007)

Source : Team Consulting Engineering and Management Co., Ltd., 2016

When considered together with the existing monitoring results, the highest concentration level of NO_2 in the ambience over the period of 1 hour on average is 221.56 $\mu g/m^3$, or 69.24% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of NO_2 in the ambience over the period of 1 hour on average range between 34.97-71.77 $\mu g/m^3$ or 10.93-22.43% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-24**.

The NO_2 released into the ambience during the operation phase of the project results in the highest concentration level of NO_2 in the study area over the period of 1 year on average in the area of Jom Hae Mountain (grid reference - 728828 E 1419114 N), which is about 14.88 kilometers away from the project location to the south - southwest (SSW). The concentration level is 2.30 $\mu g/m^3$, accounting for 4.04% of that stipulated in general ambient air quality standards, according to which the average NO_2 in the ambience over the period of 1 year must not exceed 57 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of NO_2 in the ambience over the period of 1 year on average range between 0.001-0.0016 $\mu g/m^3$ or 0.001-0.028% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-24** and **Apendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of NO_2 in the ambience over the period of 1 year on average is 13.32 $\mu g/m^3$, or 23.37% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of NO_2 in the ambience over the period of 1 hour on average range between 5.602-11.026 $\mu g/m^3$ or 9.828-19.344% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-24**.

- **Average concentration of sulfur dioxide (SO_2) over the period of 1 hour, 24 hours, and 1 year**

The sulfur dioxide (SO_2) released into the ambience during the operation phase of the project results in the highest concentration level of SO_2 in the study area over the period of 1 hour on average in the area of Jom Hae Mountain (grid reference - 729828 E 1419614 N), which is about 14.39 kilometers away from the project location to the south - southwest (SSW). The concentration level is 136.39 $\mu g/m^3$, accounting for 17.49% of that stipulated in general ambient air quality standards, according to which the average SO_2 in the ambience over the period of 1 hour must not exceed 780 microgram/ cubic meter. For the 31 sensitive receptors, the highest concentration levels of SO_2 in the ambience over the period of 1 hour on average range between 0.05-7.91 $\mu g/m^3$ or 0.01-1.01% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-24** and **Apendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of SO_2 in the ambience over the period of 1 hour on average is 176.22 $\mu g/m^3$, or 22.59% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of SO_2 in the ambience over the period of 1 hour on average range between 6.98-42.54 $\mu g/m^3$ or 0.90-5.45% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-24**.

The SO_2 released into the ambience during the operation phase of the project results in the highest concentration level of SO_2 in the study area over the period of 24 hours on average in the area of Jom Hae Mountain (grid reference - 728828 E 1419614 N), which is about 14.04 kilometers away from the project location to the south - southwest (SSW). The concentration level is 27.35 micrograms/ cubic meter, accounting for 9.12% of that stipulated in general ambient air quality standards, according to which the average SO_2 in the ambience over the period of 24 hours must not exceed 300 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of SO_2 in the ambience over the period of 24 hours on average range between 0.01-1.05 $\mu g/m^3$ or 0.002- 0.35% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-24** and **Apendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of SO_2 in the ambience over the period of 24 hours on average is 74.52 $\mu g/m^3$, or 24.84% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of SO_2 in the ambience over the period of 24 hours on average range between 5.27-47.30 $\mu g/m^3$ or 1.76-15.77% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-24**.

The SO_2 released into the ambience during the operation phase of the project results in the highest concentration level of SO_2 in the study area over the period of 1 year on average in the area of Jom Hae Mountain (grid reference - 728828 E 1419114 N), which is about 14.88 kilometers away from the project location to the south - southwest (SSW). The concentration level is 2.12 $\mu g/m^3$, accounting for 2.12% of that stipulated in general ambient air quality standards, according to which the average SO_2 in the ambience over the period of 1 year must not exceed 100 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of SO_2 in the ambience over the period of 1 year on average range between 0.001-0.007 $\mu g/m^3$ or 0.001-0.007% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-24** and **Apendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of SO_2 in the ambience over the period of 1 year on average is 8.60 μg/m^3, or 8.60% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of SO_2 in the ambience over the period of 1 year on average range between 1.071-6.483 μg/m^3 or 1.071-6.483% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-24**.

- **Average total suspended particulate (TSP) over the period of 24 hours and 1 year**

The execution of the project causes the highest concentration level of the average TSP in the ambience over the period of 24 hours in the area of Jom Hae Mountain (grid reference - 728828 E 1419614 N), which is about 14.04 kilometers away from the project location to the south - southwest (SSW). The concentration level is 16.47 μg/m^3, accounting for 4.99% of that stipulated in general ambient air quality standards, according to which the average TSP in the ambience over the period of 24 hours must not exceed 330 μg/m^3. For the 31 sensitive receptors, the highest concentration levels of TSP in the ambience over the period of 24 hours on average range between 0.003-0.632 μg/m^3 or 0.001-0.191% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-24** and **Apendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of TSP in the ambience over the period of 24 hours on average is 160.47 μg/m^3, or 48.63% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of TSP in the ambience over the period of 24 hours on average range between 106.00-144.08 μg/m^3 or 32.12-43.66% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-24**.

The execution of the project causes the highest concentration level of the average TSP in the ambience over the period of 1 year in the area of Jom Hae Mountain (grid reference - 728828 E 1419114 N), which is about 14.88 kilometers away from the project location to the south - southwest (SSW). The concentration level is 1.28 μg/m^3, accounting for 1.31% of that stipulated in general ambient air quality standards, according to which the average TSP in the ambience over the period of 1 year must not exceed 100 μg/m^3. For the 31 sensitive receptors, the highest concentration levels of TSP in the ambience over the period of 1 year on average range between 0.0004 - 0.0043 μg/m^3 or 0.0004-0.0043% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-24** and **Apendix 5A-5.**

When considered together with the existing monitoring results, the highest concentration level of TSP in the ambience over the period of 1 year on average is 45.53 µg/m^3, or 45.53% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of TSP in the ambience over the period of 1 year on average range between 32.570-44.252 µg/m^3 or 28.94-49.64% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-24**.

- **Average amount of particulate matter 10 micrometers or less in diameter (PM-10) over the period of 24 hours, and 1 year**

The execution of the project causes the highest concentration level of PM-10 in the ambience over the period of 24 hours on average in the area of Jom Hae Mountain (grid reference - 728828 E 1419614 N), which is about 14.04 kilometers away from the project location to the south - southwest (SSW). The concentration level is 13.51 µg/m^3, accounting for 11.26% of that stipulated in general ambient air quality standards, according to which the average PM-10 in the ambience over the period of 24 hours must not exceed 120 µg/m^3. For the 31 sensitive receptors, the highest concentration levels of PM-10 in the ambience over the period of 24 hours on average range between 0.003-0.518 µg/m^3 or 0.002-0.432% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-24** and **Apendix 5A-5.**

When considered together with the existing monitoring results, the highest concentration level of PM-10 in the ambience over the period of 24 hours on average is 101.51 µg/m^3, or 84.59% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of PM-10 in the ambience over the period of 24 hours on average range between 63.00-73.76 µg/m^3 or 52.50-73.76% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-24**.

The execution of the project causes the highest concentration level of PM-10 in the ambience over the period of 1 year on average in the area of Jom Hae Mountain (grid reference - 728828 E 1419114 N), which is about 14.88 kilometers away from the project location to the south - southwest (SSW). The concentration level is 1.05 µg/m^3, accounting for 2.10% of that stipulated in general ambient air quality standards, according to which the average PM-10 in the ambience over the period of 1 year must not exceed 50 µg/m^3. For the 31 sensitive receptors, the highest concentration levels of PM-10 in the ambience over the period of 1 year on average range between 0.0003-0.0035 µg/m^3 or 0.0006-0.007% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-24** and **Apendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of PM-10 in the ambience over the period of 1 year on average is 28.09 $\mu g/m^3$, or 56.18% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of PM-10 in the ambience over the period of 1 year on average range between 19.360-27.043 $\mu g/m^3$ or 38.721-54.087% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-24**.

(f) Case 6: Impacts caused by Pluak Daeng Power Plant Project in the event of diesel-fuelled operation at 100% load; plus the proposed emission from other non-operated factories as specified in the environmental impact assessment report within 15-kilometer radius from the project location; are assessed in conjunction with results of ambient air quality measurement

- **Average concentration of nitrogen dioxide (NO_2) over the period of 1 hour, and 1 year**

The nitrogen dioxide (NO_2) released into the ambience during the operation phase of the project results in the highest concentration level NO_2 in the study area over the period of 1 hour on average in the area of Song Phi Nong Mountain (grid reference - 722328 E 1438114 N), which is about 12.52 kilometers away from the project location to the northwest (NW). The concentration level is 236.76 $\mu g/m^3$, accounting for 73.99% of that stipulated in general ambient air quality standards, according to which the average NO_2 in the ambience over the period of 1 hour must not exceed 320 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of NO_2 in the ambience over the period of 1 hour on average range between 5.79-16.59 $\mu g/m^3$ or 1.81-5.19% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-25** and **Apendix 5A-5.**

When considered together with the existing monitoring results, the highest concentration level of NO_2 in the ambience over the period of 1 hour on average is 304.50 $\mu g/m^3$, or 95.16% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of NO_2 in the ambience over the period of 1 hour on average range between 45.91-76.07 $\mu g/m^3$ or 14.35-23.77% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-25**.

TABLE 5.1.1-25

RESULTS OF THE PREDICTION OF AIR QUALITY BY USING THE AERMOD MODEL IN NORMAL CONDITION (WITHOUT DOWNWASH EFFECT),

CASE 6: IMPACTS CAUSED BY PLUAK DAENG POWER PLANT PROJECT IN THE EVENT OF DIESEL-FIRED OPERATION AT 100% LOAD; PLUS THE EXISTING IMPACTS CAUSED BY OTHER INDUSTRIAL PLANTS AS SPECIFIED IN THE ENVIRONMENTAL IMPACT ASSESSMENT REPORT THOUGH THERE IS NOT YET AIR POLLUTANT EMISSION WITHIN THE RADIUS OF 15 KILOMETERS FROM THE PROJECT LOCATION

Details	Estimated highest concentration levels of air pollutants in case 6 ($\mu g/m^3$)																										
	1-hour average NO_2			1-year average NO_2			1-hour average SO_2			24-hour average SO_2			1-year average SO_2			24-hour average TSP			1-year average TSP			24-hour average PM-10			1-year average PM-10		
	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total
Highest concentration value	236.76	67.74[1/]	304.50	6.37	11.02[1/]	17.39	150.39	39.83[1/]	190.22	30.89	47.17[1/]	78.06	3.16	6.48[1/]	9.64	18.96	144[1/]	162.96	2.92	44.25[1/]	47.17	15.56	88.00[1/]	103.56	2.83	27.04[1/]	29.87
Grid reference	722328E, 1438114N			722328E, 1439114N			729328E, 1419114N			728328E, 1418614N			721828E, 1438614N			728328E, 1418614N			722328E, 1439114N			728328E, 1418614N			722328E, 1439114N		
Location	Song Phi Nong Mountain			a cassava plantation			Jom Hae Mountain			Jom Hae Mountain			Song Phi Nong Mountain			Jom Hae Mountain			a cassava plantation			Jom Hae Mountain			a cassava plantation		
Direction and distance from the project site	NW 12.52 km			SW 18.07 km			SSW 14.71 km			SSW 15.47 km			NW 13.22 km			SSW 15.47 km			SW 18.07 km			SSW 15.47 km			SW 18.07 km		
Type of land	mountain			agricultural			mountain			mountain			mountain			mountain			agricultural			mountain			agricultural		
Sensitive receptor																											
1. Map Yang Phon Sub-district Administrative Organization	12.81	41.40	54.21	0.12	6.74	6.86	1.93	7.08	9.01	0.39	5.24	5.63	0.02	1.15	1.17	0.66	138	138.66	0.02	42.41	42.43	0.66	88.00	88.66	0.02	27.04	27.06
2. Ban Map Toey School	12.81	41.40	54.21	0.12	6.74	6.86	1.98	7.08	9.06	0.40	5.24	5.64	0.02	1.15	1.17	0.67	138	138.67	0.02	42.41	42.43	0.67	88.00	88.67	0.02	27.04	27.06
3. Map Toey Temple	13.14	41.40	54.54	0.13	6.74	6.87	2.04	7.08	9.12	0.41	5.24	5.65	0.02	1.15	1.17	0.67	138	138.67	0.03	42.41	42.44	0.67	88.00	88.67	0.02	27.04	27.06
4. Nikhom Sang Ton Eng 9 School	15.40	34.44	49.84	0.23	5.60	5.83	3.74	6.55	10.29	0.83	5.24	6.07	0.04	1.07	1.11	0.98	128	128.98	0.0	39.33	39.38	0.93	88.00	88.93	0.05	27.04	27.09
5. Prasitharam Temple	15.03	34.44	49.47	0.24	5.60	5.84	3.70	6.55	10.25	0.85	5.24	6.09	0.04	1.07	1.11	0.99	128	128.99	0.05	39.33	39.38	0.94	88.00	88.94	0.05	27.04	27.09
6. Map Yang Phon Sub-district Health Promoting Hospital	12.20	57.96	70.16	0.27	9.43	9.70	3.24	11.79	15.03	0.72	47.17	47.89	0.05	1.92	1.97	1.29	144	145.29	0.07	44.25	44.32	1.29	78.00	79.29	0.07	23.97	24.04
7. Ban Map Yang Phon School	12.79	57.96	70.75	0.26	9.43	9.69	3.63	11.79	15.42	0.67	47.17	47.84	0.05	1.92	1.97	1.01	144	145.01	0.06	44.25	44.31	1.01	78.00	79.01	0.06	23.97	24.03
8. Map Yang Phon Temple	14.42	57.96	72.38	0.20	9.43	9.63	3.16	11.79	14.95	0.65	47.17	47.82	0.04	1.92	1.96	0.80	144	144.80	0.05	44.25	44.30	0.80	78.00	78.80	0.05	23.97	24.02
9. Pluak Daeng Sub-district Administrative Organization	5.82	67.74	73.56	0.07	11.02	11.09	1.72	39.83	41.55	0.33	7.88	8.21	0.02	6.48	6.50	0.33	138	138.33	0.02	42.41	42.43	0.33	86.50	86.83	0.02	26.58	26.60
10. Orawin Witthaya School	5.79	67.74	73.53	0.06	11.02	11.08	1.61	39.83	41.44	0.30	7.88	8.18	0.02	6.48	6.50	0.27	138	138.27	0.01	42.41	42.42	0.27	86.50	86.77	0.01	26.58	26.59
11. Pluak Daeng High Voltage Electricity Station	8.33	67.74	76.07	0.07	11.02	11.09	1.63	39.83	41.46	0.30	7.88	8.18	0.02	6.48	6.50	0.53	138	138.53	0.02	42.41	42.43	0.53	86.50	87.03	0.02	26.58	26.60
12. Wang Pradu Temple	8.44	41.40	49.84	0.09	6.74	6.83	4.27	7.08	11.35	0.53	5.24	5.77	0.02	1.15	1.17	0.37	138	138.37	0.02	42.41	42.43	0.36	88.00	88.36	0.02	27.04	27.06
13. Wang Pradu School (closed down)	8.28	41.40	49.68	0.08	6.74	6.82	4.09	7.08	11.17	0.54	5.24	5.78	0.02	1.15	1.17	0.36	138	138.36	0.02	42.41	42.43	0.36	88.00	88.36	0.02	27.04	27.06
14. Village No.5, Ban Khlong Plu	16.26	34.44	50.70	0.19	5.60	5.79	3.49	6.55	10.04	0.67	5.24	5.91	0.03	1.07	1.10	0.82	128	128.82	0.03	39.33	39.36	0.79	88.00	88.79	0.03	27.04	27.07
15. Village No.7, Ban Wang Pla	14.47	34.44	48.91	0.23	5.60	5.83	3.61	6.55	10.16	0.84	5.24	6.08	0.04	1.07	1.11	1.01	128	129.01	0.05	39.33	39.38	0.97	88.00	88.97	0.04	27.04	27.08
16. Village No.8, Ban Soi 13	13.53	34.44	47.97	0.21	5.60	5.81	3.75	6.55	10.30	0.75	5.24	5.99	0.04	1.07	1.11	1.11	128	129.11	0.05	39.33	39.38	1.10	88.00	89.10	0.05	27.04	27.09
17. Village No.7, Ban Wang Pradu	7.48	41.40	48.88	0.08	6.74	6.82	3.17	7.08	10.25	0.40	5.24	5.64	0.02	1.15	1.17	0.36	138	138.36	0.02	42.41	42.43	0.36	88.00	88.36	0.02	27.04	27.06
18. Village No.4, Ban Khao Mapud	11.47	34.44	45.91	0.22	5.60	5.82	3.69	6.55	10.24	0.86	5.24	6.10	0.04	1.07	1.11	1.27	128	129.27	0.05	39.33	39.38	1.24	88.00	89.24	0.05	27.04	27.09
19. Village No.5 , Ban Wang Tan Mon	10.49	40.65	51.14	0.20	6.62	6.82	3.35	11.01	14.36	0.74	6.03	6.77	0.04	1.79	1.83	0.97	106	106.97	0.05	32.57	32.62	0.93	63.00	63.93	0.04	19.36	19.40
20. Village No.1, Ban Map Toey	12.66	41.40	54.06	0.11	6.74	6.85	2.04	7.08	9.12	0.35	5.24	5.59	0.02	1.15	1.17	0.55	138	138.55	0.02	42.41	42.43	0.54	88.00	88.54	0.02	27.04	27.06
21. Village No.7, Ban Chak Oi	7.56	41.40	48.96	0.07	6.74	6.81	1.76	7.08	8.84	0.30	5.24	5.54	0.02	1.15	1.17	0.38	138	138.38	0.01	42.41	42.42	0.38	88.00	88.38	0.01	27.04	27.05
22. Village No.6, Ban Map Yang Mai	11.62	48.36	59.98	0.19	7.87	8.06	2.86	10.74	13.60	0.66	5.5	6.16	0.03	1.75	1.78	0.82	110	110.82	0.04	33.80	33.84	0.80	65.00	65.80	0.04	19.97	20.01
23. Village No.6, Ban Thab Tong	7.90	41.40	49.30	0.07	6.74	6.81	2.07	7.08	9.15	0.34	5.24	5.58	0.02	1.15	1.17	0.40	138	138.40	0.01	42.41	42.42	0.40	88.00	88.40	0.01	27.04	27.05
24. Village No.2, Ban Noen Sawan	10.90	57.96	68.86	0.19	9.43	9.62	3.26	11.79	15.05	0.60	47.17	47.77	0.04	1.92	1.96	0.98	144	144.98	0.05	44.25	44.30	0.98	78.00	78.98	0.05	23.97	24.02
25. Village No.4, Ban Wang Ta Phin	8.36	41.40	49.76	0.07	6.74	6.81	1.54	7.08	8.62	0.32	5.24	5.56	0.02	1.15	1.17	0.43	138	138.43	0.02	42.41	42.43	0.43	88.00	88.43	0.02	27.04	27.06
26. Village No.3, Ban Map Yang Phon	10.12	57.96	68.08	0.14	9.43	9.57	2.03	11.79	13.82	0.49	47.17	47.66	0.03	1.92	1.95	0.65	144	144.65	0.04	44.25	44.29	0.64	78.00	78.64	0.03	23.97	24.00

TABLE 5.1.1-25

RESULTS OF THE PREDICTION OF AIR QUALITY BY USING THE AERMOD MODEL IN NORMAL CONDITION (WITHOUT DOWNWASH EFFECT), CASE 6: IMPACTS CAUSED BY PLUAK DAENG POWER PLANT PROJECT IN THE EVENT OF DIESEL-FIRED OPERATION AT 100% LOAD; PLUS THE EXISTING IMPACTS CAUSED BY OTHER INDUSTRIAL PLANTS AS SPECIFIED IN THE ENVIRONMENTAL IMPACT ASSESSMENT REPORT THOUGH THERE IS NOT YET AIR POLLUTANT EMISSION WITHIN THE RADIUS OF 15 KILOMETERS FROM THE PROJECT LOCATION (CONT'D)

Details	Estimated highest concentration levels of air pollutants in case 6 ($\mu g/m^3$)																										
	1-hour average NO_2			1-year average NO_2			1-hour average SO_2			24-hour average SO_2			1-year average SO_2			24-hour average TSP			1-year average TSP			24-hour average PM-10			1-year average PM-10		
	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total
28. Village No.5, Ban Khlong Phlu	15.63	40.65	56.28	0.20	6.62	6.82	4.14	11.01	15.15	0.74	6.03	6.77	0.03	1.79	1.82	0.86	106	106.86	0.03	32.57	32.60	0.84	63.00	63.84	0.03	19.36	19.39
29. Village No.7, Ban Wang Pla	16.59	34.44	51.03	0.23	5.60	5.83	4.13	6.55	10.68	0.87	5.24	6.11	0.04	1.07	1.11	1.00	128	129.00	0.04	39.33	39.37	0.95	88.00	88.95	0.04	27.04	27.08
30. Village No.8, Ban Soi 13	15.82	34.44	50.26	0.25	5.60	5.85	6.24	6.55	12.79	1.21	5.24	6.45	0.04	1.07	1.11	1.19	128	129.19	0.05	39.33	39.38	1.17	88.00	89.17	0.05	27.04	27.09
31. Village No.4, Ban Chak Manthed	6.45	41.40	47.85	0.06	6.74	6.80	3.76	7.08	10.84	0.44	5.24	5.68	0.02	1.15	1.17	0.27	138	138.27	0.01	42.41	42.42	0.22	88.00	88.22	0.01	27.04	27.05
Standard value [3/]	320			57			780			300			100			330			100			120			50		
WHO [4/]	200			40			-			20			-			-			-			50			20		

Remark : [1/] With reference to Table 5.1.1-5 : Highest values in the existing data on the ambient air quality monitoring in the project's vicinity

[2/] With reference to Table 5.1.1-8 : Highest values in the existing data on air quality monitoring which are used to represent each receptor's air pollutant concentration level

[3/] With reference to the standards in :

- Announcement of the National Environment Board No. 10 (1995) and No. 24 (2004) on ambient air quality standard specification
- Announcement of the National Environment Board No. 21 (2001) on sulfur dioxide ambient concentration standard specification
- Announcement of the National Environment Board No. 33 (2009) on nitrogen dioxide ambient concentration standard specification

[4/] Referenced from WHO Ambient Air Quality Guidelines in Environmental, Health, and Safety (EHS) Guidelines for International Finance Corporation (2007)

Source : Team Consulting Engineering and Management Co., Ltd., 2016

The NO_2 released into the ambience during the operation phase of the project results in the highest concentration level of NO_2 in the study area over the period of 1 year on average in the area of a cassava plantation (grid reference - 722328 E 1439114 N), which is about 18.07 kilometers away from the project location to the southwest (SW). The concentration level is 6.37 $\mu g/m^3$, accounting for 11.18% of that stipulated in general ambient air quality standards, according to which the average NO_2 in the ambience over the period of 1 year must not exceed 57 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of NO_2 in the ambience over the period of 1 year on average range between 0.06-0.27 $\mu g/m^3$ or 0.11-0.47% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-25** and **Apendix 5A-5.**

When considered together with the existing monitoring results, the highest concentration level of NO_2 in the ambience over the period of 1 year on average is 17.39 $\mu g/m^3$, or 30.51% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of NO_2 in the ambience over the period of 1 year on average range between 0.06-0.27 $\mu g/m^3$ or 0.11-0.47% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-25**.

- **Average concentration of sulfur dioxide (SO_2) over the period of 1 hour, 24 hours, and 1 year**

The sulfur dioxide (SO_2) released into the ambience during the operation phase of the project results in the highest concentration level of SO_2 in the study area over the period of 1 hour on average in the area of Jom Hae Mountain (grid reference - 729328 E 1419114 N), which is about 14.71 kilometers away from the project location to the south - southwest (SSW). The concentration level is 150.39 $\mu g/m^3$, accounting for 19.28% of that stipulated in general ambient air quality standards, according to which the average SO_2 in the ambience over the period of 1 hour must not exceed 780 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of SO_2 in the ambience over the period of 1 hour on average range between 1.54-6.24 $\mu g/m^3$ or 0.20-0.80% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-25** and **Apendix 5A-5.**

When considered together with the existing monitoring results, the highest concentration level of SO_2 in the ambience over the period of 1 hour on average is 190.22 $\mu g/m^3$, or 24.39% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of SO_2 in the ambience over the period of 1 hour on average range between 8.62-41.55 $\mu g/m^3$ or 1.11-5.33% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-25**.

The SO_2 released into the ambience during the operation phase of the project results in the highest concentration level of SO_2 in the study area over the period of 24 hours on average in the area of Jom Hae Mountain (grid reference - 728328 E 1418614 N), which is about 15.47 kilometers away from the project location to the south - southwest (SSW). The concentration level is 30.89 $\mu g/m^3$, accounting for 10.30% of that stipulated in general ambient air quality standards, according to which the average SO_2 in the ambience over the period of 24 hours must not exceed 300 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of SO_2 in the ambience over the period of 24 hours on average range between 0.30-1.21 $\mu g/m^3$ or 0.10-0.40% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-25** and **Apendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of SO_2 in the ambience over the period of 24 hours on average is 78.06 $\mu g/m^3$, or 26.02% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of SO_2 in the ambience over the period of 24 hours on average range between 5.54-47.89 $\mu g/m^3$ or 1.85-15.96% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-25**.

The SO_2 released into the ambience during the operation phase of the project results in the highest concentration level of SO_2 in the study area over the period of 1 year on average in the area of Song Phi Nong Mountain (grid reference - 721828 E 1438614 N), which is about 13.22 kilometers away from the project location to the northwest (NW). The concentration level is 3.16 $\mu g/m^3$, accounting for 3.16% of that stipulated in general ambient air quality standards, according to which the average SO_2 in the ambience over the period of 1 year must not exceed 100 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of SO_2 in the ambience over the period of 1 year on average range between 0.02-0.05 $\mu g/m^3$ or 0.02-0.05% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-25** and **Apendix 5A-5.**

When considered together with the existing monitoring results, the highest concentration level of SO_2 in the ambience over the period of 1 year on average is 9.64 $\mu g/m^3$, or 9.64% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of SO_2 in the ambience over the period of 1 year on average range between 1.10-6.50 $\mu g/m^3$ or 1.10-6.50 % of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-25**.

- **Average total suspended particulate (TSP) over the period of 24 hours and 1 year**

The execution of the project causes the highest concentration level of the average TSP in the ambience over the period of 24 hours in the area of Jom Hae Mountain (grid reference - 728328 E 1418614 N), which is about 15.47 kilometers away from the project location to the south - southwest (SSW). The concentration level is 18.96 $\mu g/m^3$, accounting for 5.75% of that stipulated in general ambient air quality standards, according to which the average TSP in the ambience over the period of 24 hours must not exceed 330 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of TSP in the ambience over the period of 24 hours on average range between 0.27-1.29 $\mu g/m^3$ or 0.08-0.39% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-25** and **Apendix 5A-5.**

When considered together with the existing monitoring results, the highest concentration level of TSP in the ambience over the period of 24 hours on average is 162.96 $\mu g/m^3$, or 49.38% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of TSP in the ambience over the period of 24 hours on average range between 106.47-145.29 $\mu g/m^3$ or 32.26-44.03% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-25**.

The execution of the project causes the highest concentration level of the average TSP in the ambience over the period of 1 year in the area of a cassava plantation (grid reference - 722328 E 1439114 N), which is about 18.07 kilometers away from the project location to the southwest (SW). The concentration level is 2.92 $\mu g/m^3$, accounting for 2.92% of that stipulated in general ambient air quality standards, according to which the average TSP in the ambience over the period of 1 year must not exceed 100 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of TSP in the ambience over the period of 1 year on average range between 0.01-0.07 $\mu g/m^3$ or 0.01-0.07% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-25** and **Apendix 5A-5.**

When considered together with the existing monitoring results, the highest concentration level of TSP in the ambience over the period of 1 year on average is 47.17 $\mu g/m^3$, or 47.17% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of TSP in the ambience over the period of 1 year on average range between 32.59-44.32 $\mu g/m^3$ or 32.59-44.32% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-25**.

- **Average amount of particulate matter 10 micrometers or less in diameter (PM-10) over the period of 24 hours, and 1 year**

The execution of the project causes the highest concentration level of PM-10 in the ambience over the period of 24 hours on average in the area of Jom Hae Mountain (grid reference - 728328 E 1418614 N), which is about 15.47 kilometers away from the project location to the south - southwest (SSW). The concentration level is 15.56 $\mu g/m^3$, accounting for 12.97% of that stipulated in general ambient air quality standards, according to which the average PM-10 in the ambience over the period of 24 hours must not exceed 120 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of PM-10 in the ambience over the period of 24 hours on average range between 0.22-1.29 $\mu g/m^3$ or 0.19-1.07 of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-25** and **Apendix 5A-5**.

When considered together with the existing monitoring results, the highest concentration level of PM-10 in the ambience over the period of 24 hours on average is 103.56 $\mu g/m^3$, or 86.30% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of PM-10 in the ambience over the period of 24 hours on average range between 63.46-89.24 $\mu g/m^3$ or 52.88-74.37% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-25.**

The execution of the project causes the highest concentration level of PM-10 in the ambience over the period of 1 year on average in the area of a cassava plantation (grid reference - 722328 E 1439114 N), which is about 18.07 kilometers away from the project location to the southwest (SW). The concentration level is 2.83 $\mu g/m^3$, accounting for 5.66% of that stipulated in general ambient air quality standards, according to which the average PM-10 in the ambience over the period of 1 year must not exceed 50 $\mu g/m^3$. For the 31 sensitive receptors, the highest concentration levels of PM-10 in the ambience over the period of 1 year on average range between 0.01-0.07 $\mu g/m^3$ or 0.02-0.14% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-25** and **Apendix 5A-5.**

When considered together with the existing monitoring results, the highest concentration level of PM-10 in the ambience over the period of 1 year on average is 29.87 $\mu g/m^3$, or 59.74% of that stipulated in general ambient air quality standards. For the 31 sensitive receptors, the highest concentration level of PM-10 in the ambience over the period of 1 year on average range between 19.38-27.09 $\mu g/m^3$ or 38.76-54.18% of that stipulated in general ambient air quality standards, as shown in **Table 5.1.1-25**.

(2.3.2) Assessment under the effect of downwash condition

The assessment of the air quality impacts caused by the execution of the project under the effect of downwash condition, which is possible to happen because the height of the stacks in the project is less than that stipulated in the Guideline for Determination of Good Practice Stack Height [Technical Support Document for the Stack Height Regulations (Revised) U.S.EPA (1985)], reveals that the concentration levels of all the air pollutants are the same as those in the assessment under normal condition in all the 6 cases. This means that there is no downwash effect from the air pollutant emission from the project.

The result of the calculation for the good engineering practice stack height, which should be at least 65.68 meters tall, is not much different from the project's stack height, which is 60 meters tall. As a consequence, the results of the estimation of the air quality impact caused by the execution of the project under the effect of downwash condition are not significantly different from those under the normal condition in all the cases prescribed by the project, as shown in **Table 5.1.1-26 and Apendix 5A-5**.

(3) Conclusion

The results of the prediction of the air quality by using the AERMOD mathematical model reveal that the project's average air pollutant values in one year in the case natural gas is used as fuel are lower than the values assessed through the use of the mathematical model and existing monitoring data. Whereas in the case diesel is used as fuel instead of natural gas, the project's estimated average air pollutant values in one year are higher. However, in the project's electricity production, natural gas is to be used as the main fuel, while diesel is used as reserved fuel in the cases that there is problem of natural gas supply from PTT and when there is an official order from the Electricity Generating Authority of Thailand to test the diesel-fired operation. The amount of diesel to be reserved in the project is enough to power the operation for three days; but in the air quality assessment, calculation is based on operation fired by a certain fuel in the whole year, as the days on which each fuel is used cannot be determined.

In addition, when considering the findings concerning the concentration of the pollutants in the study areas around the project, two factors are found to be contributory, which are 1) the height level of the receptor in comparison with the height of the pollutant source, and 2) the position of the receptor with respect to the wind direction; the details of which are as follows:

TABLE 5.1.1-26

RESULTS OF THE PREDICTION OF AIR QUALITY BY USING THE AERMOD MODEL IN NORMAL CONDITION (WITH DOWNWASH EFFECT), CASE 1: IMPACTS CAUSED BY PLUAK DAENG POWER PLANT PROJECT IN THE EVENT OF NATURAL GAS-FIRED OPERATION AT 100% LOAD ARE ASSESSED IN CONJUNCTION WITH RESULTS OF AMBIENT AIR QUALITY MONITORING

Details	estimated highest concentration levels of air pollutants in case 1 ($\mu g/m^3$)																										
	1-hour average NO_2			1-year average NO_2			1-hour average SO_2			24-hour average SO_2			1-year average SO_2			24-hour average TSP			1-year average TSP			24-hour average PM-10			1-year average PM-10		
	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total
Highest concentration value	123.69	67.74[1/]	191.43	1.94	11.02[1/]	12.96	80.44	39.83[1/]	120.27	14.78	47.17[1/]	61.95	1.42	6.48[1/]	7.90	10.32	144.00[1/]	154.32	0.99	44.25[1/]	45.24	10.32	88.00[1/]	98.32	0.99	27.04[1/]	28.03
Grid reference	728828E, 1419614N			728828E, 1419614N			729328E, 1419114N			728828E, 1419614N			728828E, 1419114N			728828E, 1419614N			728828E, 1419114N			728828E, 1419614N			728828E, 1419114N		
Location	Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain		
Direction and distance from the project site	SSW 14.04 km			SSW 14.04 km			SSW 14.71 km			SSW 14.04 km			SSW 14.88 km			SSW 14.39 km			SSW 14.88 km			SSW 14.39 km			SSW 14.88 km		
Type of land	mountain			mountain			mountain			mountain			mountain			mountain			mountain			mountain			mountain		
Sensitive receptor																											
1. Map Yang Phon Sub-district Administrative Organization	0.25	41.40	41.65	0.003	6.74	6.743	0.16	7.08	7.24	0.03	5.24	5.27	0.002	1.15	1.152	0.018	138	138.02	0.0013	42.41	42.411	0.018	88.00	88.02	0.0013	27.04	27.041
2. Ban Map Toey School	0.24	41.40	41.64	0.003	6.74	6.743	0.16	7.08	7.24	0.03	5.24	5.27	0.002	1.15	1.152	0.019	138	138.02	0.0014	42.41	42.411	0.019	88.00	88.02	0.0014	27.04	27.041
3. Map Toey Temple	0.25	41.40	41.65	0.003	6.74	6.743	0.16	7.08	7.24	0.03	5.24	5.27	0.002	1.15	1.152	0.020	138	138.02	0.0016	42.41	42.412	0.020	88.00	88.02	0.0016	27.04	27.042
4. Nikhom Sang Ton Eng 9 School	2.48	34.44	36.92	0.007	5.60	5.607	1.33	6.55	7.88	0.17	5.24	5.41	0.003	1.07	1.073	0.121	128	128.12	0.0022	39.33	39.332	0.121	88.00	88.12	0.0022	27.04	27.042
5. Prasitharam Temple	1.90	34.44	36.34	0.006	5.60	5.606	1.02	6.55	7.57	0.13	5.24	5.37	0.003	1.07	1.073	0.087	128	128.09	0.0022	39.33	39.332	0.087	88.00	88.09	0.0022	27.04	27.042
6. Map Yang Phon Sub-district Health Promoting Hospital	0.33	57.96	58.29	0.003	9.43	9.433	0.37	11.79	12.16	0.05	47.17	47.22	0.002	1.92	1.922	0.032	144	144.03	0.0015	44.25	44.251	0.032	78.00	78.03	0.0015	23.97	23.971
7. Ban Map Yang Phon School	0.34	57.96	58.30	0.004	9.43	9.434	0.36	11.79	12.15	0.05	47.17	47.22	0.003	1.92	1.923	0.036	144	144.04	0.0019	44.25	44.252	0.036	78.00	78.04	0.0019	23.97	23.972
8. Map Yang Phon Temple	0.22	57.96	58.18	0.003	9.43	9.433	0.21	11.79	12.00	0.02	47.17	47.19	0.002	1.92	1.922	0.017	144	144.02	0.0015	44.25	44.252	0.017	78.00	78.02	0.0015	23.97	23.972
9. Pluak Daeng Sub-district Administrative Organization	1.58	67.74	69.32	0.004	11.02	11.024	0.83	39.83	40.66	0.06	7.88	7.94	0.001	6.48	6.481	0.040	138	138.04	0.0010	42.41	42.411	0.040	86.50	86.54	0.0010	26.58	26.581
10. Orawin Witthaya School	1.29	67.74	69.03	0.004	11.02	11.024	0.48	39.83	40.31	0.05	7.88	7.93	0.002	6.48	6.482	0.033	138	138.03	0.0011	42.41	42.411	0.033	86.50	86.53	0.0011	26.58	26.581
11. Pluak Daeng High Voltage Electricity Station	0.66	67.74	68.40	0.002	11.02	11.022	0.49	39.83	40.32	0.06	7.88	7.94	0.001	6.48	6.481	0.039	138	138.04	0.0009	42.41	42.411	0.039	86.50	86.54	0.0009	26.58	26.581
12. Wang Pradu Temple	1.80	41.40	43.20	0.004	6.74	6.744	2.81	7.08	9.89	0.35	5.24	5.59	0.002	1.15	1.152	0.241	138	138.24	0.0017	42.41	42.412	0.241	88.00	88.24	0.0017	27.04	27.042
13. Wang Pradu School (closed down)	1.90	41.40	43.30	0.004	6.74	6.744	2.69	7.08	9.77	0.35	5.24	5.59	0.002	1.15	1.152	0.247	138	138.25	0.0016	42.41	42.412	0.247	88.00	88.25	0.0016	27.04	27.042
14. Village No.5, Ban Khlong Plu	0.25	34.44	34.69	0.002	5.60	5.602	0.13	6.55	6.68	0.01	5.24	5.25	0.001	1.07	1.071	0.009	128	128.01	0.0009	39.33	39.331	0.009	88.00	88.01	0.0009	27.04	27.041
15. Village No.7, Ban Wang Pla	1.29	34.44	35.73	0.005	5.60	5.605	0.59	6.55	7.14	0.06	5.24	5.30	0.003	1.07	1.073	0.039	128	128.04	0.0019	39.33	39.332	0.039	88.00	88.04	0.0019	27.04	27.042
16. Village No.8, Ban Soi 13	2.47	34.44	36.91	0.005	5.60	5.605	1.72	6.55	8.27	0.17	5.24	5.41	0.002	1.07	1.072	0.115	128	128.12	0.0017	39.33	39.332	0.115	88.00	88.12	0.0017	27.04	27.042
17. Village No.7, Ban Wang Pradu	1.70	41.40	43.10	0.003	6.74	6.743	2.08	7.08	9.16	0.26	5.24	5.50	0.002	1.15	1.152	0.183	138	138.18	0.0012	42.41	42.411	0.183	88.00	88.18	0.0012	27.04	27.041
18. Village No.4, Ban Khao Mapud	1.18	34.44	35.62	0.004	5.60	5.604	0.36	6.55	6.91	0.04	5.24	5.28	0.002	1.07	1.072	0.028	128	128.03	0.0015	39.33	39.331	0.028	88.00	88.03	0.0015	27.04	27.041
19. Village No.5, Ban Wang Tan Mon	0.61	40.65	41.26	0.006	6.62	6.626	0.33	11.01	11.34	0.04	6.03	6.07	0.004	1.79	1.794	0.027	106	106.03	0.0026	32.57	32.573	0.027	63.00	63.03	0.0026	19.36	19.363
20. Village No.1, Ban Map Toey	0.44	41.40	41.84	0.003	6.74	6.743	0.67	7.08	7.75	0.06	5.24	5.30	0.002	1.15	1.152	0.045	138	138.05	0.0013	42.41	42.411	0.045	88.00	88.05	0.0013	27.04	27.041
21. Village No.7, Ban Chak Oi	0.59	41.40	41.99	0.003	6.74	6.743	0.43	7.08	7.51	0.03	5.24	5.27	0.002	1.15	1.152	0.024	138	138.02	0.0011	42.41	42.411	0.024	88.00	88.02	0.0011	27.04	27.041
22. Village No.6, Ban Map Yang Mai	0.14	48.36	48.50	0.002	7.87	7.872	0.09	10.74	10.83	0.01	5.5	5.51	0.002	1.75	1.752	0.009	110	110.01	0.0011	33.80	33.801	0.009	65.00	65.01	0.0011	19.97	19.971
23. Village No.6, Ban Thab Tong	0.98	41.40	42.38	0.002	6.74	6.742	0.79	7.08	7.87	0.05	5.24	5.29	0.001	1.15	1.151	0.032	138	138.03	0.0008	42.41	42.411	0.032	88.00	88.03	0.0008	27.04	27.041
24. Village No.2, Ban Noen Sawan	0.23	57.96	58.19	0.005	9.43	9.435	0.15	11.79	11.94	0.02	47.17	47.19	0.003	1.92	1.923	0.014	144	144.01	0.0024	44.25	44.252	0.014	78.00	78.01	0.0024	23.97	23.972
25. Village No.4, Ban Wang Ta Phin	0.30	41.40	41.70	0.002	6.74	6.742	0.17	7.08	7.25	0.02	5.24	5.26	0.001	1.15	1.151	0.014	138	138.01	0.0008	42.41	42.411	0.014	88.00	88.01	0.0008	27.04	27.041
26. Village No.3, Ban Map Yang Phon	0.18	57.96	58.14	0.003	9.43	9.433	0.15	11.79	11.94	0.02	47.17	47.19	0.002	1.92	1.922	0.014	144	144.01	0.0013	44.25	44.251	0.014	78.00	78.01	0.0013	23.97	23.971
27. Village No.6, Ban Nong Rakam	0.06	40.65	40.71	0.001	6.62	6.621	0.04	11.01	11.05	0.01	6.03	6.04	0.001	1.79	1.791	0.004	106	106.00	0.0004	32.57	32.570	0.004	63.00	63.00	0.0004	19.36	19.360

TABLE 5.1.1-26

RESULTS OF THE PREDICTION OF AIR QUALITY BY USING THE AERMOD MODEL IN NORMAL CONDITION (WITH DOWNWASH EFFECT), CASE 1: IMPACTS CAUSED BY PLUAK DAENG POWER PLANT PROJECT IN THE EVENT OF NATURAL GAS-FIRED OPERATION AT 100% LOAD ARE ASSESSED IN CONJUNCTION WITH RESULTS OF AMBIENT AIR QUALITY MONITORING (CONT'D)

Details	estimated highest concentration levels of air pollutants in case 1 ($\mu g/m^3$)																										
	1-hour average NO_2			1-year average NO_2			1-hour average SO_2			24-hour average SO_2			1-year average SO_2			24-hour average TSP			1-year average TSP			24-hour average PM-10			1-year average PM-10		
	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total	Using the model	Using existing monitoring data [2/]	Total
28. Village No.5, Ban Khlong Phlu	0.64	40.65	41.29	0.002	6.62	6.622	0.35	11.01	11.36	0.03	6.03	6.06	0.001	1.79	1.791	0.020	106	106.02	0.0009	32.57	32.571	0.020	63.00	63.02	0.0009	19.36	19.361
29. Village No.7, Ban Wang Pla	2.46	34.44	36.90	0.006	5.60	5.606	1.03	6.55	7.58	0.11	5.24	5.35	0.002	1.07	1.072	0.074	128	128.07	0.0017	39.33	39.332	0.074	88.00	88.07	0.0017	27.04	27.042
30. Village No.8, Ban Soi 13	4.84	34.44	39.28	0.009	5.60	5.609	3.81	6.55	10.36	0.46	5.24	5.70	0.004	1.07	1.074	0.318	128	128.32	0.0028	39.33	39.333	0.318	88.00	88.32	0.0028	27.04	27.043
31. Village No.4, Ban Chak Manthed	2.83	41.40	44.23	0.005	6.74	6.745	2.49	7.08	9.57	0.29	5.24	5.53	0.003	1.15	1.153	0.202	138	138.20	0.0019	42.41	42.412	0.202	88.00	88.20	0.0019	27.04	27.042
Standard value [3/]	320			57			780			300			100			330			100			120			50		
WHO [4/]	200			40			-			20			-			-			-			50			20		

Remark : [1/] With reference to Table 5.1.1-5 : Highest values in the existing data on the ambient air quality monitoring in the project's vicinity

[2/] With reference to Table 5.1.144-8 : Highest values in the existing data on air quality monitoring which are used to represent each receptor's air pollutant concentration level

[3/] With reference to the standards in :

- Announcement of the National Environment Board No. 10 (1995) and No. 24 (2004) on ambient air quality standard specification
- Announcement of the National Environment Board No. 21 (2001) on sulfur dioxide ambient concentration standard specification
- Announcement of the National Environment Board No. 33 (2009) on nitrogen dioxide ambient concentration standard specification

[4/] Referenced from WHO Ambient Air Quality Guidelines in Environmental, Health, and Safety (EHS) Guidelines for International Finance Corporation (2007)

Source : Team Consulting Engineering and Management Co., Ltd., 2016

TABLE 5.1.1-27

RESULTS OF THE PREDICTION OF AIR QUALITY BY USING THE AERMOD MODEL IN NORMAL CONDITION (WITH DOWNWASH EFFECT), CASE 4: IMPACTS CAUSED BY PLUAK DAENG POWER PLANT PROJECT IN THE EVENT OF DIESEL-FIRED OPERATION AT 100% LOAD ARE ASSESSED IN CONJUNCTION WITH RESULTS OF AMBIENT AIR QUALITY MONITORING

Details	Estimated highest concentration levels of air pollutants in case 4 ($\mu g/m^3$)																										
	1-hour average NO_2			1-year average NO_2			1-hour average SO_2			24-hour average SO_2			1-year average SO_2			24-hour average TSP			1-year average TSP			24-hour average PM-10			1-year average PM-10		
	using the model	using existing monitoring data [2/]	total	using the model	using existing monitoring data [2/]	total	using the model	using existing monitoring data [2/]	total	using the model	using existing monitoring data [2/]	total	using the model	using existing monitoring data [2/]	total	using the model	using existing monitoring data [2/]	total	using the model	using existing monitoring data [2/]	total	using the model	using existing monitoring data [2/]	total	using the model	using existing monitoring data [2/]	total
Highest concentration value	154.73	67.74[1/]	222.47	2.43	11.02[1/]	13.45	119.72	39.83[1/]	159.55	21.70	47.17[1/]	68.87	2.12	6.48[1/]	8.60	13.33	144[1/]	157.33	14.69	44.25[1/]	58.94	10.94	88.00[1/]	98.94	1.07	27.04[1/]	28.11
Grid reference	729828E, 1419614N			728828E, 1419114N			729328E, 1419114N			728828E, 1419114N			728828E, 1419114N			728828E, 1419114N			728828E, 1419614N			728828E, 1419114N			728828E, 1419114N		
Location	Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain			Jom Hae Mountain		
Direction and distance from the project site	SSW 14.39 km			SSW 14.88 km			SSW 14.71 km			SSW 14.88 km			SSW 14.88 km			SSW 14.88 km			SSW 14.04 km			SSW 14.88 km			SSW 14.88 km		
Type of land	mountain			mountain			mountain			mountain			mountain			mountain			mountain			mountain			mountain		
Sensitive receptor																											
1. Map Yang Phon Sub-district Administrative Organization	0.31	41.40	41.71	0.004	6.74	6.744	0.24	7.08	7.32	0.04	5.24	5.28	0.003	1.15	1.153	0.02	138	138.02	0.002	42.41	42.412	0.019	88.00	88.02	0.0015	27.04	27.041
2. Ban Map Toey School	0.30	41.40	41.70	0.004	6.74	6.744	0.25	7.08	7.33	0.04	5.24	5.28	0.003	1.15	1.153	0.03	138	138.03	0.002	42.41	42.412	0.021	88.00	88.02	0.0016	27.04	27.042
3. Map Toey Temple	0.31	41.40	41.71	0.004	6.74	6.744	0.24	7.08	7.32	0.04	5.24	5.28	0.003	1.15	1.153	0.03	138	138.03	0.002	42.41	42.412	0.022	88.00	88.02	0.0017	27.04	27.042
4. Nikhom Sang Ton Eng 9 School	3.18	34.44	37.62	0.009	5.60	5.609	2.07	6.55	8.62	0.27	5.24	5.51	0.005	1.07	1.075	0.16	128	128.16	0.003	39.33	39.333	0.135	88.00	88.13	0.0025	27.04	27.042
5. Prasitharam Temple	2.44	34.44	36.88	0.008	5.60	5.608	1.53	6.55	8.08	0.19	5.24	5.43	0.005	1.07	1.075	0.12	128	128.12	0.003	39.33	39.333	0.097	88.00	88.10	0.0024	27.04	27.042
6. Map Yang Phon Sub-district Health Promoting Hospital	0.42	57.96	58.38	0.004	9.43	9.434	0.57	11.79	12.36	0.07	47.17	47.24	0.003	1.92	1.923	0.04	144	144.04	0.002	44.25	44.252	0.036	78.00	78.04	0.0017	23.97	23.972
7. Ban Map Yang Phon School	0.43	57.96	58.39	0.005	9.43	9.435	0.54	11.79	12.33	0.08	47.17	47.25	0.004	1.92	1.924	0.05	144	144.05	0.003	44.25	44.253	0.039	78.00	78.04	0.0021	23.97	23.972
8. Map Yang Phon Temple	0.28	57.96	58.24	0.004	9.43	9.434	0.31	11.79	12.10	0.04	47.17	47.21	0.003	1.92	1.923	0.02	144	144.02	0.002	44.25	44.252	0.019	78.00	78.02	0.0017	23.97	23.972
9. Pluak Daeng Sub-district Administrative Organization	1.91	67.74	69.65	0.005	11.02	11.025	1.20	39.83	41.03	0.08	7.88	7.96	0.002	6.48	6.482	0.05	138	138.05	0.001	42.41	42.411	0.042	86.50	86.54	0.0011	26.58	26.581
10. Orawin Witthaya School	1.55	67.74	69.29	0.005	11.02	11.025	0.71	39.83	40.54	0.07	7.88	7.95	0.002	6.48	6.482	0.04	138	138.04	0.001	42.41	42.411	0.034	86.50	86.53	0.0011	26.58	26.581
11. Pluak Daeng High Voltage Electricity Station	0.82	67.74	68.56	0.003	11.02	11.023	0.71	39.83	40.54	0.08	7.88	7.96	0.002	6.48	6.482	0.05	138	138.05	0.001	42.41	42.411	0.042	86.50	86.54	0.0009	26.58	26.581
12. Wang Pradu Temple	2.26	41.40	43.66	0.005	6.74	6.745	4.26	7.08	11.34	0.53	5.24	5.77	0.004	1.15	1.154	0.32	138	138.32	0.002	42.41	42.412	0.265	88.00	88.26	0.0018	27.04	27.042
13. Wang Pradu School (closed down)	2.39	41.40	43.79	0.005	6.74	6.745	4.08	7.08	11.16	0.54	5.24	5.78	0.004	1.15	1.154	0.33	138	138.33	0.002	42.41	42.412	0.271	88.00	88.27	0.0018	27.04	27.042
14. Village No.5, Ban Khlong Plu	0.31	34.44	34.75	0.003	5.60	5.603	0.19	6.55	6.74	0.02	5.24	5.26	0.002	1.07	1.072	0.01	128	128.01	0.001	39.33	39.331	0.009	88.00	88.01	0.0010	27.04	27.041
15. Village No.7, Ban Wang Pla	1.64	34.44	36.08	0.006	5.60	5.606	0.88	6.55	7.43	0.08	5.24	5.32	0.004	1.07	1.074	0.05	128	128.05	0.003	39.33	39.333	0.043	88.00	88.04	0.0021	27.04	27.042
16. Village No.8, Ban Soi 13	3.18	34.44	37.62	0.006	5.60	5.606	2.67	6.55	9.22	0.25	5.24	5.49	0.004	1.07	1.074	0.16	128	128.16	0.002	39.33	39.332	0.128	88.00	88.13	0.0019	27.04	27.042
17. Village No.7, Ban Wang Pradu	2.14	41.40	43.54	0.003	6.74	6.743	3.16	7.08	10.24	0.40	5.24	5.64	0.003	1.15	1.153	0.25	138	138.25	0.002	42.41	42.412	0.201	88.00	88.20	0.0013	27.04	27.041
18. Village No.4, Ban Khao Mapud	1.49	34.44	35.93	0.005	5.60	5.605	0.53	6.55	7.08	0.06	5.24	5.30	0.003	1.07	1.073	0.04	128	128.04	0.002	39.33	39.332	0.031	88.00	88.03	0.0016	27.04	27.042
19. Village No.5, Ban Wang Tan Mon	0.78	40.65	41.43	0.008	6.62	6.628	0.52	11.01	11.53	0.06	6.03	6.09	0.006	1.79	1.796	0.04	106	106.04	0.004	32.57	32.574	0.030	63.00	63.03	0.0029	19.36	19.363
20. Village No.1, Ban Map Toey	0.52	41.40	41.92	0.003	6.74	6.743	0.93	7.08	8.01	0.09	5.24	5.33	0.003	1.15	1.153	0.06	138	138.06	0.002	42.41	42.412	0.046	88.00	88.05	0.0014	27.04	27.041
21. Village No.7, Ban Chak Oi	0.72	41.40	42.12	0.003	6.74	6.743	0.63	7.08	7.71	0.05	5.24	5.29	0.002	1.15	1.152	0.03	138	138.03	0.001	42.41	42.411	0.026	88.00	88.03	0.0012	27.04	27.041
22. Village No.6, Ban Map Yang Mai	0.18	48.36	48.54	0.003	7.87	7.873	0.13	10.74	10.87	0.02	5.5	5.52	0.003	1.75	1.753	0.01	110	110.01	0.002	33.80	33.802	0.010	65.00	65.01	0.0013	19.97	19.971
23. Village No.6, Ban Thab Tong	1.18	41.40	42.58	0.003	6.74	6.743	1.14	7.08	8.22	0.07	5.24	5.31	0.002	1.15	1.152	0.04	138	138.04	0.001	42.41	42.411	0.033	88.00	88.03	0.0009	27.04	27.041
24. Village No.2, Ban Noen Sawan	0.29	57.96	58.25	0.006	9.43	9.436	0.23	11.79	12.02	0.03	47.17	47.20	0.005	1.92	1.925	0.02	144	144.02	0.003	44.25	44.253	0.015	78.00	78.02	0.0026	23.97	23.973
25. Village No.4, Ban Wang Ta Phin	0.37	41.40	41.77	0.002	6.74	6.742	0.25	7.08	7.33	0.03	5.24	5.27	0.002	1.15	1.152	0.02	138	138.02	0.001	42.41	42.411	0.016	88.00	88.02	0.0008	27.04	27.041
26. Village No.3, Ban Map Yang Phon	0.22	57.96	58.18	0.004	9.43	9.434	0.23	11.79	12.02	0.03	47.17	47.20	0.003	1.92	1.923	0.02	144	144.02	0.002	44.25	44.252	0.015	78.00	78.01	0.0015	23.97	23.971

TABLE 5.1.1-27

RESULTS OF THE PREDICTION OF AIR QUALITY BY USING THE AERMOD MODEL IN NORMAL CONDITION (WITH DOWNWASH EFFECT), CASE 4: IMPACTS CAUSED BY PLUAK DAENG POWER PLANT PROJECT IN THE EVENT OF DIESEL-FIRED OPERATION AT 100% LOAD ARE ASSESSED IN CONJUNCTION WITH RESULTS OF AMBIENT AIR QUALITY MONITORING (CONT'D)

Details	Estimated highest concentration levels of air pollutants in case 4 ($\mu g/m^3$)																										
	1-hour average NO_2			1-year average NO_2			1-hour average SO_2			24-hour average SO_2			1-year average SO_2			24-hour average TSP			1-year average TSP			24-hour average PM-10			1-year average PM-10		
	using the model	using existing monitoring data 2/	total	using the model	using existing monitoring data 2/	total	using the model	using existing monitoring data 2//	total	using the model	using existing monitoring data 2/	total	using the model	using existing monitoring data 2/	total	using the model	using existing monitoring data 2/	total	using the model	using existing monitoring data 2/	total	using the model	using existing monitoring data 2/	total	using the model	using existing monitoring data 2/	total
27. Village No.6, Ban Nong Rakam	0.08	40.65	40.73	0.001	6.62	6.621	0.07	11.01	11.08	0.01	6.03	6.04	0.001	1.79	1.791	0.01	106	106.01	0.001	32.57	32.571	0.004	63.00	63.00	0.0005	19.36	19.360
28. Village No.5, Ban Khlong Phlu	0.78	40.65	41.43	0.003	6.62	6.623	0.51	11.01	11.52	0.04	6.03	6.07	0.002	1.79	1.792	0.03	106	106.03	0.001	32.57	32.571	0.021	63.00	63.02	0.0010	19.36	19.361
29. Village No.7, Ban Wang Pla	3.10	34.44	37.54	0.007	5.60	5.607	1.54	6.55	8.09	0.16	5.24	5.40	0.004	1.07	1.074	0.10	128	128.10	0.002	39.33	39.332	0.081	88.00	88.08	0.0019	27.04	27.042
30. Village No.8, Ban Soi 13	6.20	34.44	40.64	0.012	5.60	5.612	5.87	6.55	12.42	0.70	5.24	5.94	0.006	1.07	1.076	0.43	128	128.43	0.004	39.33	39.334	0.351	88.00	88.35	0.0030	27.04	27.043
31. Village No.4, Ban Chak Manthed	3.53	41.40	44.93	0.006	6.74	6.746	3.75	7.08	10.83	0.44	5.24	5.68	0.004	1.15	1.154	0.27	138	138.27	0.003	42.41	42.413	0.222	88.00	88.22	0.0021	27.04	27.042
Standard value 3/	**320**			**57**			**780**			**300**			**100**			**330**			**100**			**120**			**50**		
	200			**40**			**-**			**20**			**-**			**-**			**-**			**50**			**20**		

Remark : 1/ With reference to Table 5.1.1-5 : Highest values in the existing data on the ambient air quality monitoring in the project's vicinity

2/ With reference to Table 51.1-8 : Highest values in the existing data on air quality monitoring which are used to represent each receptor's air pollutant concentration level

3/ With reference to the standards in :

- Announcement of the National Environment Board No. 10 (1995) and No. 24 (2004) on ambient air quality standard specification
- Announcement of the National Environment Board No. 21 (2001) on sulfur dioxide ambient concentration standard specification
- Announcement of the National Environment Board No. 33 (2009) on nitrogen dioxide ambient concentration standard specification

4/ Referenced from WHO Ambient Air Quality Guidelines in Environmental, Health, and Safety (EHS) Guidelines for International Finance Corporation (2007)

Source : Team Consulting Engineering and Management Co., Ltd., 2016

1) The height level of the area: the receptor that is higher than the pollutant source will be more adversely affected by air pollutants than other areas.

Most of the highest pollutant concentration values are found in the mountainous areas in the south-southwest (SSW) and northwest (NW) direction from the project location. The line showing the average concentration level of sulfur dioxide in one hour is shown in**Appendix 5A-5.**

2) The position of the receptor with respect to the wind direction: the receptor that is downwind will be more adversely affected by air pollutants than the receptor that is upwind.

According to the data concerning the wind direction in the project as collected by Pluak Daeng District Public Health Office's Air Quality Monitoring Station during 2013-2015, as shown in **Figure 5.1.1-4**, the wind blows mostly from the south-southwest (SSW) and northeast direction, causing the sensitive receptors downwind to register higher pollutant concentration values than the sensitive receptors in other areas.

Also, the highest average air pollutant values are from the worst case scenarios in the assessment of air quality impacts Case 3 and Case 6, in which impacts caused by natural gas-fired/diesel-fired operation at 100% load; plus the existing impacts caused by other industrial plants as specified in the environmental impact assessment report though there is not yet air pollutant emission within the radius of 15 kilometers from the project location; are assessed in conjunction with existing data on ambient air quality monitoring. These values are to be put into comparison with US.EPA's National Ambient Air Quality Standards (2010), in the category of Secondary Standards; which are aimed to provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings, as shown in **Table 5.1.1-28**. Nevertheless, the average value of nitrogen dioxide (NO_2) in US.EPA's National Ambient Air Quality Standards is per year and the average value of sulfur dioxide is per every 3 hours. Therefore, in the case of sulfur dioxide (SO_2), the average value in the assessment of air quality impacts is converted from 1-hour average to 3-hour average. The equation used is as follows:

$$C_1/C_2 = (t_2/t_1)^n$$

(reference - Air Pollution: Original and Control, 2nd Edition, Harper Collins Publisher, 1981)

Where C_1 and C_2 = concentration value during t_1 and t_2
N = constant, which is 0.17-0.20 (n = 0.2)
t_1 and t_2 = a given period of time (minute)

TABLE 5.1.1-28

US NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Primary/Secondary	Averaging time	Concentration level	Remark
NO_2	Primary	1 hour	100 ppb or 183 $\mu g/m^3$	98^{th} percentile, averaged over 3 years
	Primary/Secondary	1 year	53 ppb or 100 $\mu g/m^3$	Annual mean
SO_2	Primary	1 hour	75 ppb or 196 $\mu g/m^3$	99^{th} percentile of 1-hour daily maximum concentrations, average over 3 years
	Secondary	3 hour	0.5 ppm or 1,310 $\mu g/m^3$	Not to be exceeded more then once per year

Remark :
- Primary standards provide public health protection, including protecting the health of sensitive populations such as asthmatics, children, and the elderly.
- Secondary standards provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

Source : Adapted from National Ambient Air Quality Standards (NAAQS) (US.EPA, 2011), http://www.3.epa.gov/tth/naaqs/criteria.htm, as retrieved on 16^{th} June 2016

For the worst case resulting in the highest pollutant values (Case 3 and Case 6) in the assessment of air quality impacts caused by the development of the project, when considered together with the existing monitoring results, the 1-year average value of nitrogen dioxide (NO_2) is 17.57 micrograms per cubic meter and the 1-hour average value of sulfur dioxide (SO_2) is 190.22 $\mu g/m^3$. When the equation above is applied, the 3-hour average value of sulfur dioxide (SO_2) is 152.70 $\mu g/m^3$. The details are as follows:

The results of the assessment of air quality impacts in the worst case scenarios (Case 3 and Case 6), in which impacts caused by natural gas-fired/diesel-fired operation at 100% load; plus the existing impacts caused by other industrial plants as specified in the environmental impact assessment report though there is not yet air pollutant emission within the radius of 15 kilometers from the project location; are assessed in conjunction with existing data on ambient air quality monitoring, reveal the highest concentration level of NO_2 and SO_2 over the average period of 1 hour at Song Phi Nong Mountain and Jom Hae Mountain, which are about 300 and 400 meters above the mean sea level, respectively.

5.1.1.2 Greenhouse Gas (GHGs)

Fuel combustion for electricity generation is the main source of greenhouse gases (GHGs) emission for the Project. The quantities of GHG emissions will depend primarily on the consumption rate and heating value of the fuel used. The quantities of GHGs emission have been calculated using a simple mathematical model or equation together with the emission factors from 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Details are provided in **Table 5.1.1-29**.

Mitigation Measures

(a) Construction Phase

- Trucks transporting construction materials shall be covered and/ or fastened to prevent the falling of materials and reduce the diffusion of dust.
- While being transported, construction materials will be covered with tarpaulin sheets to prevent accidents and dust.
- Water shall be sprayed at the construction site, earth piles or the areas where construction activities cause diffusion of dust, such as roads, land leveling, etc., to reduce dust diffusion at least twice a day (morning-afternoon). However, when it is dry or windy and it is considered that the sprayed areas are getting dry and dust dispersion is likely to occur, water spraying will be additionally done.
- Inspection, maintenance or checking of vehicles and construction engines/ machinery shall be performed on a monthly basis to reduce air pollution emissions.
- Truck wheels shall be washed before the trucks leave the construction site or construction-related areas to prevent dirt and sand from falling onto the roads, both inside and outside the project area.
- Truck speed limits shall be 20 kilometers/hour for the construction site and Pluak Daeng Industrial Park and 80 kilometers/hour for the highway.
- Construction waste or garbage shall not be incinerated or disposed of at the construction site.
- Construction site shall be controlled and construction works undertaken quickly.
- Workers shall be provided to clean the road surface in front of the project area after the arrival-departure of trucks.

TABLE 5.1.1-29

GREENHOUSE GAS EMISSION FROM TRANSPORT OF PROJECT CONSUMPTION

Project Activities	Activity data							Emission Factor			Emission		Global Warming Potential 4/	Tonne CO2eq/yr	
	Data			Working Duration		C=A*B									
	A			B				D		Data Source 1/,2/,3/	E		F		
1. Construction Phase															
1.1 Tap water used	Water consumption	1,711	m3/day	365	day/yr	624,515	m3/yr	0.2722	kgCO2eq/m3	Thai National LCI Database/MTEC	-	-	-	169.99	C*D/1000
1.2 Wastewater Treatment															
Septic tank	B0 ; maximum CH4 producing capacity	0.6	kg CH4/kg BOD		-	-	-	0.3	kg CH4/kg BOD =B0*MCF	IPCC 2006 Vol 5 Ch6.2.2 Domestic Wastewater	28.47	kg CH4/yr =(U*T*EF)(TOW-S)-R)	25	0.71	E*F/1000
	MCF ; methane correction factor	0.5	fraction		-	-	-	-	-	-					
	TOW ; total organics in wastewater in inventory year	94.9	kg BOD/yr		-	-	-	-	-	-					
	S ; organic component removed as sludge in inventory year	0	kg BOD/yr		-	-	-	-	-	-					
	Ui ; fraction of population in income group i in inventory year, See Table 6.5.	1	-		-	-	-	-	-	-					
	Ti,j ; degree of utilisation of treatment/discharge pathway or system, j, for each income group fraction i in inventory year, See Table 6.5.	1	-		-	-	-	-	-	-					
	R ; amount of CH4 recovered in inventory year	0	kg CH4/yr		-	-	-	-	-	-					
1.3 Fuel combustion of diesel vehicles															
Engine transportation ; trailer	Loading Weight	32	tonne	365	day/yr	1,168,000	tonne-km/yr	0.0409	kgCO2eq/tonne-km	TGO,2015	-	-	-	47.77	C*D/1000
	daily vehicle kilometers traveled, DVKT	100	vehicle-km								-	-	-		
Worker transportation ; small truck	Loading Weight	7	tonne	365	day/yr	1,226,400	tonne-km/yr	0.1402	kgCO2eq/tonne-km	TGO,2015	-	-	-	171.94	C*D/1000
	daily vehicle kilometers traveled, DVKT	480	vehicle-km								-	-	-		
Equipment transportation ; trailer	Loading Weight	32	tonne	365	day/yr	3,504,000	tonne-km/yr	0.0409	kgCO2eq/tonne-km	TGO,2015	-	-	-	143.31	C*D/1000
	daily vehicle kilometers traveled, DVKT	300	vehicle-km								-	-	-		
Total														533.72	
2. Operation Phase															
2.1 Stationary combustion in processes	- Natural Gas Consumption	150,380.00	MMSCF/yr	365	day/yr	-	-	56,100.00	kgCO2/TJ	IPCC 2006 Vol 2 table 2.2	9,611,359,838.51	kgCO2/yr	1	9,611,359.84	E*F/1000
		162,260,020.00	MMBtu/yr	-	-	-	-	1	kgCH4/TJ	IPCC 2006 Vol 2 table 2.2	171,325.49	kgCH4/yr	25	4,283.14	E*F/1000
		171,325.49	TJ/yr	-	-	-	-	0.1	kgN2O/TJ	IPCC 2006 Vol 2 table 2.2	17,132.55	kgN2O/yr	298	5,105.50	E*F/1000
	(HHV of Natural Gas)	1,079	Btu/scf	-	-	-	-								
	- Diesel Consumption	25,893,000	L/yr	365	day/yr	-	-	0.0741	kgCO2/MJ	IPCC 2006 Vol 2 table 2.2	69,839,635.32	kgCO2/yr	1	69,839.64	E*F/1000
		942,505,200.00	MJ/yr	-	-	-	-	0.000003	kgCH4/MJ	IPCC 2006 Vol 2 table 2.2	2,827.52	kgCH4/yr	25	70.69	E*F/1000
	(Heating Value of Diesel)	36.4	MJ/L	-	-	-	-	0.0000006	kgN2O/MJ	IPCC 2006 Vol 2 table 2.2	565.50	kgN2O/yr	298	168.52	E*F/1000
2.2 Diesel fuel combustion of Stationary Pumps for Fire Protection	Diesel consumption	3,000	gallon/min	2	hr/yr	1,362,747.60	Litre/yr	2.708	kgCO2eq/L	IPCC 2006 Vol.2 table 2.2, DEDE	-	-	-	3,690.32	C*D/1000

TABLE 5.1.1-29

GREENHOUSE GAS EMISSION FROM TRANSPORT OF PROJECT CONSUMPTION (Cont'd)

Project Activities	Activity data							Emission Factor			Emission		Global Warming Potential 4/	Tonne CO2eq/yr	
	Data			Working Duration		C=A*B									
	A			B				D		Data Source 1/,2/,3/	E		F		
2.3 Tap water used	Water consumption	30	m3/day	365	day/yr	23,073,840.00	m3/yr	0.2722	kgCO2eq/ m3	Thai National LCI Database/MTEC	-	-	-	2.98	C*D/1000
2.4 Wastewater Treatment															
Septic tank	B0 ; maximum CH4 producing capacity	0.6	kg CH4/kg BOD		-	-	-	0.3	kg CH4/kg BOD =B0*MCF	IPCC 2006 Vol 5 Ch6.2.2 Domestic Wastewater	28.47	kg CH4/yr =(U*T*EF)(TOW-S)-R)	25	0.71	E*F/1000
	MCF ; methane correction factor	0.5	fraction		-	-	-	-	-	-	-	-	-		
	TOW ; total organics in wastewater in inventory year	94.9	kg BOD/yr		-	-	-	-	-	-	-	-	-		
	S ; organic component removed as sludge in inventory year	0	kg BOD/yr		-	-	-	-	-	-	-	-	-		
	Ui ; fraction of population in income group i in inventory year, See Table 6.5.	1	-		-	-	-	-	-	-	-	-	-		
	Ti,j ; degree of utilisation of treatment/discharge pathway or system, j, for each income group fraction i in inventory year, See Table 6.5.	1	-		-	-	-	-	-	-	-	-	-		
	R ; amount of CH4 recovered in inventory year	0	kg CH4/yr		-	-	-	-	-	-	-	-	-		
2.5 Fuel combustion of gasoline and diesel vehicles															
Commuting power plant personnel ; personal car	Gasoline consumption	57.12	L/day	365	day/yr	20,848.80	L/yr	2.2376	kgCO2eq/L	IPCC 2006 Vol.2 table 3.2.1, 3.2.2, DEDE	-	-	-	46.65	C*D/1000
Solid wastes transportation ; small truck	Loading Weight	7	tonne	365	day/yr	25,550.00	tonne-km/yr	0.1402	kgCO2eq/tonne-km	TGO,2015	-	-	-	3.58	C*D/1000
	daily vehicle kilometers traveled, DVKT	10	vehicle-km								-	-	-		
Transportation of sediment from water pre-treatment plant ; 10-wheeled trucks	Loading Weight	16	tonne	30	day/yr	115,200	tonne-km/yr	0.053	kgCO2eq/tonne-km	TGO,2015	-	-	-	6.11	C*D/1000
	daily vehicle kilometers traveled, DVKT	240	vehicle-km								-	-	-		
Transportation of chemical ; Trailer	Loading Weight	32	tonne	365	day/yr	2,803,200	tonne-km/yr	0.0409	kgCO2eq/tonne-km	TGO,2015	-	-	-	114.65	C*D/1000
	daily vehicle kilometers traveled, DVKT	240	vehicle-km								-	-	-		
Total														9,694,692.33	

Source : 1/ IPCC Guideline For National Greenhouse Gas Inventories, 2006
2/ Emission Factor of National Metal and Materials Technology Center (MTEC), 2015
3/ Emission Factor of Thai National Life Cycle Inventory Database of Thailand Greenhouse Gas Management Organization (Public Organization) (TGO), 2015
4/ Global Warming Potential (GWP) ,the Fourth Assessment Report (AR4) in 2007, IPCC, 2007

(b) Operation Phase

- The Continuous Emission Monitoring System (CEMs) shall be installed at the stacks of the power plant for continuous emission monitoring. Measurement parameters include nitrogen oxides (NO_x), sulphur dioxide (SO_2), total suspended particulate (TSP), oxygen (O_2) and the flow rate. In addition, the display of air quality monitoring results (NO_X, SO2 and TSP) shall be installed in front of the project area. Monitoring results shall be reported to Pluak Daeng Industrial Park throughout the project life.
- CEMs shall be audited once a year throughout the project life.
- Air pollution emissions shall not exceed the values determined in the environmental impact assessment report. Details are provided below.

Natural gas as fuel scenario

Full load

- SO_2 : concentration not to exceed 10 ppm at 7% O_2 and emission rate not to exceed 13.9 g/s/stack
- NO_x : concentration not to exceed 59 ppm at 7% O_2 and emission rate not to exceed 58.6 g/s/stack
- Particulate : concentration not to exceed 20 mg/m^3 at 7% O_2 and emission rate not to exceed 9.7 g/s/stack

Minimum load

- SO_2 : concentration not to exceed 10 ppm at 7% O_2 and emission rate not to exceed 8.4 g/s/stack
- NO_x : concentration not to exceed 59 ppm at 7% O_2 and emission rate not to exceed 35.4 g/s/stack
- Particulate : concentration not to exceed 20 mg/m^3 at 7% O_2 and emission rate not to exceed 5.9 g/s/stack

Diesel oil as fuel scenario

Full load

- SO_2 : concentration not to exceed 20 ppm at 7% O_2 and emission rate not to exceed 21.0 g/s/stack
- NO_x : concentration not to exceed 99 ppm at 7% O_2 and emission rate not to exceed 74.0 g/s/stack
- Particulate : concentration not to exceed 35 mg/m^3 at 7% O_2 and emission rate not to exceed 12.9 g/s/stack

Minimum load

- SO_2 : concentration not to exceed 20 ppm at 7% O_2 and emission rate not to exceed 17.6 g/s/stack

- NO_x : concentration not to exceed 99 ppm at 7% O_2 and emission rate not to exceed 61.2 g/s/stack
- Particulate : concentration not to exceed 35 mg/m^3 at 7% O_2 and emission rate not to exceed 10.6 g/s/stack

- In case of using natural gas as fuel: Dry low NO_x combustion shall be applied to control NOx during combustion.
- In case of using diesel oil as fuel: Water injection system shall be applied to control NOx during combustion.
- The concentration of the above pollutants is calculated in the normal temperature of 25 degree Celsius, one atmospheric pressure and 7% of excess oxygen during combustion.
- In case of the air pollution control system failure and the emission rate exceeds the control value, the project will stop the gas turbine engine in order to check NOx control system immediately and fix the problem quickly.
- Knowledgeable personnel shall be provided for regulating the air emission rates of the Project.

5.1.2 Noise

(1) Selection of representatives for assessment of noise impacts

The project is located in Pluak Daeng Industrial Park, Map Yang Phon sub-district, Pluak Daeng district, Rayong province. Therefore, land use pattern is the factory in a close building. The consultant selected potential monitoring stations which will be most affected by noise due to the project operation, namely houses outside Pluak Daeng Industrial Park and the ones closest to the project as the representatives for the assessment of noise impacts (**Figure 5.1.2-1**) as follows:

- **West of the project:** Village no. 2, Map Yang Phon sub-district, about 243 m from the project boundary
- **South of the project:** Village no. 5, Map Yang Phon sub-district, about 193 m from the project boundary
- **North of the project:** Village no. 2, Map Yang Phon sub-district, about 71 km from the project boundary

(a) Environment and positions for installation of noise monitoring equipment

Details of the environment and positions for installation of noise monitoring equipment at 3 representatives monitoring stations are as follows:

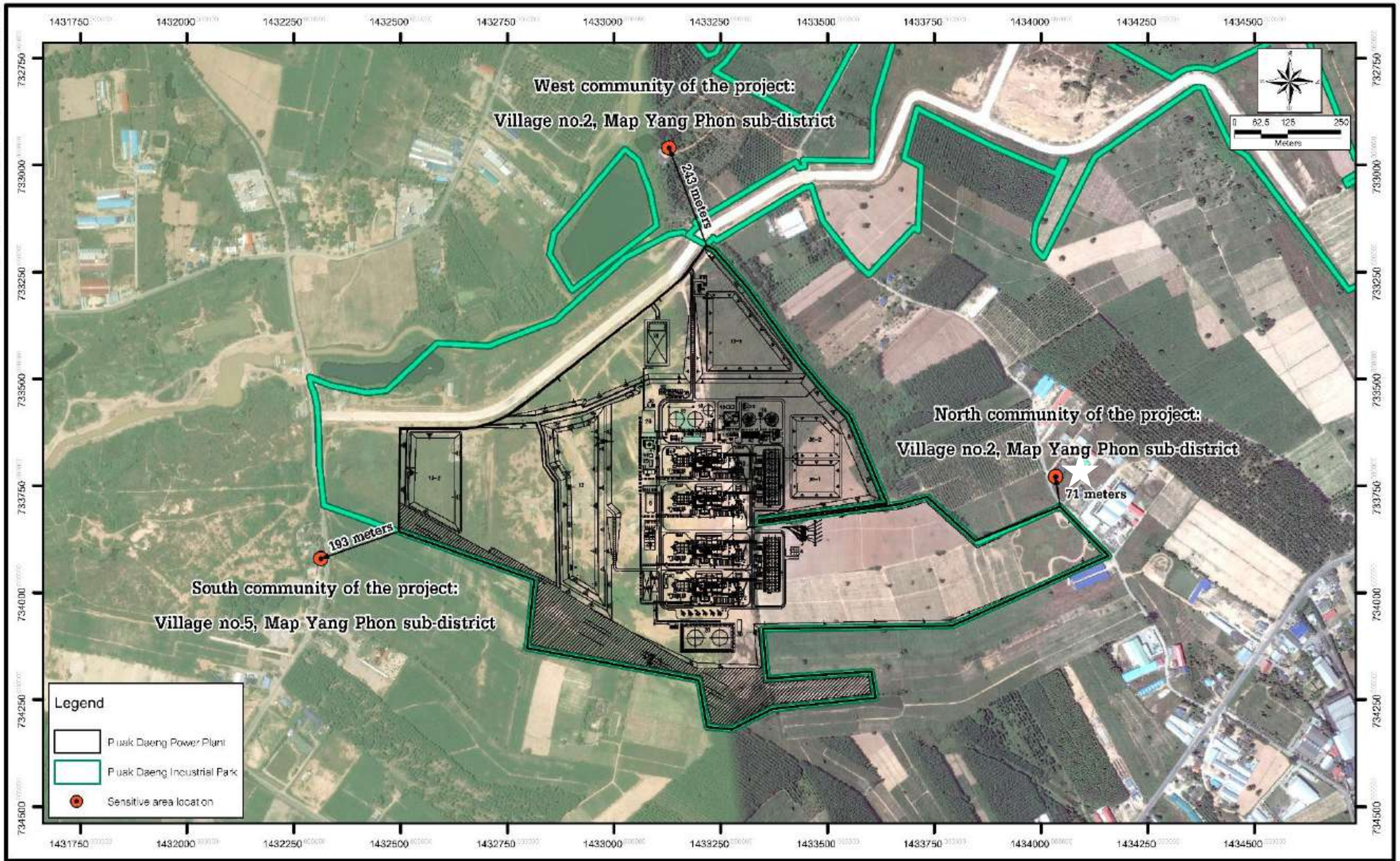


FIGURE 5.1.2-1 : LOCATIONS OF SENSITIVE RECEPTORS IN VICINITIES OF PROJECT

TEAM

- **West of the project (Village no. 2, Map Yang Phon sub-district**: The measurement position is an open space as shown in **Photo 5.1.2-1**. The noise monitoring equipment is installed about 5 m from the roadside and about 20 m from houses as shown in **Figure 5.1.2-2**.
- **South of the project**: **(Village no. 5, Map Yang Phon sub-district:** The measurement position is a one-storey concrete house adjacent to an open space as illustrated in **Photo 5.1.2-2.** The noise monitoring equipment was installed about 10 m from the roadside and about 5 m from houses as illustrated in **Figure 5.1.2-3.**
- **North of the project (Village no. 2, Map Yang Phon sub-district:** The measurement position is a one-storey concrete house adjacent to an open space as illustrated in **Photo 5.1.2-3.** The noise monitoring equipment was installed about 10 m from the roadside and about 18 m from houses as illustrated in **Figure 5.1.2-4.**

(b.) Representatives of current noise levels

Representatives of current noise levels for the assessment of noise impacts from the project operation are summarized in **Table 5.1.2-1.**

PHOTO 5.1.2-1: GENERAL CONDITION OF NOISE MONITORING EQUIPMENT INSTALLATION POSITION IN COMMUNITY IN WEST SIDE OF PROJECT (VILLAGE NO. 2 MAP YANG PHON SUB-DISTRICT)

PHOTO 5.1.2-2: GENERAL CONDITION OF NOISE MONITORING EQUIPMENT INSTALLATION POSITION IN COMMUNITY, SOUTH OF PROJECT (VILLAGE NO. 5 MAP YANG PHON SUB-DISTRICT)

PHOTO 5.1.2-3: GENERAL CONDITION OF NOISE MONITORING EQUIPMENT INSTALLATION POSITION IN COMMUNITY, NORTH OF PROJECT (VILLAGE NO. 2 MAP YANG PHON SUB-DISTRICT)

TABLE 5.1.2-1

REPRESENTATIVES OF CURRENT NOISE LEVELS OF RECEPTOR AREAS

Sensitive Receptors	Measurement Dates	Measurement Results (Leq. 24 hr)	Maximum Leq. 24 hr	Leq 1 hr	L_{90}
Community, west of project (Village no. 2)	13-18/02/2016	63.0-66.3	66.3	Measurement results from 13-18/02/2016, which are at the same time of the representative of the Leq 24 hr measurement results, are used.	
Community, south of project (Village no. 5)	13-18/02/2016	64.4-66.1	66.1	Measurement results from 13-18/02/2016, which are at the same time of the representative of the Leq 24 hr measurement results, are used.	
Community, north of project (Village no. 2)	13-18/02/2016	51.2-59.4	59.4	Measurement results from13-18/02/2016, which are at the same of the representative of the Leq 24 hr measurement results, are used.	

(2) Construction phase

(a) Assessment of noise impacts

Construction activities, such as transportation of construction materials, operation of heavy machinery, pile driving, piping, etc. may generate noise that disturb people in the sensitive receptor surrounding the project. The Manual for Environmental Impact Assessment of Canter (1997) specified 5 construction activities that cause L_{max}, namely land leveling, excavation for foundation construction, foundation construction, structural and building construction and finishing/inspection. Details are given in **Table 5.1.2-2.**

According to **Table 5.1.2-2**, the power plant project is categorized as building and structure. Therefore, assessment of noise impacts is made in the worst case scenario that the machinery or equipment are used concurrently for excavation for foundation construction at the distance of 15 m from the noise source of 89 dB(A). This is the representative of noise level generated from construction activities.

(a.1) Calculation of noise level

The equation used to calculate the maximum noise level at the distance of 1 m or 15 m from the noise source for Leq 1 hr, Leq 8 hr, Leq 24 hr and noise annoyance in the sensitive receptor is given below.

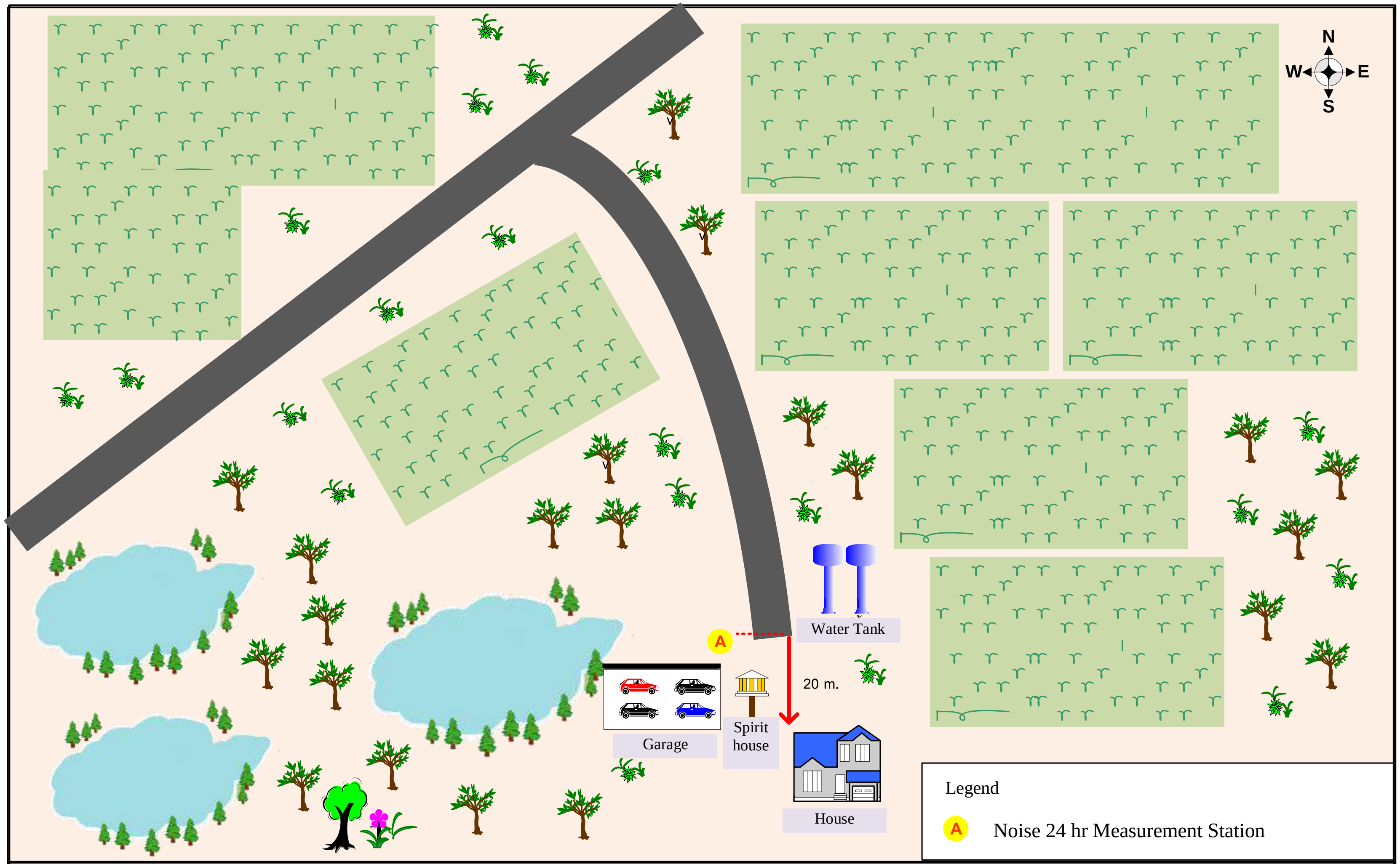


FIGURE 5.1.2-2: LAYOUT OF SAMPLING STATION OF ENVIRONMENTAL QUALITY IN COMMUNITY, WEST OF PROJECT (VILLAGE NO. 2 MAP YANG PHON SUB-DISTRICT, PLUAK DAENG DISTRICT, RAYONG PROVINCE)

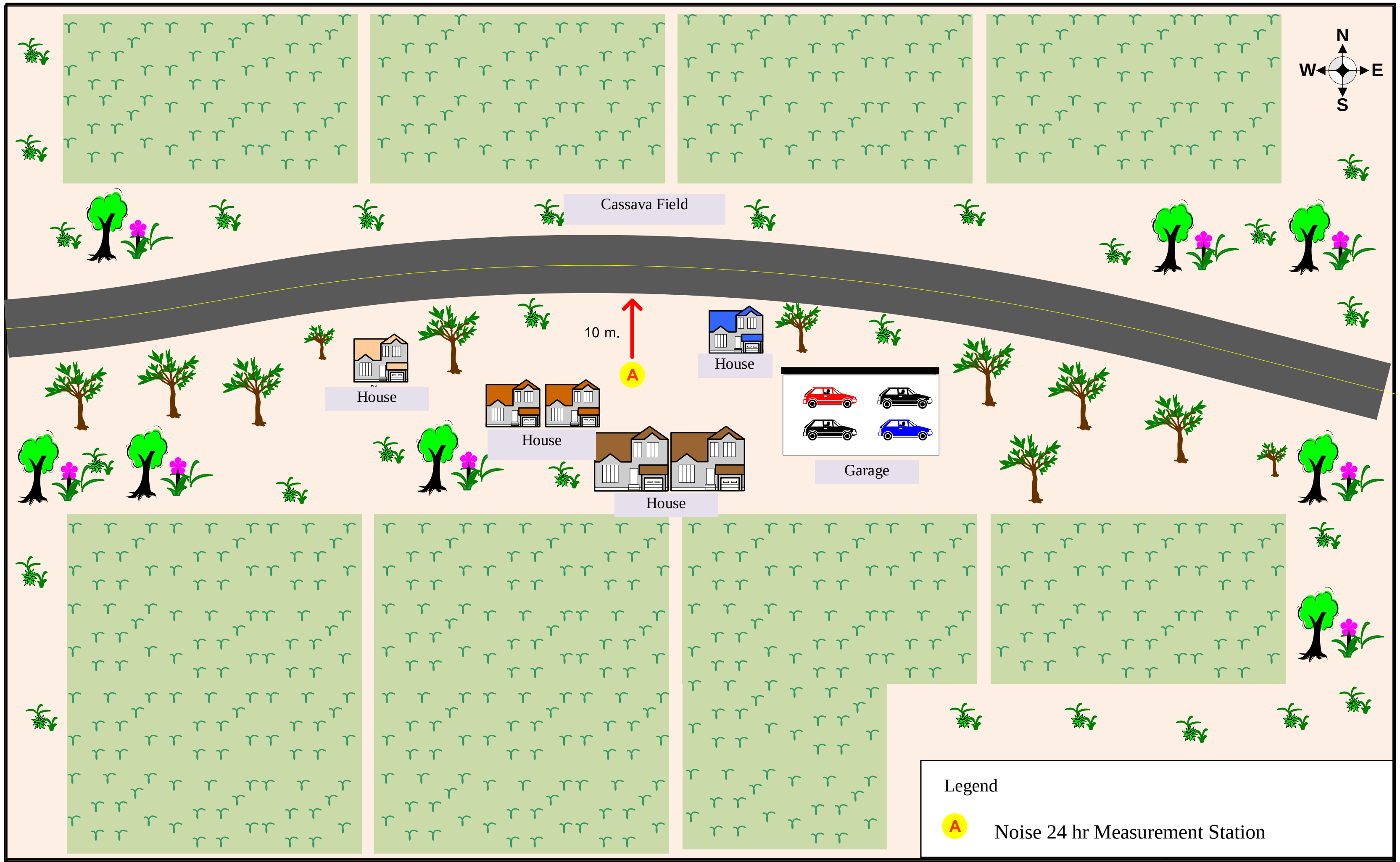


FIGURE 5.1.2-3: LAYOUT OF SAMPLING STATION OF ENVIRONMENTAL QUALITY, SOUTH OF PROJECT
(VILLAGE NO. 5 MAP YANG PHON SUB-DISTRICT, PLUAK DAENG, RAYONG PROVINCE)

FIGURE 5.1.2-4: LAYOUT OF SAMPLING STATION OF ENVIRONMENTAL QUALITY, NORTH OF PROJECT (VILLAGE NO. 2 MAP YANG PHON SUB-DISTRICT, PLUAK DAENG DISTRICT, RAYONG PROVINCE)

TABLE 5.1.2-2

MAXIMUM NOISE LEVEL OF EACH CONSTRUCTION ACTIVITY, 15 METERS AWAY FROM NOISE SOURCE

Unit : Decibel (A)

Construction Activities	Types of Building/Structure							
	Residential Building		Office Building, Hotel, School and Public Utilities		Factory, Parking Lot, Department and Service Station		Road, Highway and Drainage System	
	I	II	I	II	I	II	I	II
– Land leveling	83	83	84	84	84	83	84	84
– Excavation for foundation construction	88	75	89	79	89	71	88	78
– foundation construction	81	81	78	78	77	77	88	88
– Structural and building construction	81	65	87	75	84	72	79	78
– Finishing/inspection	88	72	89	75	89	74	84	84

Remarks : I = Maximum noise level in case the machinery and all pertinent equipment are used.
II = Maximum noise level in case use of the machinery and equipment meet minimum requirement.

Source: Carry W. Canter, Environmental Impact Assessment, 1997

- **Calculation of noise level for a certain period of time**

The following equation is used to calculate noise level from the noise source and converted it into the average noise level for a certain period of time.

$$Leq_T = Lp + 10 \log \frac{t}{T} \quad (1)$$

Where Leq_T = Noise level occurs for a certain period of time (T) [dB(A)]

Lp = Noise level from noise source [dB(A)]

t = Duration of noise from noise source (hour)

T = Duration of noise needed to be known (hour)

- **Calculation of noise level from noise source to receiver**

Noise level at the distance of 1 m or 15 m from the noise source (machinery) is converted into the noise level that the person will be affected, using the following equation.

$$Lp_2 = Lp_1 - 20 \log \left(\frac{r_2}{r_1}\right) \ldots\ldots\ldots\ldots (2)$$

Where Lp1 = Noise level measured at the distance r1 from noise source

Lp2 = Noise level occurs at the distance r2 from noise source

r1, r2 = Distance from noise source where Lp_1 and Lp_2 noise levels are measured, respectively.

- **Calculation of combined noise level**

A combined noise level generated from activities of the project and the noise level measured at the sensitive receptor is calculated using the following equation.

$$Lp_{total} = 10\log\left(\sum_{i=1}^{n} 10^{Lp_i/10}\right) \qquad \text{(3)}$$

Where Lp_{total} = Combined noise level, dB(A)

Lp_i = Noise level from each noise source, dB(A)

n = Number of noise sources

- **Noise annoyance**

Apart from performing noise level forecast to compare with the ambient noise standard, the Consultant considered noise annoyance level generated from the project activities. The calculation method is given below.

Noise Annoyance Level = Noise level during disturbance (Leq)- Background noise level (L_{90})

(when annoyance level is >10 dB(A), there is disturbance)

The project applies the noise level with disturbance calculation method for the measurement of noise level in the field according to the notification of the Pollution Control Board re: Method for Measurement of Basic Noise Level without Disturbance, Measurement and Calculation of Noise Level with Disturbance, calculation of annoyance level and record form of disturbance noise, methods for calculating noise level during disturbance for field measurement is specified. Noise annoyance levels from activities of the project are calculated as follows:

(1) Estimated value of noise level during activities (forecasted noise + maximum measured noise level) deduct by noise level with no disturbance (noise level Leq from current measurement), this will yield a result in form of difference in noise level.

(2) The difference of noise level from (1) will be compared with the value, as shown in the following Table in order to find out adjustment value of noise level.

Difference of Noise Level (dB(A))	Noise Level Adjustment Value (dB(A))
1.4 or less	7.0
1.5-2.4	4.5
2.5-3.4	3.0
3.5-4.4	2.0
4.5-6.4	1.5
6.5-7.4	1.0
7.5-12.4	0.5
12.5 or higher	0

(3) The estimate noise level during activities (forecasted noise level + maximum measured noise level) will be deducted by the adjustment value from (2), this will yield a noise level with disturbance.

Add 3 dB(A) for the noise source that generates noise from 22.00-06.00 hr. As for impulsive noise, add 5 plus dB(A). The result is the noise level with disturbance.

(4) Noise level during disturbance from (3) will be deducted by measured background noise level (L_{90}).

In addition, the noise annoyance measurement manual of Air Quality and Noise Management Bureau, Pollution Control Department, Ministry of Natural Resources and Environment (2007) determines 4 scenarios for the calculation of noise annoyance from noise sources as shown in **Figure 5.1.2-5.**

(a.2) Noise impact during construction phase

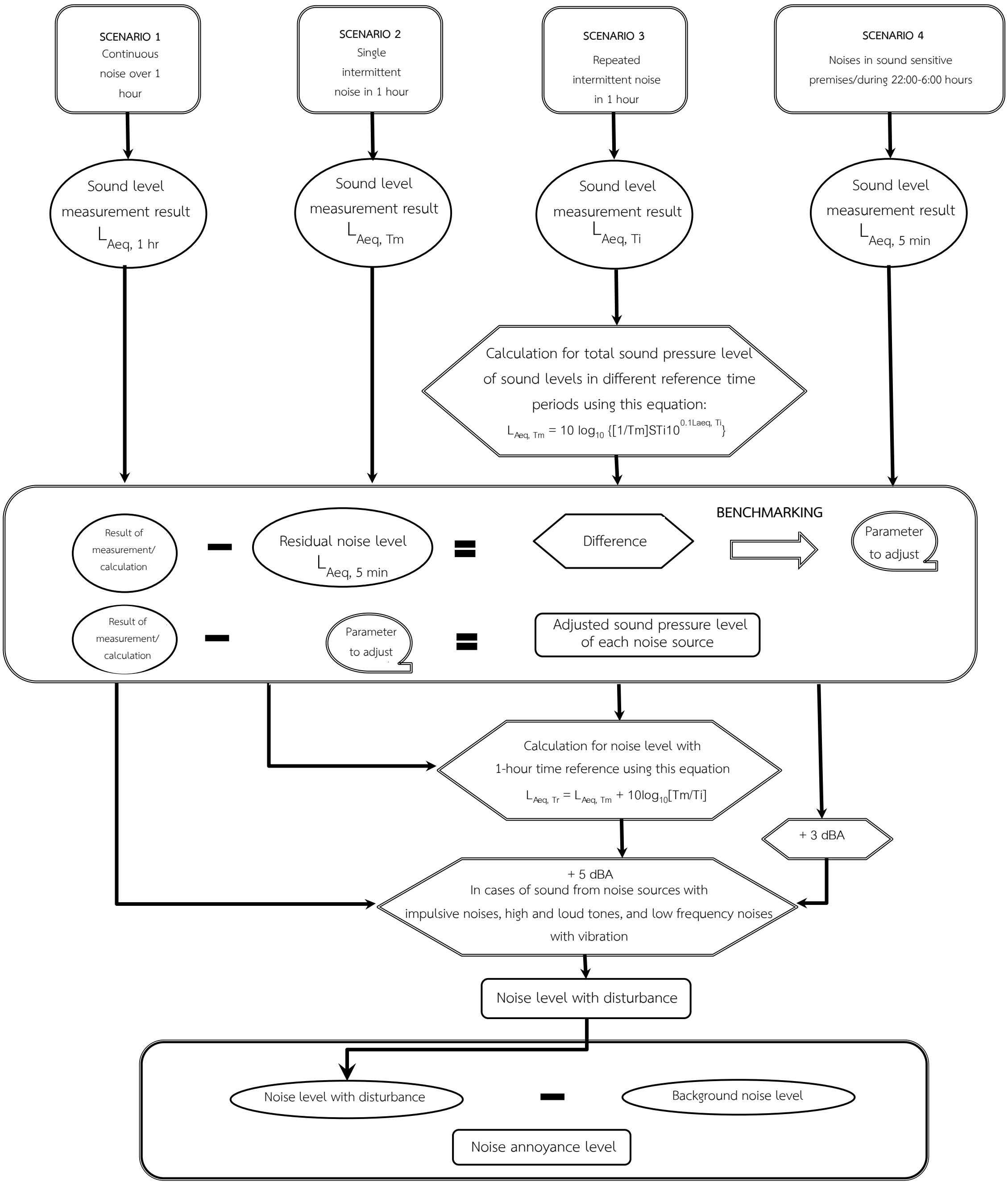
- **Leq 8 hr and Leq 24 hr**

The loudest sound from the machinery or equipment used for excavation for foundation construction will be considered for noise impact. The 89 dB(A)-L_{max} at the distance of 15 m from the noise source is the representative of noise generated from construction activities for 8 working hours in the worst case scenario. Leq 1 hr, Leq 8 hr and Leq 24 hr is calculated as follows:

$$\text{Leq 1 hr.} = 89.0 + 10\log\frac{1}{1} = 89.0 \text{ dB(A)}$$

$$\text{Leq 8 hr.} = 89.0 + 10\log\frac{8}{8} = 89.0 \text{ dB(A)}$$

$$\text{Leq 24 hr.} = 89.0 + 10\log\frac{8}{24} = 84.2 \text{ dB(A)}$$



Source : Air Quality and Noise Management Bureau, Pollution Control Department, Ministry of Natural Resources and Environment, 2007

FIGURE 5.1.2-5 : MEASUREMENT AND ANALYSIS OF NOISE LEVEL WITH DISTURBANCE PROCEDURE

Noise impact on construction workers and staff at construction site: Construction workers will expose to 89.0 dB(A) of noise level from construction activities. Combined with the maximum Leq 8 hr measured in the current project location (51.0 dB(A)), it will reach into 89.0 dB(A). This noise level meets the standard of ministerial regulation of Ministry of Labour, B.E.2549 on establishment of standard for management of safety, occupational health and work environment relating to heat, light and noise. The standard determines that an average noise level for 8 consecutive working hours shall not exceed 90 dB(A). In addition, construction workers or staff working in the noisy area are required to wear personal protective equipment, i.e. ear muffs and earplugs all the time. Therefore, noise impact on construction workers or staff at the construction site is at a low level (negative impact level = 1).

Noise impact on communities and sensitive receptors: The combined noise level between Leq 24 hr from construction activities and the current maximum measured noise level (**Table 5.1.2-1**) in the sensitive receptors near the project area, i.e. Village no. 2, Map Yang Phon sub-district, which is in the west and the north 601.3 m and 667.6 m, respectively away from the construction site that pile driving is undertaken and Village no. 5, Map Yang Phon sub-district, which is 814.6 m in the south of the construction site that pile driving is undertaken do not exceed the standard. As a result, noise impacts on communities and the sensitive receptors are at the low level (**Table 5.1.2-3**).

TABLE 5.1.2-3

FORECAST RESULTS OF NOISE SENSITIVE RECEPTORS DURING CONSTRUCTION PHASE

Sensitive Receptors	Distance from Pile Driving Activity (m)	Leq 24 hr (dB(A))		
		Construction Activity	Maximum Leq 24 hr	Combined Noise Level
1. Community, west of the project (Village no. 2 Map Yang Phon sub-district)	601.3	52.1	66.3 1/	66.5
2. Community, south of the project (Village no. 5 Map Yang Phon sub-district)	814.6	49.5	66.1 1/	66.2
3. Community, north of the project (Village no. 2 Map Yang Phon sub-district)	667.6	49.5	59.4 1/	59.8
Standard		70 2/		

Remarks : 1/ Measurement results of the maximum Leq 24 hr during 13nd-18th February, 2016 from the field survey by Team Consulting Engineering and Management Co., Ltd., 2016

2/ The standard in accordance with the Announcement of the National Environment Board, No. 15 (B.E. 2540) on determination of noise level standard.

- Noise Annoyance

Construction activities will be undertaken during the daytime for 8 hours from 08.00-17.00 hr. only (except lunch time 12.00-13.00 hr.) Therefore, consideration is made for the noise impact in the sensitive receptors during the daytime only. As the noise source of the project continuously generates more than 1 hour it is categorized in Scenario 1 according to the noise annoyance level measurement manual of Air Quality and Noise Management Bureau, Pollution Control Department, Ministry of Natural Resources and Environment (2007), which determines that the Leq 1 hr is the representative of the noise level with disturbance (**Figure 5.1.2-5**).

Thus, the Leq 1 hr noise level from construction activities will be used for assessment. The reduction in noise level based on the distance to receivers is calculated using equation (2) as the representative of noise generated from construction activities from 08.00-17.00 hr (except lunch time 12.00-13.00 hr) Assessment results are shown in **Table 5.1.2-4** to **Table 5.1.2-6**. It was found that **noise levels in the three sensitive receptors during the construction phase are higher than the standard.**

- The west of project: Village no.2 Map Yang Phon sub-district. Noise annoyance levels during the construction phase range from 2.3 to 31.5 dB(A).
- The south of project: Village no.5 Map Yang Phon sub-district. Noise annoyance levels during the construction phase range from 9.5 to 22.8 dB(A).
- The north of project: Village no.2 Map Yang Phon sub-district. Noise annoyance levels during the construction phase range from 1.7 to 29.9 dB(A).

Noise mitigation measures during construction phase

According to forecast results of Leq 24 hr and noise annoyance in **Table 5.1.2-3** to **Table 5.1.2-6**, Leq 24 hr during the construction phase in all three communities near the project area does not exceed the standard. However, the noise annoyance is higher than the standard.

Thus, to mitigate potential impacts from construction activities on nearby communities during the construction phase, the impact prevention and mitigation measures are established. Contractors shall use the machinery and equipment that cause low noise. Noise barriers shall be installed in the pile driving area, 10 m of distance from the noise sources which are noisy machinery and equipment, in the west and north of village no.2 Map yang Phon sub-district, and in the south at village no.5 Map yang Phon sub-district. A metal sheet of 1.27 mm thick (Steel 18 ga) or thicker is chosen. The transmission loss (TL) is 25 dB(A) Details are shown in **Table 5.1.2-7**.

TABLE 5.1.2-4
NOISE ANNOYANCE LEVEL FROM PILE DRIVING ACTIVITY NEAR COMMUNITY, WEST OF PROJECT

Duration of Time	Leq 1 hr[1/]	L_{90}[1/]	Noise Level from Pile Driving Activity	Total Noise Level	Difference of Noise Level	Noise Level Adjustment Value	Value Added from Impulsive Noise	Noise Annoyance Level during Construction Phase
February 13th, 2016								
08:00-09:00	59.9	49.6	56.9	61.7	1.8	4.5	5.0	12.6
09:00-10:00	67.4	43.9	56.9	67.8	0.4	7.0	5.0	21.9
10:00-11:00	65.4	41.5	56.9	66.0	0.6	7.0	5.0	22.5
11:00-12:00	65.6	43.1	56.9	66.1	0.5	7.0	5.0	21.0
13:00-14:00	65.5	35.8	56.9	66.1	0.6	7.0	5.0	28.3
14:00-15:00	58.7	36.4	56.9	60.9	2.2	4.5	5.0	25.0
15:00-16:00	56.0	40.2	56.9	59.5	3.5	0.0	5.0	24.3
16:00-17:00	57.2	40.6	56.9	60.1	2.9	3.0	5.0	21.5
February 14th, 2016								
08:00-09:00	69.9	39.6	56.9	70.1	0.2	7.0	5.0	28.5
09:00-10:00	68.0	40.4	56.9	68.3	0.3	7.0	5.0	25.9
10:00-11:00	66.6	38.9	56.9	67.0	0.4	7.0	5.0	26.1
11:00-12:00	64.2	38.4	56.9	64.9	0.7	7.0	5.0	24.5
13:00-14:00	65.2	34.5	56.9	65.8	0.6	7.0	5.0	29.3
14:00-15:00	64.7	41.6	56.9	65.4	0.7	7.0	5.0	21.8
15:00-16:00	66.3	38.6	56.9	66.8	0.5	7.0	5.0	26.2
16:00-17:00	56.8	39.2	56.9	59.9	3.1	3.0	5.0	22.7
February 15th, 2016								
08:00-09:00	66.9	40.9	56.9	67.3	0.4	7.0	5.0	24.4
09:00-10:00	67.5	37.8	56.9	67.9	0.4	7.0	5.0	28.1
10:00-11:00	65.0	38.5	56.9	65.6	0.6	7.0	5.0	25.1
11:00-12:00	67.6	39.8	56.9	68.0	0.4	7.0	5.0	26.2
13:00-14:00	57.7	39.8	56.9	60.3	2.6	3.0	5.0	22.5
14:00-15:00	65.9	62.1	56.9	66.4	0.5	7.0	5.0	2.3
15:00-16:00	62.6	51.4	56.9	63.6	1.0	7.0	5.0	10.2
16:00-17:00	59.2	39.2	56.9	61.2	2.0	4.5	5.0	22.5

TABLE 5.1.2-4

NOISE ANNOYANCE LEVEL FROM PILE DRIVING ACTIVITY NEAR COMMUNITY, WEST OF PROJECT (CONT'D)

Duration of Time	Leq 1 hr[1/]	L_{90}[1/]	Noise Level from Pile Driving Activity	Total Noise Level	Difference of Noise Level	Noise Level Adjustment Value	Value Added from Impulsive Noise	Noise Annoyance Level during Construction Phase
February 16th, 2016								
08:00-09:00	65.5	42.1	56.9	66.1	0.6	7.0	5.0	22.0
09:00-10:00	63.2	39.8	56.9	64.1	0.9	7.0	5.0	22.3
10:00-11:00	64.0	40.6	56.9	64.8	0.8	7.0	5.0	22.2
11:00-12:00	64.1	39.3	56.9	64.9	0.8	7.0	5.0	23.6
13:00-14:00	58.5	36.1	56.9	60.8	2.3	4.5	5.0	25.2
14:00-15:00	59.0	36.6	56.9	61.1	2.1	4.5	5.0	25.0
15:00-16:00	57.5	38.7	56.9	60.2	2.7	3.0	5.0	23.5
16:00-17:00	54.4	39.2	56.9	58.8	4.4	0.0	5.0	24.6
February 17th, 2016								
08:00-09:00	66.5	46.6	56.9	67.0	0.5	7.0	5.0	18.4
09:00-10:00	68.0	39.8	56.9	68.3	0.3	7.0	5.0	26.5
10:00-11:00	68.4	35.2	56.9	68.7	0.3	7.0	5.0	31.5
11:00-12:00	66.1	37.5	56.9	66.6	0.5	7.0	5.0	27.1
13:00-14:00	60.3	36.4	56.9	61.9	1.6	4.5	5.0	26.0
14:00-15:00	56.4	31.7	56.9	59.7	3.3	3.0	5.0	30.0
15:00-16:00	56.1	42.7	56.9	59.5	3.4	0.0	5.0	21.8
16:00-17:00	55.0	37.3	56.9	59.1	4.1	2.0	5.0	24.8
Standard value								10.0[2/]

Remarks : 1/ Measurement results of the Leq 1 hr and L_{90} from 08.00-17.00 hr. at Village no. 2 Map Yang Phon sub-district, west of the project during 13th-18th February, 2016 from the field survey by Team Consulting Engineering and Management Co., Ltd., 2016

2/ The standard in accordance with the Announcement of the National Environment Board, No. 29 (B.E. 2550) on noise level.

The underlined figure means the noise level is higher than the standard.

TABLE 5.1.2-5
NOISE ANNOYANCE LEVEL FROM PILE DRIVING ACTIVITY NEAR COMMUNITY, SOUTH OF PROJECT

Duration of Time	Leq 1 hr[1/]	L_{90}[1/]	Noise Level from Pile Driving Activity	Total Noise Level	Difference of Noise Level	Noise Level Adjustment Value	Value Added from Impulsive Noise	Noise Annoyance Level during Construction Phase
February 13th, 2016								
08:00-09:00	67.6	45.5	54.3	67.8	0.2	7.0	5.0	20.3
09:00-10:00	65.0	44.0	54.3	65.4	0.4	7.0	5.0	19.4
10:00-11:00	67.1	46.6	54.3	67.3	0.2	7.0	5.0	18.7
11:00-12:00	65.7	41.5	54.3	66.0	0.3	7.0	5.0	22.5
13:00-14:00	65.7	43.2	54.3	66.0	0.3	7.0	5.0	20.8
14:00-15:00	65.2	45.6	54.3	65.5	0.3	7.0	5.0	17.9
15:00-16:00	67.1	48.0	54.3	67.3	0.2	7.0	5.0	17.3
16:00-17:00	65.7	47.9	54.3	66.0	0.3	7.0	5.0	16.1
February 14th, 2016								
08:00-09:00	68.5	50.1	54.3	68.7	0.2	7.0	5.0	16.6
09:00-10:00	66.7	47.4	54.3	66.9	0.2	7.0	5.0	17.5
10:00-11:00	66.8	45.4	54.3	67.0	0.2	7.0	5.0	19.6
11:00-12:00	67.3	42.7	54.3	67.5	0.2	7.0	5.0	22.8
13:00-14:00	65.9	44.0	54.3	66.2	0.3	7.0	5.0	20.2
14:00-15:00	66.8	45.2	54.3	67.0	0.2	7.0	5.0	19.8
15:00-16:00	67.1	45.9	54.3	67.3	0.2	7.0	5.0	19.4
16:00-17:00	66.6	45.9	54.3	66.8	0.2	7.0	5.0	18.9
February 15th, 2016								
08:00-09:00	68.2	50.2	54.3	68.4	0.2	7.0	5.0	16.2
09:00-10:00	68.8	48.3	54.3	69.0	0.2	7.0	5.0	18.7
10:00-11:00	66.4	46.8	54.3	66.7	0.3	7.0	5.0	17.9
11:00-12:00	67.5	43.7	54.3	67.7	0.2	7.0	5.0	22.0
13:00-14:00	66.0	46.2	54.3	66.3	0.3	7.0	5.0	18.1
14:00-15:00	69.7	58.3	54.3	69.8	0.1	7.0	5.0	9.5
15:00-16:00	67.9	51.9	54.3	68.1	0.2	7.0	5.0	14.2
16:00-17:00	68.7	48.1	54.3	68.9	0.2	7.0	5.0	18.8

TABLE 5.1.2-5
NOISE ANNOYANCE LEVEL FROM PILE DRIVING ACTIVITY NEAR COMMUNITY, SOUTH OF PROJECT (CONT'D)

Duration of Time	Leq 1 hr[1/]	L_{90}[1/]	Noise Level from Pile Driving Activity	Total Noise Level	Difference of Noise Level	Noise Level Adjustment Value	Value Added from Impulsive Noise	Noise Annoyance Level during Construction Phase
February 16th, 2016								
08:00-09:00	69.4	50.6	54.3	69.5	0.1	7.0	5.0	16.9
09:00-10:00	68.2	49.8	54.3	68.4	0.2	7.0	5.0	16.6
10:00-11:00	66.8	48.1	54.3	67.0	0.2	7.0	5.0	16.9
11:00-12:00	67.3	48.2	54.3	67.5	0.2	7.0	5.0	17.3
13:00-14:00	65.7	44.8	54.3	66.0	0.3	7.0	5.0	19.2
14:00-15:00	65.7	45.9	54.3	66.0	0.3	7.0	5.0	18.1
15:00-16:00	65.5	45.2	54.3	65.8	0.3	7.0	5.0	18.6
16:00-17:00	67.6	48.2	54.3	67.8	0.2	7.0	5.0	17.6
February 17th, 2016								
08:00-09:00	69.1	50.6	54.3	69.2	0.1	7.0	5.0	16.6
09:00-10:00	67.8	46.4	54.3	68.0	0.2	7.0	5.0	19.6
10:00-11:00	67.8	45.7	54.3	68.0	0.2	7.0	5.0	20.3
11:00-12:00	66.0	43.5	54.3	66.3	0.3	7.0	5.0	20.8
13:00-14:00	67.1	45.0	54.3	67.3	0.2	7.0	5.0	20.3
14:00-15:00	66.6	45.1	54.3	66.8	0.2	7.0	5.0	19.7
15:00-16:00	68.2	48.0	54.3	68.4	0.2	7.0	5.0	18.4
16:00-17:00	66.4	48.2	54.3	66.7	0.3	7.0	5.0	16.5
Standard value								**10.0[2/]**

Remarks : 1/ Measurement results of the Leq 1 hr and L_{90} from 08.00-17.00 hr. at Village no. 5 Map Yang Phon sub-district, west of the project during 13th-18th February, 2016 from the field survey by Team Consulting Engineering and Management Co., Ltd., 2016

2/ The standard in accordance with the Announcement of the National Environment Board, No. 29 (B.E. 2550) on noise level.

The underlined figure means the noise level is higher than the standard.

TABLE 5.1.2-6
NOISE ANNOYANCE LEVEL FROM PILE DRIVING ACTIVITY NEAR COMMUNITY, NORTH OF PROJECT

Duration of Time	Leq 1 hr1/	L90 1/	Noise Level from Pile Driving Activity	Total Noise Level	Difference of Noise Level	Noise Level Adjustment Value	Value Added from Impulsive Noise	Noise Annoyance Level during Construction Phase
February 13th, 2016								
08:00-09:00	50.5	36.4	56.0	57.1	6.6	1.0	5.0	24.7
09:00-10:00	49.9	34.1	56.0	57.0	7.1	1.0	5.0	26.9
10:00-11:00	49.4	35.7	56.0	56.9	7.5	0.0	5.0	26.2
11:00-12:00	56.6	36.1	56.0	59.3	2.7	3.0	5.0	25.2
13:00-14:00	47.3	35.2	56.0	56.5	9.2	0.5	5.0	25.8
14:00-15:00	51.5	39.7	56.0	57.3	5.8	1.5	5.0	21.1
15:00-16:00	49.3	40.4	56.0	56.8	7.5	0.5	5.0	20.9
16:00-17:00	55.8	44.7	56.0	58.9	3.1	3.0	5.0	16.2
February 14th, 2016								
08:00-09:00	52.5	37.4	56.0	57.6	5.1	1.5	5.0	23.7
09:00-10:00	51.1	35.3	56.0	57.2	6.1	1.5	5.0	25.4
10:00-11:00	52.1	34.7	56.0	57.5	5.4	1.5	5.0	26.3
11:00-12:00	49.1	31.4	56.0	56.8	7.7	0.5	5.0	29.9
13:00-14:00	49.0	33.5	56.0	56.8	7.8	0.5	5.0	27.8
14:00-15:00	49.7	37.2	56.0	56.9	7.2	1.0	5.0	23.7
15:00-16:00	49.9	36.4	56.0	57.0	7.1	1.0	5.0	24.6
16:00-17:00	52.1	37.0	56.0	57.5	5.4	1.5	5.0	24.0
February 15, 2016								
08:00-09:00	50.9	36.9	56.0	57.2	6.3	1.5	5.0	23.8
09:00-10:00	48.0	35.8	56.0	56.6	8.6	0.5	5.0	25.3
10:00-11:00	51.9	33.7	56.0	57.4	5.5	1.5	5.0	27.2
11:00-12:00	51.1	34.6	56.0	57.2	6.1	1.5	5.0	26.1
13:00-14:00	52.5	41.6	56.0	57.6	5.1	1.5	5.0	19.5
14:00-15:00	62.0	59.3	56.0	63.0	1.0	7.0	5.0	1.7
15:00-16:00	55.0	42.7	56.0	58.5	3.5	2.0	5.0	18.8
16:00-17:00	52.0	39.0	56.0	57.5	5.5	1.5	5.0	22.0

TABLE 5.1.2-6

NOISE ANNOYANCE LEVEL FROM PILE DRIVING ACTIVITY NEAR COMMUNITY, NORTH OF PROJECT (CONT'D)

Duration of Time	Leq 1 hr[1/]	L_{90}[1/]	Noise Level from Pile Driving Activity	Total Noise Level	Difference of Noise Level	Noise Level Adjustment Value	Value Added from Impulsive Noise	Noise Annoyance Level during Construction Phase
February 16th, 2016								
08:00-09:00	54.4	40.6	56.0	58.3	3.9	2.0	5.0	20.7
09:00-10:00	50.4	40.9	56.0	57.1	6.7	1.0	5.0	20.2
10:00-11:00	59.1	41.0	56.0	60.8	1.7	4.5	5.0	20.3
11:00-12:00	51.7	38.4	56.0	57.4	5.7	1.5	5.0	22.5
13:00-14:00	52.4	35.9	56.0	57.6	5.2	1.5	5.0	25.2
14:00-15:00	52.5	35.3	56.0	57.6	5.1	1.5	5.0	25.8
15:00-16:00	50.5	37.5	56.0	57.1	6.6	1.0	5.0	23.6
16:00-17:00	55.1	39.7	56.0	58.6	3.5	0.0	5.0	23.9
February 17th, 2016								
08:00-09:00	52.9	37.8	56.0	57.7	4.8	1.5	5.0	23.4
09:00-10:00	51.6	35.6	56.0	57.3	5.7	1.5	5.0	25.2
10:00-11:00	52.2	37.0	56.0	57.5	5.3	1.5	5.0	24.0
11:00-12:00	53.3	36.7	56.0	57.9	4.6	1.5	5.0	24.7
13:00-14:00	48.2	34.4	56.0	56.7	8.5	0.5	5.0	26.8
14:00-15:00	50.3	33.7	56.0	57.0	6.7	1.0	5.0	27.3
15:00-16:00	48.7	35.3	56.0	56.7	8.0	0.5	5.0	25.9
16:00-17:00	52.7	37.2	56.0	57.7	5.0	1.5	5.0	24.0
Standard value								10.0[2/]

Remarks : **1/** Measurement results of the Leq 1 hr and L_{90} from 08.00-17.00 hr. at Village no. 2 Map Yang Phon sub-district, west of the project during 13th-18th February, 2016 from the field survey by Team Consulting Engineering and Management Co., Ltd., 2016

2/ The standard in accordance with the Announcement of the National Environment Board, No. 29 (B.E. 2550) on noise level.

The underlined figure means the noise level is higher than the standard.

TABLE 5.1.2-7

TRANSMISSION LOSS DUE TO USE OF SOUND ABSORBING MATERIALS

Materials	Thickness (mm)	Surface Density (Kg/m^2)	Transmission Loss* (dB)
- Concrete block 200×200×400 light weight	200	151	34
- Dense concrete	100	244	40
- Light concrete	150	244	39
- Light concrete	100	161	36
- Brick	150	288	40
- **Steel, 18 ga**	**1.27**	**9.8**	**25**
- Steel, 20 ga	0.95	7.3	22
- Steel, 22 ga	0.79	6.1	20
- Steel, 24 ga	0.64	4.9	18

Remark: *Values assuming no openings or gaps in the barriers

Source: Modified from Environmental Protection Department and Highways Department, Government of the Hong Kong SAR., 2003

- **Total sound pressure level calculation with noise barriers**

The calculation of Total sound pressure level calculation with noise barriers is made in case a metal sound absorbing material with the thickness of 1.27 mm (Steel 18 ga) or thicker is chosen. The transmission loss is 25 dB(A). A temporary noise barrier will be installed. The calculation of noise level when it travels through the sound absorbing material can be made by computing Fresnel number from Equation (4). Then use the resulting Fresnel number to calculate the reduced noise level after it travels through the sound absorbing material from the graph **(Figure 5.1.2-6)**. After that, subtract the reduced noise level with the noise level generated from construction activities in the sensitive receptor. The sensitive receptor will be affected by the reduced noise level.

$$N_0 = \frac{2(a+b-c)}{W} \quad (4)$$

Where N_0 = Fresnel number

a = Eliminating distance from noise source to upper edge of wall (m)

b = Eliminating distance from upper edge of wall to receiver (m)

c = Eliminating distance from noise source to receiver (m)

W = Sound wavelength (m) = v/f

v = Speed of sound (m/sec)

= $331.4\ [1+ (T_c / 273.2)]^{1/2}$

T_c = Average temperature of atmosphere. Source: A 11-year period climate statistics of Huai Pong Meteorological Station = 28.0 Celcius degree

f = Frequency of sound wave = 550 Hz

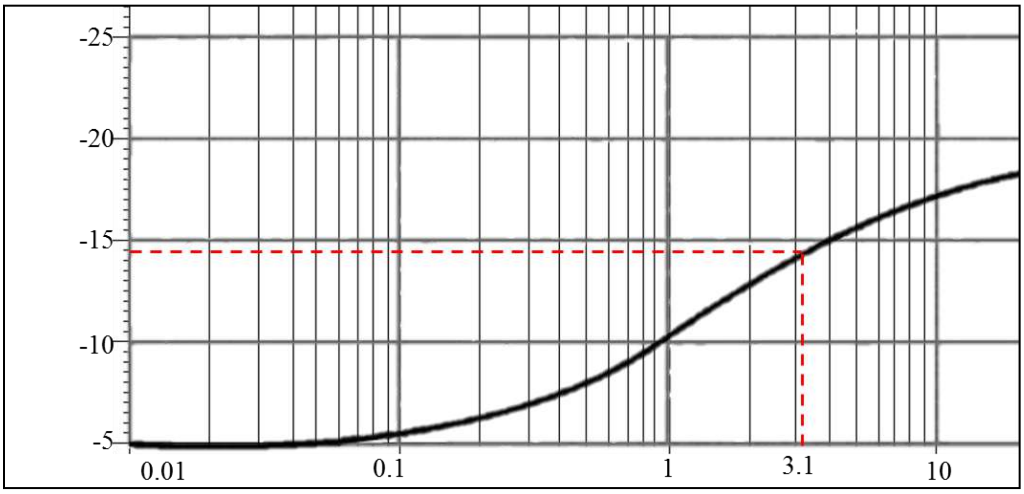
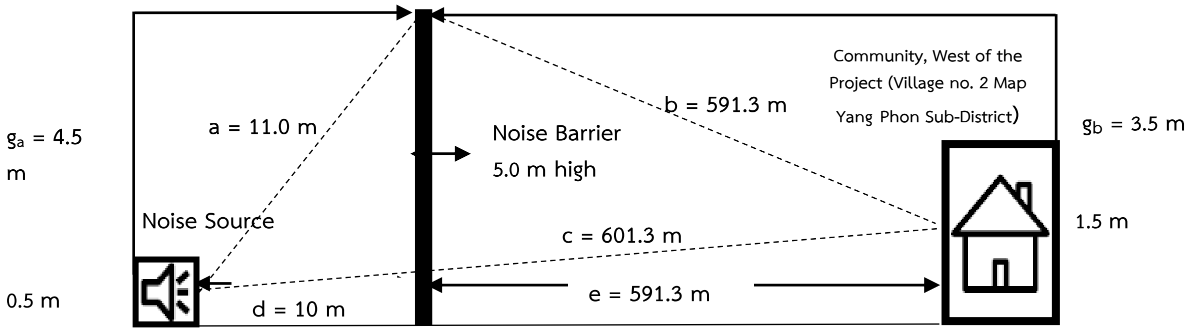


FIGURE 5.1.2-6: GRAPH SHOWING CORRELATION BETWEEN NOISE REDUCTION NUMBER OF SOUND ABSORBING MATERIAL AND FRESNEL NUMBER

Noise barriers will be installed in the pile driving area, 10 m distance from the noisy machinery which is the noise source, in the west and north of village no.2, Map Yang Phon sub-district and in the south at village no.5 Map Yang Phon sub-district **(Figure 5.1.2-1)**. The height of the noise barrier at each side will be about 5 m, which is higher than the height of the affected receptor (1.5 m) **(Figure 5.1.2-7** to **Figure 5.1.2-9)**. The calculation of the reduced noise level due to travel through the sound absorbing material is shown in **Table 5.1.2-8.**



IGURE 5.1.2-7: DISTANCE AND ELIMINATING DISTANCE FOR CALCULATION OF REDUCED NOISE LEVEL DUE TO TRAVEL THROUGH TEMPORARY NOISE BARRIER OF 5 M HEIGHT, WEST OF PROJECT

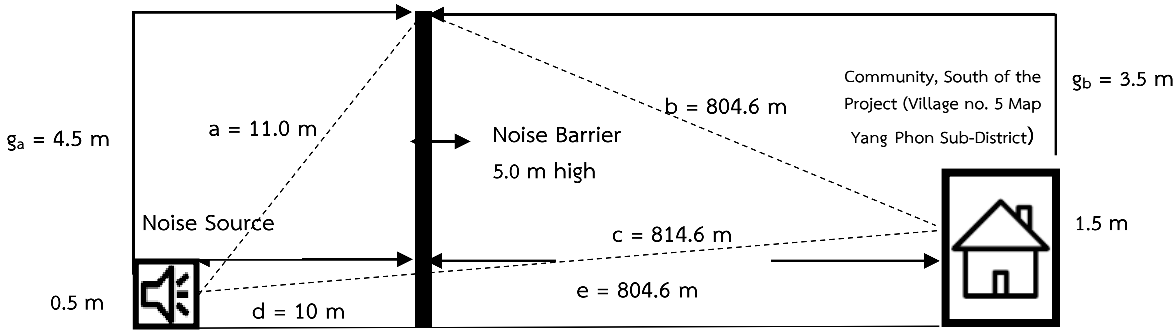


FIGURE 5.1.2-8: DISTANCE AND ELIMINATING DISTANCE FOR CALCULATION OF REDUCED NOISE LEVEL DUE TO TRAVEL THROUGH TEMPORARY NOISE BARRIER OF 5 M HEIGHT, SOUTH OF PROJECT

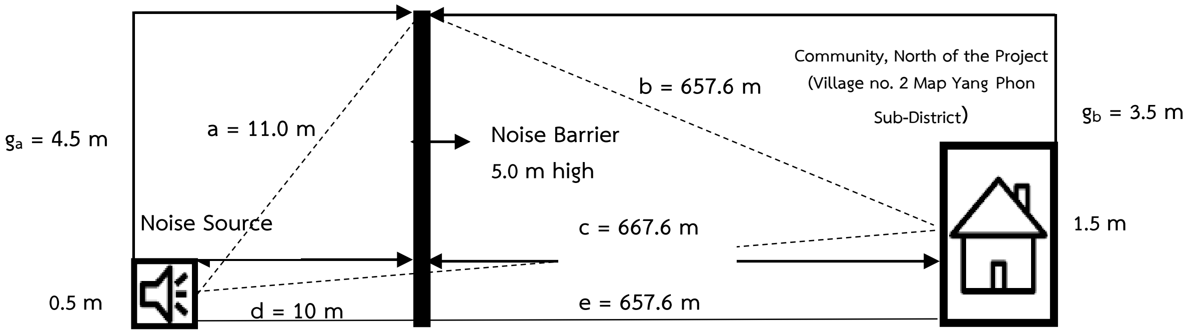


FIGURE 5.1.2-9: DISTANCE AND ELIMINATING DISTANCE FOR CALCULATION OF REDUCED NOISE LEVEL DUE TO TRAVEL THROUGH TEMPORARY NOISE BARRIER OF 5 M HEIGHT, NORTH OF PROJECT

TABLE 5.1.2-8

DESCRIPTIONS OF TRANSMISSION LOSS DUE TO TRAVEL THROUGH SOUND ABSORBING MATERIAL

Descriptions		Community, West of Project	Community, South of Project	Community, North of Project
Eliminating distance from noise source to the upper edge of wall (m)	$a=(d^2+g_a^2)^{1/2}$	11.0	11.0	11.0
Eliminating distance from the upper edge of wall to affected receptor (m)	$b=(e^2+g_b^2)^{1/2}$	591.3	804.6	657.6
Eliminating distance from noise source to affected receptor (m)	c	601.3	814.6	667.6
Distance from noise barrier to affected receptor (m)	e	591.3	804.6	657.6
Height of noise barrier (m)	f	5.0	5.0	5.0
Eliminating distance from noise source to wall (m)	d	10.0	10.0	10.0
Height from noise source to the upper edge of wall (m)	g_a=(f-0.5)	4.5	4.5	4.5
Height from affected receptor to the upper edge of wall (m)	g_b=(f-1.5)	3.5	3.5	3.5
Average temperature of atmosphere, Source: A 11-year period climate statistics (Celcius degree)	Tc	28.0	28.0	28.0
Speed of sound (m/sec)	$v = (331.4\ [1+ (Tc / 273.2)]^{1/2})$	348.0	348.0	348.0
Frequency of sound wave (Hz)	F	550.0	550.0	550.0
Sound wavelength (m)	W =(v/F)	0.6	0.6	0.6
Fresnel number	N_0 = 2 (a+b-c)/W	3.1	3.1	3.1
Reduced noise level due to travel through sound absorbing material (dB(A)) (Comparison with graph in **Figure 5.1.2-6**)		14.5	14.5	14.5

As a result, a metal sheet with the thickness of 1.27 mm (Steel 18 ga) or thicker is chosen for the installation of noise barriers in the pile driving area in the west, the south and the north of the project. The transmission loss (TL) is 25 dB(A). The three sides of the wall are approx. 5 m height from the ground. By this, noise level in communities in the west, the south and the north will be reduced as follows:

Noise (Leq 1 hr) from sources travelling through noise barrier to community in the west (village no.2 Map Yang Phon sub-district)

= 56.9-14.5 dB(A)

= 42.4 dB (A)

Noise (Leq 1 hr) from sources travelling through noise barrier to community in the south (village no.5 Map Yang Phon sub-district)

= 54.3-14.5 dB (A)

= 39.8 dB(A)

Noise (Leq 1 hr) from sources travelling through noise barrier to community in the north (village no.2 Map Yang Phon sub-district)

= 56.0-14.5 dB(A)

= 41.5 dB(A)

Noise annoyance level from construction activities in the sensitive receptor near the project area after noise barrier installation will be reduced as follows:

- Community in the west: village no.2 Map Yang Phon sub-district noise annoyance level ranges from 1.8 to 31.2 dB(A).
- Community in the south: village no.5 Map Yang Phon sub-district noise annoyance level ranges from 9.4 to 22.6 dB(A).
- Community in the north: village no.2 Map Yang Phon sub-district noise annoyance level ranges from 0.7 to 18.6 dB(A).

Taking into account the duration of time that noise level is higher than 10 dB(A), the combination of noise from construction activities of the project and the currently measured noise level equals to the currently measured noise level. Therefore, noise level from the project operation will not increasingly affect communities in the west, the south and the north. Details are given in **Table 5.1.2-9** to **Table 5.1.2-11.**

- **Conclusion of forecast noise impacts during construction phase**

Forecast result of impacts on construction workers and staff at the construction site: Noise level from construction activities is 89.0 dB(A). Combined with the maximum Leq 8 hr measured at the current construction site (51.0 dB(A)), it will be 89.0 dB(A). This noise level meets the standard of ministerial regulation of Ministry of Labour, B.E.2549 on establishment of standard for management of safety, occupational health and work environment relating to heat, light and noise. The standard determines that an average noise level for 8 consecutive working hours shall not exceed 90 dB(A). Therefore, noise impact on construction workers or staff at the construction site is at a low level (Negative impact level = 1).

TABLE 5.1.2-9
NOISE ANNOYANCE LEVEL FROM PILE DRIVING ACTIVITY AFTER INSTALLATION OF TEMPORARY NOISE BARRIER NEAR COMMUNITY, WEST OF PROJECT (VILLAGE NO. 2 MAP YANG PHON SUB-DISTRICT)

Duration of Time	Leq 1 hr[1/]	L_{90}[1/]	Noise Level from Pile Driving Activity	Total Noise Level	Difference of Noise Level	Noise Level Adjustment Value	Value Added from Impulsive Noise	Noise Annoyance Level during Construction Phase
February 13th, 2016								
08:00-09:00	59.9	49.6	42.4	60.0	0.1	7.0	5.0	8.4
09:00-10:00	67.4	43.9	42.4	67.4	0.0	7.0	5.0	21.5
10:00-11:00	65.4	41.5	42.4	65.4	0.0	7.0	5.0	21.9
11:00-12:00	65.6	43.1	42.4	65.6	0.0	7.0	5.0	20.5
13:00-14:00	65.5	35.8	42.4	65.5	0.0	7.0	5.0	27.7
14:00-15:00	58.7	36.4	42.4	58.8	0.1	7.0	5.0	20.4
15:00-16:00	56.0	40.2	42.4	56.2	0.2	7.0	5.0	14.0
16:00-17:00	57.2	40.6	42.4	57.3	0.1	7.0	5.0	14.7
February 14th, 2016								
08:00-09:00	69.9	39.6	42.4	69.9	0.0	7.0	5.0	28.3
09:00-10:00	68.0	40.4	42.4	68.0	0.0	7.0	5.0	25.6
10:00-11:00	66.6	38.9	42.4	66.6	0.0	7.0	5.0	25.7
11:00-12:00	64.2	38.4	42.4	64.2	0.0	7.0	5.0	23.8
13:00-14:00	65.2	34.5	42.4	65.2	0.0	7.0	5.0	28.7
14:00-15:00	64.7	41.6	42.4	64.7	0.0	7.0	5.0	21.1
15:00-16:00	66.3	38.6	42.4	66.3	0.0	7.0	5.0	25.7
16:00-17:00	56.8	39.2	42.4	57.0	0.2	7.0	5.0	15.8
February 15th, 2016								
08:00-09:00	66.9	40.9	42.4	66.9	0.0	7.0	5.0	24.0
09:00-10:00	67.5	37.8	42.4	67.5	0.0	7.0	5.0	27.7
10:00-11:00	65.0	38.5	42.4	65.0	0.0	7.0	5.0	24.5
11:00-12:00	67.6	39.8	42.4	67.6	0.0	7.0	5.0	25.8
13:00-14:00	57.7	39.8	42.4	57.8	0.1	7.0	5.0	16.0
14:00-15:00	65.9	62.1	42.4	65.9	0.0	7.0	5.0	1.8
15:00-16:00	62.6	51.4	42.4	62.6	0.0	7.0	5.0	9.2
16:00-17:00	59.2	39.2	42.4	59.3	0.1	7.0	5.0	18.1

TABLE 5.1.2-9
NOISE ANNOYANCE LEVEL FROM PILE DRIVING ACTIVITY AFTER INSTALLATION OF TEMPORARY NOISE BARRIER NEAR COMMUNITY, WEST OF PROJECT (VILLAGE NO. 2 MAP YANG PHON SUB-DISTRICT) (CONT'D)

Duration of Time	Leq 1 hr[1/]	L_{90}[1/]	Noise Level from Pile Driving Activity	Total Noise Level	Difference of Noise Level	Noise Level Adjustment Value	Value Added from Impulsive Noise	Noise Annoyance Level during Construction Phase
February 16th, 2016								
08:00-09:00	65.5	42.1	42.4	65.5	0.0	7.0	5.0	<u>21.4</u>
09:00-10:00	63.2	39.8	42.4	63.2	0.0	7.0	5.0	<u>21.4</u>
10:00-11:00	64.0	40.6	42.4	64.0	0.0	7.0	5.0	<u>21.4</u>
11:00-12:00	64.1	39.3	42.4	64.1	0.0	7.0	5.0	<u>22.8</u>
13:00-14:00	58.5	36.1	42.4	58.6	0.1	7.0	5.0	<u>20.5</u>
14:00-15:00	59.0	36.6	42.4	59.1	0.1	7.0	5.0	<u>20.5</u>
15:00-16:00	57.5	38.7	42.4	57.6	0.1	7.0	5.0	<u>16.9</u>
16:00-17:00	54.4	39.2	42.4	54.7	0.3	7.0	5.0	<u>13.5</u>
February 17th, 2016								
08:00-09:00	66.5	46.6	42.4	66.5	0.0	7.0	5.0	<u>17.9</u>
09:00-10:00	68.0	39.8	42.4	68.0	0.0	7.0	5.0	<u>26.2</u>
10:00-11:00	68.4	35.2	42.4	68.4	0.0	7.0	5.0	<u>31.2</u>
11:00-12:00	66.1	37.5	42.4	66.1	0.0	7.0	5.0	<u>26.6</u>
13:00-14:00	60.3	36.4	42.4	60.4	0.1	7.0	5.0	<u>22.0</u>
14:00-15:00	56.4	31.7	42.4	56.6	0.2	7.0	5.0	<u>22.9</u>
15:00-16:00	56.1	42.7	42.4	56.3	0.2	7.0	5.0	<u>11.6</u>
16:00-17:00	55.0	37.3	42.4	55.2	0.2	7.0	5.0	<u>15.9</u>
Standard value								**10.0[2/]**

Remarks: 1/ Measurement results of the Leq 1 hr and L_{90} during 08.00-17.00 hr. in the community, west of the project, at Village no. 2 Map Yang Phon sub-district during 13th-18th February, 2016 from the field survey by Team Consulting Engineering and Management Co., Ltd., 2016

2/ The standard in accordance with the Announcement of the National Environment Board, No. 29 (B.E. 2550) on determination of noise level.

The underlined figure means the noise level is higher than the standard.

TABLE 5.1.2-10
NOISE ANNOYANCE LEVEL FROM PILE DRIVING ACTIVITY AFTER INSTALLATION OF TEMPORARY NOISE BARRIER NEAR COMMUNITY, SOUTH OF PROJECT (VILLAGE NO. 5 MAP YANG PHON SUB-DISTRICT)

Duration of Time	Leq 1 hr1/	L_{90}1/	Noise Level from Pile Driving Activity	Total Noise Level	Difference of Noise Level	Noise Level Adjustment Value	Value Added from Impulsive Noise	Noise Annoyance Level during Construction Phase
February 13th, 2016								
08:00-09:00	67.6	45.5	39.8	67.6	0.0	7.0	5.0	20.1
09:00-10:00	65.0	44.0	39.8	65.0	0.0	7.0	5.0	19.0
10:00-11:00	67.1	46.6	39.8	67.1	0.0	7.0	5.0	18.5
11:00-12:00	65.7	41.5	39.8	65.7	0.0	7.0	5.0	22.2
13:00-14:00	65.7	43.2	39.8	65.7	0.0	7.0	5.0	20.5
14:00-15:00	65.2	45.6	39.8	65.2	0.0	7.0	5.0	17.6
15:00-16:00	67.1	48.0	39.8	67.1	0.0	7.0	5.0	17.1
16:00-17:00	65.7	47.9	39.8	65.7	0.0	7.0	5.0	15.8
February 14th, 2016								
08:00-09:00	68.5	50.1	39.8	68.5	0.0	7.0	5.0	16.4
09:00-10:00	66.7	47.4	39.8	66.7	0.0	7.0	5.0	17.3
10:00-11:00	66.8	45.4	39.8	66.8	0.0	7.0	5.0	19.4
11:00-12:00	67.3	42.7	39.8	67.3	0.0	7.0	5.0	22.6
13:00-14:00	65.9	44.0	39.8	65.9	0.0	7.0	5.0	19.9
14:00-15:00	66.8	45.2	39.8	66.8	0.0	7.0	5.0	19.6
15:00-16:00	67.1	45.9	39.8	67.1	0.0	7.0	5.0	19.2
16:00-17:00	66.6	45.9	39.8	66.6	0.0	7.0	5.0	18.7
February 15th, 2016								
08:00-09:00	68.2	50.2	39.8	68.2	0.0	7.0	5.0	16.0
09:00-10:00	68.8	48.3	39.8	68.8	0.0	7.0	5.0	18.5
10:00-11:00	66.4	46.8	39.8	66.4	0.0	7.0	5.0	17.6
11:00-12:00	67.5	43.7	39.8	67.5	0.0	7.0	5.0	21.8
13:00-14:00	66.0	46.2	39.8	66.0	0.0	7.0	5.0	17.8
14:00-15:00	69.7	58.3	39.8	69.7	0.0	7.0	5.0	9.4
15:00-16:00	67.9	51.9	39.8	67.9	0.0	7.0	5.0	14.0
16:00-17:00	68.7	48.1	39.8	68.7	0.0	7.0	5.0	18.6

TABLE 5.1.2-10
NOISE ANNOYANCE LEVEL FROM PILE DRIVING ACTIVITY AFTER INSTALLATION OF TEMPORARY NOISE BARRIER NEAR COMMUNITY, SOUTH OF PROJECT (VILLAGE NO. 5 MAP YANG PHON SUB-DISTRICT) (CONT'D)

Duration of Time	Leq 1 hr 1/	L_{90} 1/	Noise Level from Pile Driving Activity	Total Noise Level	Difference of Noise Level	Noise Level Adjustment Value	Value Added from Impulsive Noise	Noise Annoyance Level during Construction Phase
February 16th, 2016								
08:00-09:00	69.4	50.6	39.8	69.4	0.0	7.0	5.0	16.8
09:00-10:00	68.2	49.8	39.8	68.2	0.0	7.0	5.0	16.4
10:00-11:00	66.8	48.1	39.8	66.8	0.0	7.0	5.0	16.7
11:00-12:00	67.3	48.2	39.8	67.3	0.0	7.0	5.0	17.1
13:00-14:00	65.7	44.8	39.8	65.7	0.0	7.0	5.0	18.9
14:00-15:00	65.7	45.9	39.8	65.7	0.0	7.0	5.0	17.8
15:00-16:00	65.5	45.2	39.8	65.5	0.0	7.0	5.0	18.3
16:00-17:00	67.6	48.2	39.8	67.6	0.0	7.0	5.0	17.4
February 17th, 2016								
08:00-09:00	69.1	50.6	39.8	69.1	0.0	7.0	5.0	16.5
09:00-10:00	67.8	46.4	39.8	67.8	0.0	7.0	5.0	19.4
10:00-11:00	67.8	45.7	39.8	67.8	0.0	7.0	5.0	20.1
11:00-12:00	66.0	43.5	39.8	66.0	0.0	7.0	5.0	20.5
13:00-14:00	67.1	45.0	39.8	67.1	0.0	7.0	5.0	20.1
14:00-15:00	66.6	45.1	39.8	66.6	0.0	7.0	5.0	19.5
15:00-16:00	68.2	48.0	39.8	68.2	0.0	7.0	5.0	18.2
16:00-17:00	66.4	48.2	39.8	66.4	0.0	7.0	5.0	16.2
Standard value								**10.0 3/**

Remarks : 1/ Measurement results of the Leq 1 hr and L_{90} during 08.00-17.00 hr. in the community, south of the project, at Village no. 5 Map Yang Phon sub-district during 13th-18th February, 2016 from the field survey by Team Consulting Engineering and Management Co., Ltd., 2016

2/ The standard in accordance with the Announcement of the National Environment Board, No. 29 (B.E. 2550) on determination of noise level.

The underlined figure means the noise level is higher than the standard.

TABLE 5.1.2-11

NOISE ANNOYANCE LEVEL FROM PILE DRIVING ACTIVITY AFTER INSTALLATION OF TEMPORARY NOISE BARRIER NEAR COMMUNITY, NORTH OF PROJECT (VILLAGE NO. 2 MAP YANG PHON SUB-DISTRICT)

Duration of Time	Leq 1 hr[1/]	L_{90}[1/]	Noise Level from Pile Driving Activity	Total Noise Level	Difference of Noise Level	Noise Level Adjustment Value	Value Added from Impulsive Noise	Noise Annoyance Level during Construction Phase
February 13th, 2016								
08:00-09:00	50.5	36.4	41.5	51.0	0.5	7.0	5.0	12.6
09:00-10:00	49.9	34.1	41.5	50.5	0.6	7.0	5.0	14.4
10:00-11:00	49.4	35.7	41.5	50.1	0.7	7.0	5.0	12.4
11:00-12:00	56.6	36.1	41.5	56.7	0.1	7.0	5.0	18.6
13:00-14:00	47.3	35.2	41.5	48.3	1.0	7.0	5.0	11.1
14:00-15:00	51.5	39.7	41.5	51.9	0.4	7.0	5.0	10.2
15:00-16:00	49.3	40.4	41.5	50.0	0.7	7.0	5.0	7.6
16:00-17:00	55.8	44.7	41.5	56.0	0.2	7.0	5.0	9.3
February 14th, 2016								
08:00-09:00	52.5	37.4	41.5	52.8	0.3	7.0	5.0	13.4
09:00-10:00	51.1	35.3	41.5	51.6	0.5	7.0	5.0	14.3
10:00-11:00	52.1	34.7	41.5	52.5	0.4	7.0	5.0	15.8
11:00-12:00	49.1	31.4	41.5	49.8	0.7	7.0	5.0	16.4
13:00-14:00	49.0	33.5	41.5	49.7	0.7	7.0	5.0	14.2
14:00-15:00	49.7	37.2	41.5	50.3	0.6	7.0	5.0	11.1
15:00-16:00	49.9	36.4	41.5	50.5	0.6	7.0	5.0	12.1
16:00-17:00	52.1	37.0	41.5	52.5	0.4	7.0	5.0	13.5
February 15th, 2016								
08:00-09:00	50.9	36.9	41.5	51.4	0.5	7.0	5.0	12.5
09:00-10:00	48.0	35.8	41.5	48.9	0.9	7.0	5.0	11.1
10:00-11:00	51.9	33.7	41.5	52.3	0.4	7.0	5.0	16.6
11:00-12:00	51.1	34.6	41.5	51.6	0.5	7.0	5.0	15.0
13:00-14:00	52.5	41.6	41.5	52.8	0.3	7.0	5.0	9.2
14:00-15:00	62.0	59.3	41.5	62.0	0.0	7.0	5.0	0.7
15:00-16:00	55.0	42.7	41.5	55.2	0.2	7.0	5.0	10.5
16:00-17:00	52.0	39.0	41.5	52.4	0.4	7.0	5.0	11.4

TABLE 5.1.2-11
NOISE ANNOYANCE LEVEL FROM PILE DRIVING ACTIVITY AFTER INSTALLATION OF TEMPORARY NOISE BARRIER NEAR COMMUNITY, NORTH OF PROJECT (VILLAGE NO. 2 MAP YANG PHON SUB-DISTRICT) (CONT'D)

Duration of Time	Leq 1 hr 1/	L_{90} 1/	Noise Level from Pile Driving Activity	Total Noise Level	Difference of Noise Level	Noise Level Adjustment Value	Value Added from Impulsive Noise	Noise Annoyance Level during Construction Phase
February 16th, 2016								
08:00-09:00	54.4	40.6	41.5	54.6	0.2	7.0	5.0	12.0
09:00-10:00	50.4	40.9	41.5	50.9	0.5	7.0	5.0	8.0
10:00-11:00	59.1	41.0	41.5	59.2	0.1	7.0	5.0	16.2
11:00-12:00	51.7	38.4	41.5	52.1	0.4	7.0	5.0	11.7
13:00-14:00	52.4	35.9	41.5	52.7	0.3	7.0	5.0	14.8
14:00-15:00	52.5	35.3	41.5	52.8	0.3	7.0	5.0	15.5
15:00-16:00	50.5	37.5	41.5	51.0	0.5	7.0	5.0	11.5
16:00-17:00	55.1	39.7	41.5	55.3	0.2	7.0	5.0	13.6
February 17th, 2016								
08:00-09:00	52.9	37.8	41.5	53.2	0.3	7.0	5.0	13.4
09:00-10:00	51.6	35.6	41.5	52.0	0.4	7.0	5.0	14.4
10:00-11:00	52.2	37.0	41.5	52.6	0.4	7.0	5.0	13.6
11:00-12:00	53.3	36.7	41.5	53.6	0.3	7.0	5.0	14.9
13:00-14:00	48.2	34.4	41.5	49.0	0.8	7.0	5.0	12.6
14:00-15:00	50.3	33.7	41.5	50.8	0.5	7.0	5.0	15.1
15:00-16:00	48.7	35.3	41.5	49.5	0.8	7.0	5.0	12.2
16:00-17:00	52.7	37.2	41.5	53.0	0.3	7.0	5.0	13.8
Standard value								**10.0 3/**

Remarks : 1/ Measurement results of the Leq 1 hr and L_{90} during 08.00-17.00 hr. in the community, in the northeast of the project, at Village no. 2 Map Yang Phon sub-district during 13th-18th February, 2016 from the field survey by Team Consulting Engineering and Management Co., Ltd., 2016

2/ The standard in accordance with the Announcement of the National Environment Board, No. 29 (B.E. 2550) on determination of noise level.

The underlined figure means the noise level is higher than the standard.

Forecast result of Leq 24 hr in the three sensitive receptors in community in the west, community in the south and community in the north: Leq 24 hr in the three sensitive receptors do not exceed the standard. However, noise annoyance level at all three sensitive receptors is higher than the standard. Therefore, to forecast noise annoyance impact during the construction phase, the Consultant chooses a metal sheet with the thickness of 1.27 mm (Steel 18 ga) and the transmission loss (TL) of 25 dB(A). Taking into account the material that can be moved easily for noise barrier, ply wood is chosen. The transmission loss (TL) of ply wood is 21 dB(A) (Details are shown in **Table 5.1.2-7**). As ply wood is capable of reducing noise level much less than a metal sheet, a metal sheet of 1.27 mm (Steel 18 ga) with the transmission loss (TL) of 25 dB(A) is chosen to be installed as noise barriers in the pile driving area in the west, the south and the north of the project. Three sides of the wall are about 5 m high from the ground. This makes noise impacts from the project operation on nearby communities acceptable. As a result, noise impact during the construction phase is at a low level (Negative level impact = 1).

Comparison of Noise Level Results and International Standard

The noise level assessment was done only daytime (08.00-17.00 excepted lunch time, 12.00-13.00) because the activities that caused loud noise such as piling will be limited only that period of time. There will be only activities which do not make loud noise, e.g. concrete casting that allowed to do at night time. Maximum Leq 24-hour of existing and construction activities noise at sensitive receptors were in accordance with the National standard. As the preventive and mitigation measures, Temporary noise barriers shall be installed in the west, the south and the north of the project where pile driving is undertaken. Metal sheets having the thickness of 1.27 mm (Steel 18 ga) or thicker will be selected. Optionally, other materials with sound transmission loss (TL) of 25 decibels (A) may be used. Three sides of the barriers are determined to be 5 m high from the ground. Therefore, total noise level at sensitive areas after barriers installation will increase in background level less than 3 dB(A) but more than 55 dB(A) in accordance with IFC noise level guidelines, because background noise levels have sometimes exceed the standard as show in **Table 5.1.2-12**.

TABLE 5.1.2-12
NOISE STUDY RESULTS OF CONSTRUCTION PHASE

Noise Sensitive Area	Leq 24 hr		Leq 1 hr (Daytime)*		Leq 1 hr (Nighttime)*		Noise Barrier (m.)	Leq 1 hr (Daytime)*	
	Maximum existing	Maximum existing + activity construction	existing	existing + activity construction	existing	existing + activity construction		Total Noise Level (after installation of noise barriers)[1/]	Total Noise Level (after installation of noise barriers) - existing
1. Community, west of the project (Village no. 2 Map Yang Phon sub-district)	66.3	66.5	54.4-69.9	58.8-70.1	47.8-70.7	No activity	5	54.7-69.9	0-0.3
2. Community, south of the project (Village no. 5 Map Yang Phon sub-district)	66.1	66.2	65-69.7	65.4-69.8	51.3-68.4	No activity	5	65-69.7	0-0
3. Community, north of the project (Village no. 2 Map Yang Phon sub-district)	59.4	59.8	47.3-62	56.5-63	35.9-66.2	No activity	3	48.3-62	0-1
National Standard [1/]	**70**		**-**		**-**		**-**	**-**	**-**
WHO Guideline (Residential; institutional; education)[2/]	**-**		**55**		**45**		**-**	**55**	**<3**

Source: [1/] Standard as prescribed in the National Environment Board's Notification No. 15 re: Prescribing Noise Level Standard, B.E. 2540.

[2/] Guidelines for Community Noise, World Health Organization (WHO), 1999.

(2) Operation Phase

The main noise sources during the operation phase will be power generation activity that the following equipment and machinery are used.

- Gas turbine
- HRSG
- Steam turbine
- Generator
- Machinery of cooling tower
- Water pump for cooling water recirculation
- Water pump that feeds water to steam generation system
- Electrical motor
- Air compressor
- Control valve and pipe system
- Gas compressor
- Transformer cooling fan

As for the project, tools, machinery and equipment that cause low noise level with 85 dB(A) at maximum at the distance of 1 m from the noise source of power generation are selected. This is exceptional for a cooling tower that the maximum noise level from the impact of water on the floor shall not exceed 91.0 dB(A) at the distance of 1 m.

- **Leq 8 hr and Leq 24 hr**

Since tools, machinery and equipment used in the project will generate low noise, staff working in the noisy area shall wear personal protective equipment, i.e. ear muffs and earplugs all the time and working hours in the noisy area of 90 dB(A) shall not exceed 8 hours, impacts on the project staff will be at a low level.

Some machines will be placed in a close building where a metal sheet of 0.64 mm thick (Steel 24 ga) or thicker, with the transmission loss (TL) of 18 dB(A), or a material with the transmission loss (TL) of 18 dB(A) is installed. Details are given in **Table 5.1.2-13**. Therefore, the noise level from a gas turbine, a steam turbine and a generator will reduce to 67 dB(A).

Table 5.1.2-14 shows noise impact on three sensitive receptors, i.e. community in the west, community in the south and community in the north. Taking into account power generation activity which takes up 24 hours and all machines operate concurrently, except a control valve and a safety relief valve, the following equation is applied to calculate the reduction of noise travelling from the noise source to the an affected receptor.

TABLE 5.1.2-13

DISTANCES BETWEEN MACHINERY AND SENSITIVE RECEPTORS

Machinery	Noise Level from Machinery (dB(A))	Distance from Machinery (m)	Distance from Sensitive Receptor and Noise Source (m)			Forecast Noise[1/] dB(A)		
			Community, West of Project	Community, South of Project	Community, North of Project	Community, West of Project	Community, South of Project	Community, North of Project
1. CT Blow down Transfer Pump	85	1.0	784.6	1,135.0	611.5	27.1	23.9	29.3
2. Cooling Tower # 1	91	1.0	806.1	1,073.5	664.5	32.9	30.4	34.5
3. Cooling Tower # 2	91	1.0	1,002.3	1,057.0	695.0	31.0	30.5	34.2
4. Steam Turbine #1	67[2/]	1.0	737.9	954.9	795.3	9.6	7.4	9.0
5. Steam Turbine #2	67[2/]	1.0	825.7	937.6	795.7	8.7	7.6	9.0
6. Steam Turbine #3	67[2/]	1.0	939.6	927.5	810.9	7.5	7.7	8.8
7. Steam Turbine #4	67[2/]	1.0	1,027.8	929.4	833.3	6.8	7.6	8.6
8. Generator # 1	85	1.0	735.3	936.3	814.4	27.7	25.6	26.8
9. Generator # 2	85	1.0	823.4	918.7	814.9	26.7	25.7	26.8
10. Generator # 3	85	1.0	937.6	908.3	829.6	25.6	25.8	26.6
11. Generator # 4	85	1.0	1,025.9	910.3	910.3	24.8	25.8	25.8
12. Gas Turbine # 1	67[2/]	1.0	733.4	919.1	832.1	9.7	7.7	8.6
13. Gas Turbine # 2	67[2/]	1.0	821.7	901.2	832.5	8.7	7.9	8.6
14. Gas Turbine # 3	67[2/]	1.0	936.1	890.7	847.0	7.6	8.0	8.4
15. Gas Turbine # 4	67[2/]	1.0	1,024.5	892.6	868.5	6.8	8.0	8.2
16. HRSG # 1	85	1.0	730.4	878.0	874.5	27.7	26.1	26.2
17. HRSG # 2	85	1.0	819.0	859.2	875.0	26.7	26.3	26.2
18. HRSG # 3	85	1.0	933.7	848.2	888.7	25.6	26.4	26.0
19. HRSG # 4	85	1.0	1,022.4	850.2	909.2	24.8	26.4	25.8
20. Air Compressor #1	85	1.0	756.7	804.5	943.0	27.4	26.9	25.5

TABLE 5.1.2-13

DISTANCE BETWEEN MACHINERY AND SENSITIVE RECEPTOR (CONT'D)

Machinery	Noise Level from Machinery (dB(A))	Distance from Machinery (m)	Distance from Sensitive Receptor and Noise Source (m)			Forecast Noise[1/] dB(A)		
			Community, West of Project	Community, South of Project	Community, North of Project	Community, West of Project	Community, South of Project	Community, North of Project
21. Air Compressor #2	85	1.0	757.8	787.9	960.1	27.4	27.1	25.4
22 Gas Compressor Station # 1	85	1.0	624.8	842.0	960.3	29.1	26.5	25.4
23. Gas Compressor Station # 2	85	1.0	635.1	837.9	958.8	28.9	26.5	25.4
24. Gas Compressor Station # 3	85	1.0	645.3	834.0	957.4	28.8	26.6	25.4
25. Gas Compressor Station # 4	85	1.0	655.6	830.2	956.1	28.7	26.6	25.4
26. Gas MR Station	85	1.0	466.1	930.2	981.2	31.6	25.6	25.2
Total Noise Level from Noise Source to Sensitive Receptor[3/] (dB(A))						**41.1**	**39.5**	**40.9**
Standard Value[4/] (dB(A))						70		

Remarks: 1/ Formula: $Lp2 = Lp1 - 20 \log (r_2/r_1)$

2/ The machinery are placed in a close building equipped with a metal material having the transmission loss (TL) of dB(A)) (85-18 = 67 dB(A))

3/ Formula: $Lp_{total} = 10\log\left(\sum_{i=1}^{N} 10^{Lpi/10}\right)$

4/ The noise level standard in accordance with the Announcement of the National Environment Board, No. 15 (B.E. 2540)

TABLE 5.1.2-14

FORECAST RESULTS OF NOISE IMPACT ON SENSITIVE RECEPTORS DURING OPERATION PHASE

Noise-Sensitive Receptors	Leq 24 hr (dB(A))		
	Power Generation Activity	Maximum Measurement Values 1/	Total Noise Level
1. Community, the west of the project (Village no.2 Map Yang Phon Sub-District)	41.1	66.3	66.3
2. Community, the south of the project (Village no.5 Map Yang Phon sub-district)	39.5	66.1	66.1
3. Community, the north of the project (Village no.2 Map Yang Phon sub-district)	40.9	59.4	59.5
Standard	70 2/		

Remarks: 1/ Measurement results of the maximum Leq 24 hr during 13th-18th February, 2016 from the field survey by Team Consulting Engineering and Management Co., Ltd., 2016

2/ The standard in accordance with the Announcement of the National Environment Board, No. 15 (B.E. 2540) on determination of noise level in general.

$$Lp_2 = Lp_1 - 20 \log \left(\frac{r_2}{r_1}\right)$$

For example, the noise level of a CT blow down transfer pump in the community, west of the project is calculated as follows:

Lp_1 = Noise level measured at the distance of 1 m from the noise source (85 dB(A))

Lp_2 = Noise level at the sensitive receptor

r_1 = Distance from the noise source that noise level is measured (1 m)

r_2 = Distance from the noise source to the sensitive receptor (in the community, west of the noise source 784.6 m)

Thus, noise level of CT blow down transfer pump in the community, west of the project

$$= 85 - 20 \log \frac{784.6}{1} = 27.1 \text{ dB(A)}$$

Then calculate impacts from the main noise source, which is power generation activity, on the sensitive receptor, together with the current measurement result of noise level, as shown in the following equation.

$$Lp_{total} = 10\log(\sum_{i=1}^{N} 10^{Lpi/10})$$

For example, a total noise level in the community, west of the project is calculated as follows:

$$
\begin{aligned}
Lp_{\text{total in community, the west of project}} &= 10\ \log(10^{(27.1/10)}+10^{(32.9/10)}+10^{(31.0/10)}+10^{(9.6/10)} \\
&\quad +10^{(8.7/10)}+10^{(7.5/10)}+10^{(6.8/10)}+10^{(27.7/10)} \\
&\quad +10^{(26.7/10)}+10^{(25.6/10)}+10^{(24.8/10)}+10^{(9.7/10)} \\
&\quad +10^{(8.7/10)}+10^{(7.6/10)}+10^{(6.8/10)}+10^{(27.7/10)}+10^{(26.7/10)} \\
&\quad +10^{(25.6/10)}+10^{(24.8/10)}+10^{(27.4/10)}+10^{(27.4/10)} \\
&\quad +10^{(29.1/10)}+10^{(28.9/10)}+10^{(28.8/10)}+10^{(28.7/10)} \\
&\quad +10^{(31.6/10)}) \\
&= 41.1\ dB(A)
\end{aligned}
$$

Where the power generation activity takes up 24 hours, noise level from this activity in the community, west of the project is calculated as follows:

$$\text{Leq 1 hr} = 41.1 + 10\log\frac{1}{1} = 41.1\ dB(A)$$

$$\text{Leq 24 hr} = 41.1 + 10\log\frac{24}{24} = 41.1\ dB(A)$$

Considering a total maximum Leq 24 hr from the field survey (maximum Leq 24 hr in communities in the west, the south and the north are 66.3, 66.1 and 59.5 dB(A), respectively as illustrated in **Table 5.1.2-1**), it meets the standard as illustrated in **Table 5.1.2-14.**

- **Noise Annoyance**

The power generation activity which takes up 24 hours will cause noise annoyance impact on people living in the sensitive receptor adjacent to the project. This activity is categorized in Scenarios 1 and 4 according to a noise annoyance measurement manual. The noise measurement manual determines that the Leq 1 hr is the representative of the noise level with disturbance during 06.00-22.00 hr and Leq 5 min is the representative of the noise level with disturbance during 22.00-06.00 hr.

According to measurement results of Leq 5 min and L_{90} from community, in the west (Village no.2 Map Yang Phon sub-district), south (Village no.5 Map Yang Phon Sub-district) and north (Village no.2 Map Yang Phon sub-district) of the project during February 13th-18th, 2016 during daytime (06.01-22.00 hr) and nighttime (22.00-06.00 hr), summary is made below (**Table 1 to Table 3 in Appendix 5B**).

Community, west of the project (Village no.2 Map Yang Phon Sub-district): The forecast result of noise annoyance level based on Leq 1 hr during 06.00-22.00 hr reveals that it will be less than 32.6 dB(A), which is higher than the standard. However, considering the duration of time that the noise is higher than 10 dB(A), a combined noise level from the project activities and the currently measured noise level equals to the currently measured noise level. Therefore, noise level from the project activities will not increasingly affect the community, west of the project. Details are given in **Table 1 in Appendix 5B.**

Community, south of the project (Village no.5 Map Yang Phon Sub-district): The forecast result reveals that the noise annoyance level will be 27.0 dB(A)), which is higher than the standard. However, considering the duration of time that the noise is higher than 10 dB(A), a combined noise level from the project activities and the currently measured noise level equals to the currently measured noise level. Therefore, noise level from the project activities will not increasingly affect the community, south of the project. Details are given in **Table 2 in Appendix 5B.**

Community, north of the project (Village no.2 Map Yang Phon Sub-district): The forecast result reveals that the noise annoyance level will be 27.8 dB(A), which is not noisy and is higher than the standard. However, considering the duration of time that the noise is higher than 10 dB(A), a combined noise level from the project activities and the currently measured noise level equals to the currently measured noise level. Therefore, noise level from the project activities will not increasingly affect the community, north of the project. Details are given in **Table 3 in Appendix 5B.**

- **Summary of noise impact forecast results during the operation phase**

Impact on staff in the project area: Noise level from the power generating machine at the distance of 1 m shall not exceed 85 dB(A). This is exceptional for a cooling tower that the noise level is determined at 91.0 dB(A). The power generating machine is designed to be installed in the building where the sound absorbing material is provided. These noise levels meet the standard of ministerial regulation of Ministry of Labour, B.E.2549 on establishment of standard for management of safety, occupational health and work environment relating to heat, light and noise. The standard determines that an average noise level for 8 consecutive working hours shall not exceed 90 dB(A). Therefore, noise impact on is at a low level (Negative impact level = 1).

Forecast results of Leq 24 hr and noise annoyance during the operation phase in communities in the west, the south and the north of the project: Leq 24 hr meets the standard while noise annoyance is higher than the standard. However, a combined noise level from the project activities and the currently measured noise level equals to the currently measured noise level. This indicates that noise level from the project activities will not increasingly affect the communities. Hence, noise impact during the operation phase is at a low level. (Negative impact level = 1).

Comparison of Noise Level Results and International Standard

Leq 24-hour of maximum existing and operation activities noise at sensitive receptors were in accordance with the National standard. The operation noise was assessed for both daytime and nighttime due to 24-hour electricity production. Leq 24-hour of maximum existing and operation activities noise at sensitive receptors were in accordance with the National standard. The most of total noise level at sensitive areas will increase in background level less than 3 dB(A) but more than 55/45 dB(A) in accordance with IFC noise level guidelines, because background noise level have sometimes exceeded the standard as show in **Table 5.1.2-15**.

Mitigation Measures

(a) Construction Phase

- Noisy construction equipment shall be only used during daytime during 08.00-17.00 hr. If it is necessary to use such construction equipment outside the aforesaid period, permission or approval must be sought from involved agencies. Furthermore, adjacent communities and factories shall be notified 2 weeks in advance.
- Relations campaigns shall be conducted to inform the nearby communities of the planned noise-generating construction activities together with noise control measures at least 2 weeks in advance before construction.
- Regular inspection, maintenance and repair shall be carried out for tools, machinery and equipment to be in good condition at all times and maintenance manuals shall be continuously complied with.
- A warning sign shall be installed in the noisy area. Personal protective equipment, e.g. ear plugs or ear muffs, shall be provided for construction workers in the noisy area where noise level exceeds 85 decibels (A). Furthermore, construction workers shall be instructed to wear personal protective equipment in noisy areas.
- Contractors shall be supervised to strictly adhere to noise mitigation measures. Equipment/ machinery generating low noise level will be used.
- Temporary noise barriers shall be installed in the west, the south and the north of the project where pile driving is undertaken. Metal sheets having the thickness of 1.27 mm (Steel 18 ga) or thicker will be selected. Optionally, other materials with sound transmission loss (TL) of 25 decibels (A) may be used. Three sides of the barriers are determined to be 5 m high from the ground.

TABLE 5.1.2-15

NOISE STUDY RESULTS OF OPERATION PHASE

Noise Sensitive Area	Leq 24 hr		Leq 1 hr (Daytime)			Leq 1 hr (Nighttime)		
	Maximum existing	Maximum existing + operation activity	existing	existing + operation activity	Total Noise Level - existing	existing	existing + operation activity	Total Noise Level - existing
1. Community, the west of the project (Village no.2 Map Yang Phon Sub-District)	66.3	66.3	54.4-69.9	54.6-69.9	0-0.2	47.8-70.7	48.6-70.7	0-0.8
2. Community, the south of the project (Village no.5 Map Yang Phon sub-district)	66.1	66.1	60.5-70.7	60.5-70.7	0-0	51.3-68.4	51.6-68.4	0-0.3
3. Community, the north of the project (Village no.2 Map Yang Phon sub-district)	59.4	59.5	47.3-62	48.2-62	0-0.9	35.9-66.2	42.1-66.2	0-6.2*
National Standard 1/	70 1/		-		-	-		-
WHO Guideline (Residential; institutional; education) 2/	-		55		<3	45		<3

Remark : *Most of different noise values are less than 3 decible (A). Only at 04.00-05.00 am on 14-15 February 2016 is exceed standard values.

Source: 1/ Standard as prescribed in the National Environment Board's Notification No. 15 re: Prescribing Noise Level Standard, B.E. 2540.

2/ Guidelines for Community Noise, World Health Organization (WHO), 1999

(b) Operation Phase

- A warning sign shall be installed in the noisy area, such as a combustion chamber of a gas turbine, where noise level exceeds 85 decibels (A). The operator in the noisy area shall be worn or supervised to wear personal protective equipment, e.g. ear plugs or ear muffs.
- The average sound level of noisy machinery and equipment, such as gas turbine, steam turbine and fuel gas compressor or sound absorption material shall not exceed 85 decibels (A) from the distance of 1 m.
- Noisy machinery of Pluak Daeng Power Plant Project shall be installed with a silencer at the end of the pipe that may cause loud noise. Cover structure for machinery shall be built for a combustion chamber of a gas turbine, gas turbine generator, pump motor and the Heat Recovery Steam Generator (HRSG). A cooling unit fan shall cause low noise, etc.
- Noise level at the fence of the project shall not exceed 70 decibels (A).
- A silencer shall always be checked and inspected for its efficiency.
- Noise mapping/noise contour shall be created to determine the noisy area of the project in the first year of service and every 3 years.
- The staff of the power plant shall be trained at least once a year for the understanding and good attitude and the right behavior regarding occupational health and safety at work.
- A Hearing Conservation Program shall be established to prevent staff from being exposed to loud noise for a prolonged period of time. For example, the duration of work shall be determined so that workers will be less exposed to loud noise. Also, alternation of shifts/alternation of working days in the noisy area shall be made. The information shall be updated at least once a year.

5.1.3 Surface Water Hydrology

(1) Construction Phase

During the construction phase, wastewater sources will be bathrooms and toilets of construction workers. Wastewater will be treated by a septic tank or a prefabricated wastewater treatment system, installed at the project office. The effluent will be released into an inspection pond (capable of holding water for at least 1 day) to ensure that the effluent from the project meets the effluent quality standards of Building Type C according to the Notification of the Ministry of Natural Resources and Environment on Establishment of Building Effluents Standards for some Building Types and Sizes before discharging outside. The effluent quality will be checked once a month. During the construction phase, there will be approx. 3,200 construction workers and staff who use 224 m^3/day of water, or 70 l/person/day. Wastewater volume will be 179.2 m^3/day, or 80% of water use (Thongchai Phansawat, 1987). Contractors shall provide bathrooms and toilets for construction workers and construction supervision staff (15 persons per 1 bathroom/toilet (Source: Ministerial Regulation, No.63 (B.E.2551) issued by virtue of the Building Control act, B.E. 2552). As for water discharge from the hydrostatic test each time, it will be about 250 m^3. After the test is completed, the characteristics of hydrostatic test water discharges will be checked: pH, temperature, total suspended solids, oil and grease for compliance with the standards of Pluak Daeng Industrial Park. After that it will be conveyed to the central wastewater treatment system of the Industrial Park. Therefore, the project construction will affect surface water hydrology at a low level (Negative impact level = 1).

(2) Operation Phase

During the operation phase, wastewater includes effluent from the cooling tower and wastewater from power generation process. The project provides the cooling water holding pond to inspect the effluent before draining into the cooling water holding pond of Pluak Daeng Industrial Park. Wastewater from power generation process and others will be treated in accordance with the requirements of Pluak Daeng Industrial Park before draining into the central wastewater treatment system of Pluak Daeng Industrial Park. As a result, it will not cause trouble to water bodies around the project area and the hydrological impact is expected at a low level (Negative impact level = 1).

5.1.4 Surface Water Quality

(1) Construction Phase

Wastewater generated during the construction phase of the project will be about 234.2 m^3/day, which consists of (1) 55 m3/day of uncontaminated wastewater from construction activities collected and conveyed to the wastewater pond for inspection for compliance with the requirements of Pluak Daeng Industrial Park before discharging into the central wastewater treatment system of the Industrial Park; (2) 179.2 m^3/day of wastewater from utilization and consumption of construction workers which will be collected and conveyed to a septic tank or the prefabricated waste water treatment system for standard treatment; (3) 250 m^3 of water discharges from the hydrostatic test of natural gas pipeline and fuel pipeline (do not occur every day but only when the hydrostatic test is performed and this test is performed 1 time). As for rainfall within the project area, it will be collected in the storm drains and conveyed to a temporary sedimentation pond. The temporary sedimentation pond will store and allow sedimentation of rainfall within the project area. Settleable solids will be separated from rainfall. Clear water will be used to spray the project area to reduce the diffusion of dust. The remaining water will be drained into the storm drains of Pluak Daeng Industrial Park. As a result, it will not affect water quality in the areas nearby the project (No impact).

(2) Operational Phase

(a) Wastewater from power generation process

Wastewater from power generation process consists of the effluent from the cooling tower, wastewater from the water treatment plant, wastewater from the laboratory and wastewater from utilization and consumption. As the project is located in Pluak Daeng Industrial Park, wastewater management shall be adhered to environmental impact prevention and mitigation measures of Pluak Daeng Industrial Park. According to Pluak Daeng Industrial park, wastewater shall be separated into 2 parts: (1) wastewater from power generation process, consisting of wastewater from the water treatment system, wastewater from the laboratory and sanitary wastewater. After being treated, the wastewater will be conveyed to the central wastewater treatment system of Pluak Daeng Industrial Park and (2) the effluent from the cooling tower from the cooling water system of the power plant, which will be held in the cooling water holding pond and carried to the cooling water holding pond of Pluak Daeng Industrial Park. The effluent from these 2 parts will be drained into Huai Phu Sai. Huai Phu Sai converges into Khlong Lek and Huai Wang Krarok before flowing into Dok Krai Reservoir. Pluak Daeng Industrial Park will not release the effluent from the central wastewater treatment system in the dry season. Therefore, the evaluation of impact on water quality is divided into 2 parts.

- **Effluent from cooling tower**

The effluent from the cooling tower is slightly dirty. The effluent temperature is about 34 degree Celcius. It also contains total dissolved solids (TDS) generated from a chemical substance used for water treatment. The chemical substance does not have high concentration and it is the general chemical substance for water treatment.

As Pluak Daeng Power Plant Project is located in Pluak Daeng Industrial Park, it shall adhere to environmental impact prevention and mitigation measures regarding surface water quality. According to EIA report of Pluak Daeng Industrial Park Project (First Extension Phase), after being treated, the effluent will be released into Huai Phu Sai in the dry season (November-April). (**Appendix 2B**).

- Pluak Daeng Industrial Park shall not release the effluent from the central wastewater treatment into Huai Phu Sai.
- Effluent quality from the cooling water holding pond of the power plant's cooling tower shall be controlled as follows:
  - BOD shall not exceed 15 mg/l
  - Dissolved oxygen shall be 4 mg/l at minimum.
  - TDS shall not exceed 1,300 mg/l

Additionally, wastewater management measures for Independent Power Producer (IPP) shall be applied. The effluent from the cooling tower shall meet the Notification of Ministry of Industry, No.2 (B.E.2539) on determination quality of wastewater discharged from factories.

Hence, the management of wastewater from power generation process of the power plant shall comply with the measures of Pluak Daeng Industrial Park. Wastewater from the power plant shall be divided into 2 groups.

(1) Wastewater from power generation process: It comprises wastewater from the water treatment system, wastewater from the laboratory and sanitary wastewater. After receiving treatment and quality inspection, **it shall be conveyed to the central wastewater treatment system of Pluak Daeng Industrial Park.**

(2) Effluent from the cooling system of the power plant: After being stored in the cooling water holding pond of the project and receiving quality inspection for compliance with the Notification of Ministry of Industry, No.2 (B.E.2539) on determination quality of wastewater discharged from factories, **It shall be carried to the cooling water holding pond of Pluak Daeng Industrial Park.**

These 2 groups of effluent will be released to Huai Phu Sai (Effluent from the central wastewater treatment system shall not be discharged in the dry season.) by Pluak Daeng Industrial Park. Huai Phu Sai converges into Khlong Lek and Huai Wang Krarok prior to flowing into Dok Krai Reservoir. A comparison diagram of the effluent temperature of the project and effluent from Pluak Daeng Industrial Park and Huai Phu Sai is shown in **Figure 5.1.4-1.**

Based on the analysis report of impacts from BOD and TDS in the effluent from the power plant project in Pluak Daeng Industrial Park (December 2015), as shown in **Appendix 4F-1**, on water quality of Huai Phu Sai and Dok Krai Reservoir, the impacts will be at a low level.

1) Scoping study of impacts from effluent from cooling tower

⇨ The study of impacts from BOD and TDS in the effluent from the cooling tower of the project on Huai Phu Sai and Dok Krai Reservoir compared with existing conditions (without the project) both in the rainy and the dry season

⇨ The study of impact from SAR in the effluent from the cooling tower of the project on Huai Phu Sai and Dok Krai Reservoir

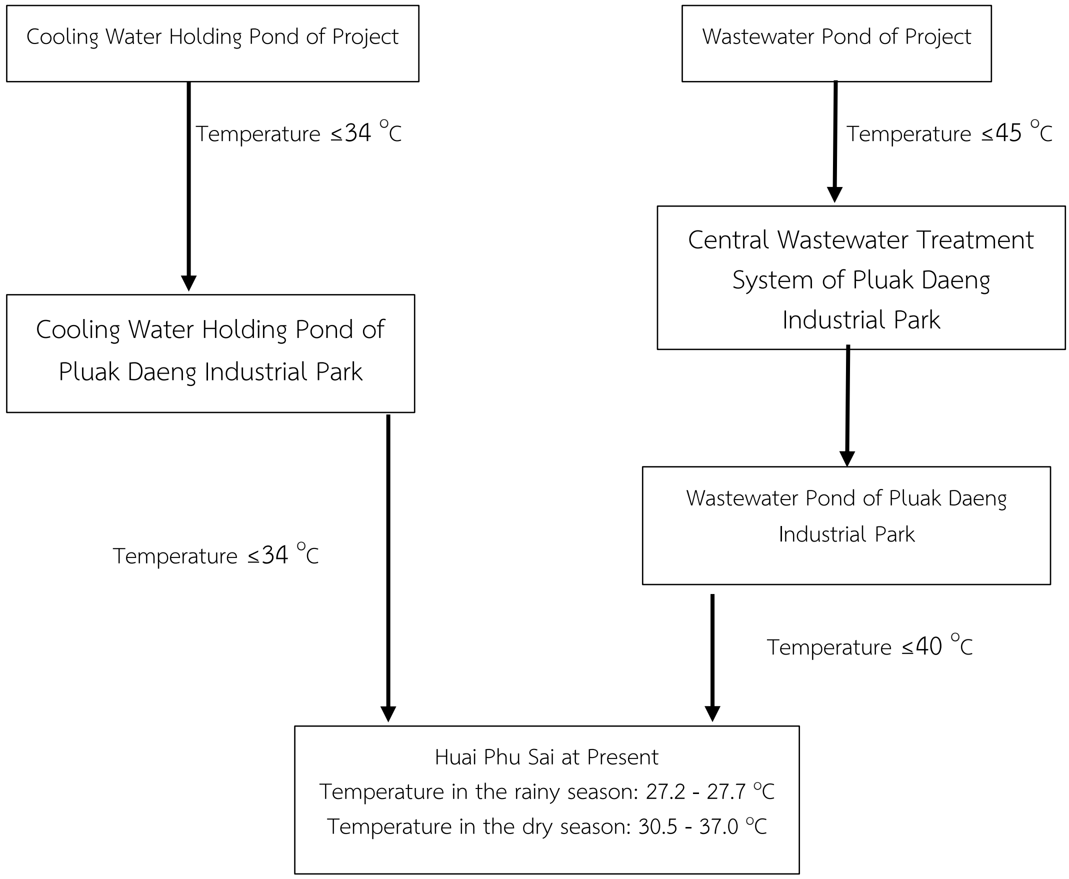


FIGURE 5.1.4-1 : COMPARISON DIAGRAM OF EFFLUENT FROM PROJECT AND EFFLUENTS FROM PLUAK DAENG INDUSTRIAL PARK AND HUAI PHU SAI

⇨ Monitoring stations for the analysis of BOD and TDS impacts are as follows:

- Station 1: Huai Phu Sai, about 4 km upstream of the project
- Station 2: Huai Phu Sai in front of the project location
- Station 3: Huai Phu Sai, about 3 km downstream of the project location
- Station 4: Dok Krai Reservoir, about 1 km from the entrance of Huai Phu Sai
- Station 5: Dok Krai Reservoir, about 2 km from the entrance of Huai Phu Sai

2) Source of data

The data of pH, electrical conductivity, BOD, DO, TDS, Na, Ca, Mg, in Huai Phu Sai and Dok Krai Reservoir and the discharge rate of Pluak Daeng Industrial Park in the rainy season are obtained from the analysis of impacts from BOD and TDS in the effluent of the power plant project in Pluak Daeng Industrial Park (December, 2015) (as shown in **Appendix 4F-1**)

3) Criteria for analysis of impacts from BOD and TDS in the effluent

Criteria for analysis of impacts from potential BOD and TDS in the effluent on surface water quality are as follows:

⇨ Effluent from cooling system: The overall analysis is made: The effluent from the cooling system of the project is released from Pluak Daeng Industrial Park into Huai Phu Sai and Dok Krai Reservoir.

- The maximum effluent rate of the project is 12,232 m^3/day or 0.142 m^3/sec (natural gas as fuel scenario: 100% Load).

⇨ The maximum effluent rate of Pluak Daeng Industrial Park which excludes the one from the project is 1,111 m^3/day, or 0.013 m^3/sec. The discharge shall be done in the rainy season only (May-October).

⇨ The flow rate of Huai Phu Sai in each season was as follows:

- The average flow rate in the rainy season was 3.52 m^3/sec. (Measurements in the rainy season: August 12th-16th, 2015).

- The average flow rate in the dry season was 0.58 m^3/sec. (Measurements in the dry season: April 14th-16th, 2015).

⇨ Water quality parameters: TDS (total dissolved solids) and BOD in the effluent were used for the analysis of impacts on surface water quality.

⇨ Analysis of impacts: Considerations were made for the following issues.

- TDS: The analysis was made for water quality, and utilization of water bodies, such as utilization and consumption, cultivation, etc.

- BOD: The analysis was made for surface water quality in terms of classification of water bodies and utilization of water bodies

- TDS and BOD: Results of analysis were further analyzed for continuous impacts on aquatic ecology, fisheries and water animal production.

4) Water quality of Huai Phu Sai and Dok Krai Reservoir

Based on the analysis of impacts from BOD and TDS in the effluent from the power plant project in Pluak Daeng Industrial Park, measurement of water quality in Huai Phu Sai and Dok Krai Reservoir was made on August 3rd, 2015 (the rainy season). The measurement result was compared with the one for Dok Krai Reservoir at Dok Krai pumping station of Eastern Water Resources Development and Management PLC. from January to April 2016 (the dry season) (Water quality measurement results of Eastern Water Resources Development and Management PLC. are included in Attachment 2 in **Appendix 4F-1**). It was found that TDS and BOD in the rainy season are likely to be higher than the ones in the dry season. Therefore, measurement results in the rainy season were used for the analysis of impacts in the rainy and the dry seasons. In the worst case scenario, the levels of pH, DO and BOD in Huai Phu Sai and Dok Krai Reservoir are as follows:

⇨ <u>Huai Phu Sai</u>

1) *Upstream of the project*
   - pH = 6.2
   - Electrical Conductivity = 132 μS/cm
   - TDS = 114 mg/l
   - DO = 7.4 mg/l
   - BOD = 1.7 mg/l
2) *In front of the project location*
   - pH = 6.0
   - Electrical Conductivity = 280 μS/cm
   - TDS = 236 mg/l
   - DO = 7.2 mg/l
   - BOD = 2.2 mg/l
3) *About 3 km downstream of the project*
   - pH = 6.0
   - Electrical Conductivity = 298 μS/cm
   - TDS = 202 mg/l
   - DO = 8.8 mg/l
   - BOD = 3.0 mg/l

⇨ <u>Dok Krai Reservoir</u>

1) *In Dok Krai Reservoir, about 1 km from the entrance of Huai Phu Sai*
   - pH = 6.1
   - Electrical Conductivity = 301 μS/cm
   - TDS = 202 mg/l

- DO = 8.9 mg/l
- BOD = 3.1 mg/l

2) *In Dok Krai Reservoir, about 2 km from the entrance of Huai Phu Sai*
   - pH = 6.1
   - Electrical Conductivity = 293 μS/cm
   - TDS = 194 mg/l
   - DO = 8.8 mg/l
   - BOD = 3.3 mg/l

Water quality measurements from 5 monitoring stations yield the following results.

- The electrical conductivity in Huai Phu Sai was less than the one in Dok Krai Reservoir and the electrical conductivity in Huai Phu Sai, downstream from the project location, was higher than the one in front of the project location. However, TDS in Huai Phu Sai, downstream from the project location is less than that in front of the project location. This is because TDS in front of Pluak Daeng Power Plant Project may consist of biodegradable organic material with low electrical conductivity and dark brown water. However, clear yellow water was found in other areas. Chemical fertilizer was applied in the agriculture area, downstream of the project. Also, high-density communities, were found along the stream and near the golf courses.

- BOD in Huai Phu Sai, upstream of the project location, was less than 2 mg/l It is categorized as the surface water source, Class 3 according to the announcement of the National Environment Board, No.8, B.E.2537. That is to say, it is the water source for utilization and consumption, that needs conventional water treatment, and for agricultural purpose. In Huai Phu Sai, from the front of the project location to Dok Krai Reservoir, BOD was higher than 2 mg/l It is likely that at the downstream of the location of Pluak Daeng Power Plant Project and in Dok Krai Reservoir, BOD was higher than the one in front of the location of Pluak Daeng Power Plant Project. This means water bodies may be affected by wastewater from communities, agriculture area and golf courses around the downstream of Huai Phu Sai and Dok Krai Reservoir. Nonetheless, measurement results reveal that DO at all monitoring stations was higher than 4 mg/l according to Surface Water Quality Standards, Class 3. In Huai Phu Sai, in front of the project location, DO was 7.2 mg/l and at the downstream of the project location, DO was 8.8 mg/l In addition to this, DO at monitoring stations in Dok Krai Reservoir was 8.8 mg/l and 8.9 mg/l, respectively. It indicates unpolluted water with no unpleasant smell. This is in line with the view of people living near Huai Phu Sai and those who fish at Dok Krai Reservoir and stated that the water had not been polluted or stinking.

The above measurement results of BOD and DO indicate that Huai Phu Sai, upstream of the project location, is classified as surface water source, Class 3, i.e. surface water source for agricultural purpose. However, downstream from the project location and in the reservoir, DO met the criteria for surface water source, Class 3 while BOD met the criteria for surface water source, Class 4, i.e. surface water source for utilization and consumption, which needs special water treatment (such as additional chlorine) and for industrial use.

5) Quality of effluent from Pluak Daeng Industrial Park

According to environmental impact prevention and mitigation measures of Pluak Daeng Industrial Park, the discharge rate and quality of effluent are as follows:

- ⇨ The discharge rate equals to 0.013 m^3/sec The discharge shall be done in the rainy season only, from May to October.
- ⇨ BOD shall not exceed 15 mg/l
- ⇨ TDS shall not exceed 3,000 mg/l and DO should larger than 2 mg/l

6) Quality of effluent discharged from the project

The effluent from the cooling system of the project: TDS shall not exceed 1,300 mg/l, BOD shall not exceed 2 mg/l (Water use treatment shall be similar to portable water with DO of about 4 mg/l)

7) Analysis of surface water quality from BOD and TDS in the effluent released from the cooling tower into Huai Phu Sai (through drainage from Pluak Daeng Industrial Park).

Calculation for the combination of BOD and TDS with effluent

$$C \quad Total = \frac{C_1Q_1+C_2Q_2+C_3Q_3}{Q_1+Q_2+Q_3}$$

C = Concentration of BOD or TDS in Huai Phu Sai after the effluent combines with water in Huai Phu Sai

C_1 = BOD or TDS of water in Huai Phu Sai before combining with the effluent

C_2 = BOD or TDS of the effluent from Pluak Daeng Industrial Park

C_3 = BOD or TDS of the effluent from the project

Q_1 = Flow rate in Huai Phu Sai before combining with th effluent

Q_2 = Flow rate of the effluent from Pluak Daeng Industrial Park

Q_3 = Flow rate of the effluent from the project

<u>Total Q in Huai Phu Sai</u>

Total Q in the dry season = $Q_1 + Q_2 + Q_3$

= 0.58 + 0 + 0.142

= 0.722 m^3/sec

Total Q in the rainy season = 3.52 + 0.013 + 0.142

= 3.68 m^3/sec

In the dry season (November-April, totaling 6 months): No drainage of effluent from Pluak Daeng Industrial Park. $Q_2 = 0$.

<u>Total BOD in Huai Phu Sai in front of the project location</u>

Total BOD in the dry season = $\frac{(0.58\times2.2)+(0\times15)+(0.142\times2)}{0.722}$

= 2.16 mg/l

Total BOD in the rainy season= $\frac{(3.52\times2.2)+(0.013\times15)+(0.142\times2)}{3.68}$

= 2.2 mg/l

<u>Total TDS in Huai Phu Sai in front of the project location</u>

Total TDS in the dry season = $\frac{(0.58\times236)+(0\times3{,}000)+(0.142\times1{,}300)}{0.722}$

= 445.26 mg/l

Total TDS in the rainy season = $\frac{(3.52\times236)+(0.013\times3{,}000)+(0.142\times1{,}300)}{3.68}$

= 286.50 mg/l

In the rainy season, the effluent from the cooling system resulted in 2.19 mg/l of BOD and 277.26 mg/l of TDS in Huai Phu Sai. This excluded the effluent from Pluak Daeng Industrial Park.

8) Analysis of BOD and TDS impacts on water quality and utilization of water in Huai Phu Sai for agricultural purpose and water supply

Based on the above calculation, the levels of BOD and TDS in Huai Phu Sai without Pluak Daeng Power Plant Project and with Pluak Daeng Power Plant Project (**Table 5.1.4-1**) are summarized below.

(a.) Considerations of BOD and TDS in the dry season

Without the project and with the project, BOD will exceed 2 mg/l but will not exceed 4 mg/l (2.2 and 2.16 mg/l, respectively). Thus, it is categorized as surface water source, Class 4. As a result, the existence of the project will not affect Huai Phu Sai because it does not change the class of surface water quality. Furthermore, water from Huai Phu Sai is not pumped for water treatment purpose.

Without the project, TDS will equal to 236 mg/l while with the project, TDS will be 445.26 mg/l These levels do not exceed the standard of water use for irrigation (agriculture) for all kinds of plants, which determines TDS in water shall not exceed 450 mg/l Moreover, water pumping for agricultural use in the dry season is minimal. Most of the plants, such as tapioca and rubber trees rely on rainwater. Therefore, in the dry season, the effluent from the project will have the impact on agricultural use at a low level.

TABLE 5.1.4-1

SUMMARY OF BOD AND TDS LEVELS IN HUAI PHU SAI AFTER RECEIVING EFFLUENT FROM PROJECT AND PLUAK DAENG INDUSTRIAL PARK

Seasons and Considerations	BOD (mg/l)	TDS (mg/l)
1. Dry season		
1.1 Without project	2.2	236
1.2 With project	2.16	445.26
2. Rainy season		
2.1 Without project	2.2	236
2.2 With project, including effluent from Pluak Daeng Industrial Park	2.2	286.50
2.3 With project but excluding effluent from Pluak Daeng Industrial Park	2.19	277.26
Surface water quality standards, Class 3	**do not exceed 2**	**According to the standard of water use for irrigation for all kinds of plants, TDS in water shall not exceed 450 mg/l**
Surface water quality standards, Class 4	**do not exceed 4**	

Remarks : In case TDS in water does not exceed 450 mg/l, the water will be suitable for all kinds of plants in all types of soil. However, the maximum standard level of TDS in water is 1,500 mg/l, which can still be used for plants but in a highly permeable soil (Direk Thong A-ram et al., 2002: Design and Plant Watering Technology)

(b.) Considerations of BOD and TDS in the rainy season

Without the project and with the project, BOD (including the effluent from Pluak Daeng Industrial Park) will exceed 2 mg/l but not more than 4 mg/l (not exceeding 2.2 mg/l) Hence, it is categorized as surface water source, Class 4. With the project, excluding of the effluent from Pluak Daeng Industrial park, total BOD in Huai Phu Sai will equal to 2.19 mg/l, which is less polluted than existing condition. The project will not affect Huai Phu Sai since it will not change the class of surface water. Moreover, there will be no water pumping from Huai Phu Sai for water treatment purpose.

Without the project, TDS will be 236 mg/l With the project, including the effluent from Pluak Daeng Industrial Park, TDS will be 286.50 mg/l With the effluent from Pluak Daeng Power Plant only, TDS will be 277.26 mg/l, which is similar to existing condition. These levels do not exceed the standard of water use for irrigation (agriculture) for all kinds of plants, which determines TDS in water shall not exceed 450 mg/l Therefore, in the rainy season, the effluent from the project will have the impact on agricultural use at a low level.

Figure 5.1.4-2 and **Figure 5.1.4-3** show the locations where BOD and TDS impacts on water quality in the dry and the rainy seasons are analyzed.

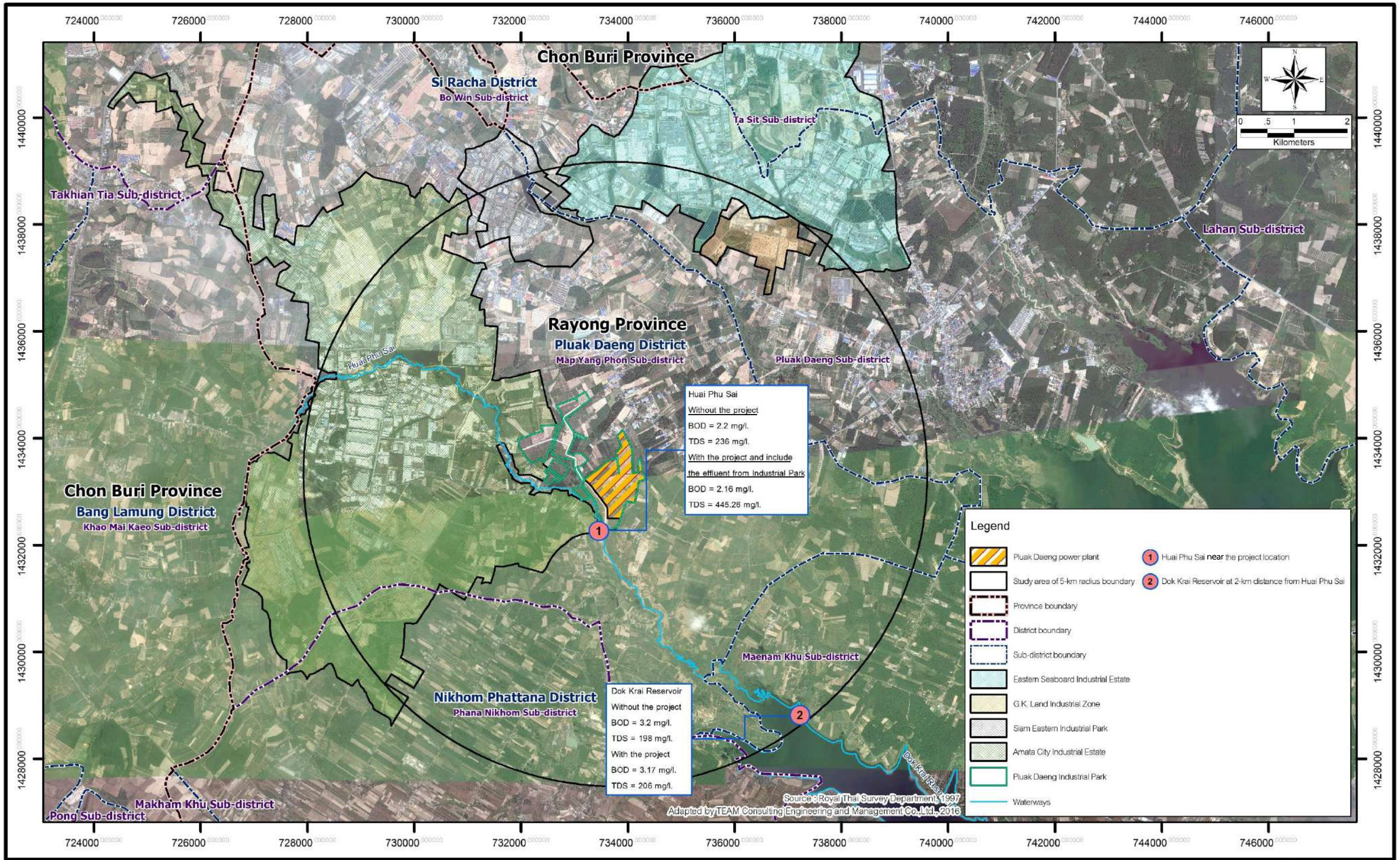


FIGURE 5.1.4-2: MONITORING STATIONS FOR ANALYSIS OF BOD AND TDS IMPACTS ON HUAI PHU SAI IN DRY SEASON

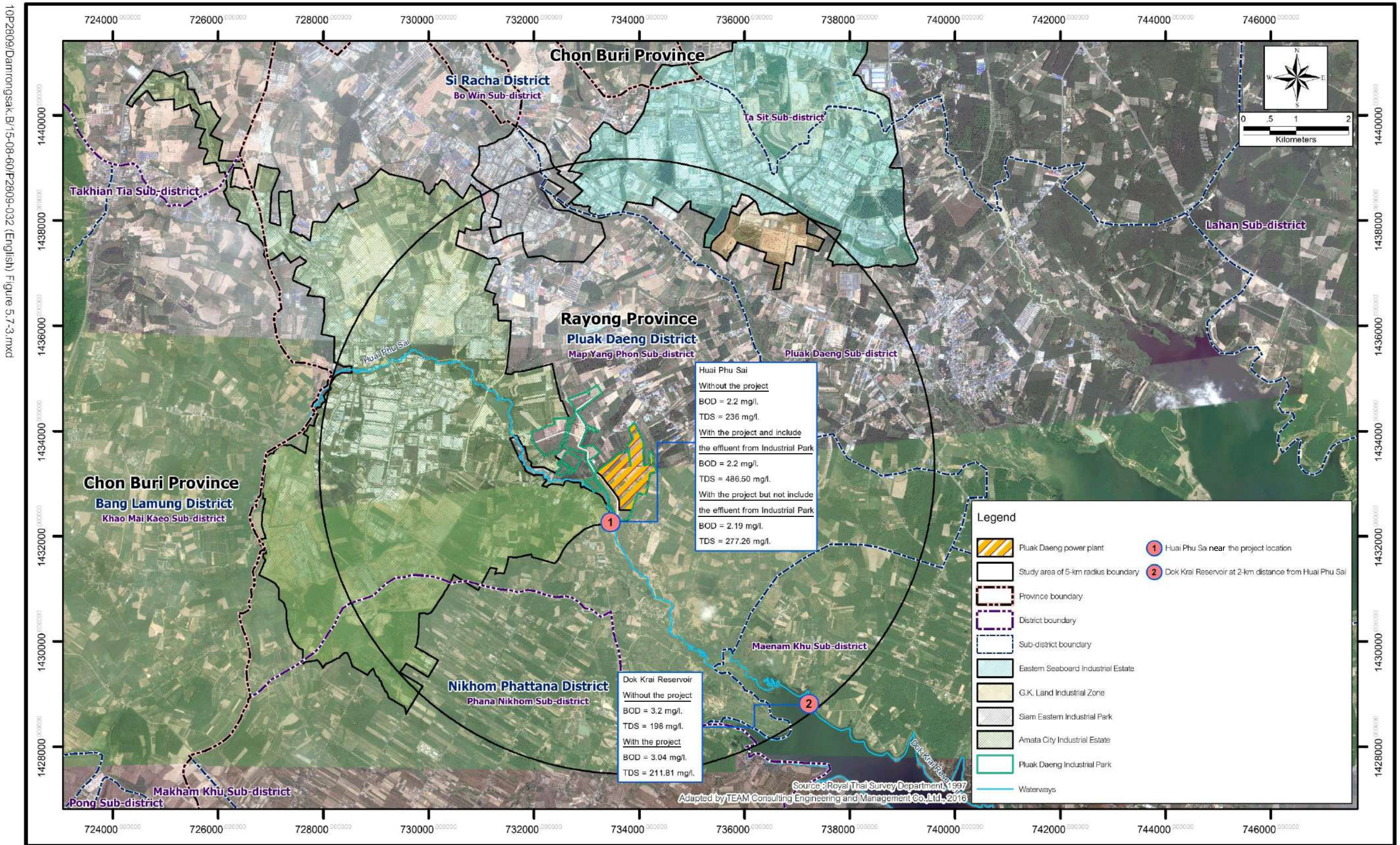


FIGURE 5.1.4-3: MONITORING STATIONS FOR ANALYSIS OF BOD AND TDS IMPACTS ON HUAI PHU SAI IN RAINY SEASON

9) Analysis of BOD and TDS impacts on water quality and utilization of water in Dok Krai Reservoir

(a) Quality of water in Dok Krai Reservoir at present, considering BOD and TDS

Dok Krai Reservoir has water storage capacity of 72 million m^3 with the average storage water volume of 53.95 million m^3 In the dry season, use of water from the reservoir for industrial purpose, utilization and consumption and agriculture on average (November to April) was 6.9 million m^3/month. In the rainy season, use of water (May to October) was 7.32 million m^3/month on average (Source: Royal Irrigation Department, B.E.2540-2557. See Attachment 3 in **Appendix 4F-1**).

⇨ Current water quality: the analyzed BOD and TDS are the average levels from measurement results of 2 monitoring stations in Dok Krai Reservoir on August 3, 2015. These measurement results were compared with measurement results of water quality in Dok Krai Reservoir at Dok Krai pumping station of Eastern Water Resources Development and Management PLC. From January to April, 2016 (the dry season). (Water quality measurement results of Eastern Water Resources Development and Management PLC. are shown in Attachment 2 in **Appendix 4F-1**) Results show that TDS and BOD levels measured in the rainy season are likely to be higher than the ones in the dry season. Thus, TDS and BOD levels measured in the rainy season were used for the analysis of impacts during the rainy and the dry seasons in the worst case scenario.

- Average BOD = 3.2 mg/l

Average TDS = 198 mg/l

(b) Analysis of BOD and TDS impacts on Dok Krai Reservoir

⇨ The rate of inflow of Dok Krai Reservoir
- In the dry season (November to April): 7.98 million m^3/month on average
- In the rainy season (May to October) 18.62 million m^3/month on average

⇨ The monthly average of water volume in reservoir
- In the dry season: 56.80 million m^3/month
- In the rainy season: 51.09 million m^3/month

⇨ Rainfall and evaporation from reservoir
- In the dry season, there was 0.57 million m^3/month of rainfall and 1.45 million m^3/month of evaporation from the reservoir.
- In the rainy season, there was 1.70 million m^3/month of rainfall and 1.17 million m^3/month of evaporation from the reservoir.

- The average drained water from reservoir in the dry season was 3.59 million m^3/month and the average drained water from reservoir in the rainy season was 6.87 million m^3/month.

According to the inspection of the monthly inflow and outflow of Dok Krai Reservoir, water use volume for industrial purpose and evaporated volume were relatively stable. However, the reservoir inflow was getting steadily higher in May and much higher in September. The highest reservoir inflow was found in October and November. After that, it gradually declined until the rainy season started again. The subtraction of reservoir inflow and outflow showed the remaining water in the reservoir from October to November as illustrated in **Figure 5.1.4-4.** In terms of water resources, the monthly average of water volume in Dok Krai Reservoir in November in the rainy season was less than the one in the dry season.

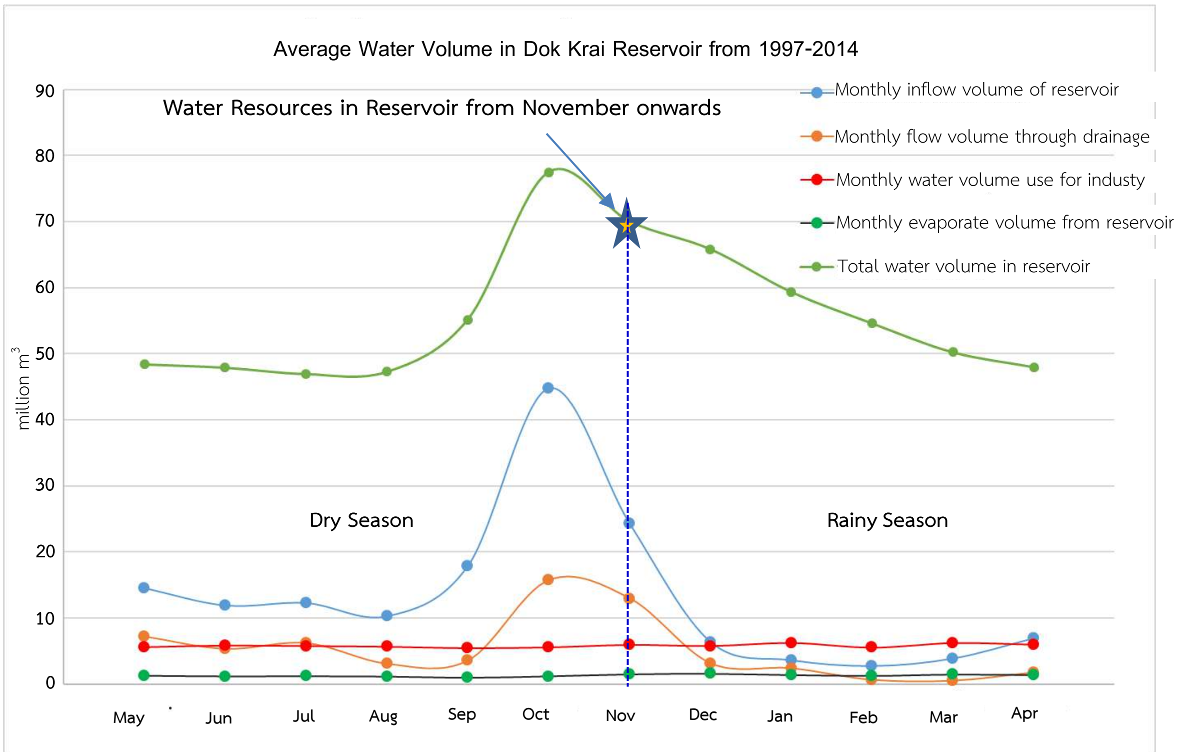


FIGURE 5.1.4-4 : GRAPHS OF MONTHLY INFLOW OF DOK KRAI RESERVOIR

⇨ With the project in Pluak Daeng Industrial Park, summary of inflow of Dok Krai Reservoir after receiving water from Huai Phu Sai, BOD and TDS in the reservoir is made as follows:

In the dry season

- The average inflow of Dok Krai Reservoir after receiving water from Huai Phu Sai in the dry season equals to 1.87 million m^3/month.
- BOD from Huai Phu Sai equals to 2.16 mg/l

TDS from Huai Phu Sai equals to 445.26 mg/l

In the rainy season

- The average inflow of Dok Krai Reservoir after receiving water from Huai Phu Sai in the rainy season equals to 9.54 million m^3/month.
- BOD from Huai Phu Sai equals to 2.2 mg/l
- TDS from Huai Phu Sai equals to 286.50 mg/l

⇨ Calculation of BOD and TDS in the inflow and the outflow of Dok Krai Reservoir (with the project)

$$\text{Total BOD or TDS in the reservoir (with the project)} = \frac{C_1Q_1+C_2(Q_2+Q_3-Q_4)}{Q_T}$$

C_1 = BOD or TDS in water from Huai Phu Sai

C_2 = BOD or TDS in water from Dok Krai Reservoir

Q_1 = Inflow of Dok Krai Reservoir after receiving water from Huai Phu Sai

Q_2 = Monthly water volume in Dok Krai Reservoir (million m^3/month)

Q_3 = Monthly rainfall in Dok Krai Reservoir (million m^3/month)

Q_4 = Monthly evaporation from Dok Krai Reservoir (million m^3/month)

Q_T = Total net water volume $Q_1 + Q_2 + Q_3 - Q_4$

$$\text{BOD in the dry season} = \frac{(2.16\times1.87)+(3.2\times(56.80+0.57-1.45))}{57.79}$$

$$= 3.17 \quad \text{mg/l}$$

$$\text{BOD in the rainy season} = \frac{(2.2\times9.54)+(3.2\times(51.09+1.70-1.17))}{61.16}$$

$$= 3.04 \quad \text{mg/l}$$

$$\text{TDS in the dry season} = \frac{(445 \times 1.87) + (198 \times (56.80 + 0.57 - 1.45))}{57.79}$$

$$= 206 \quad \text{mg/l}$$

$$\text{TDS in the rainy season} = \frac{(286.50 \times 9.54) + (198 \times (51.09 + 1.70 - 1.17))}{61.16}$$

$$= 211.81 \text{ mg/l}$$

Based on the above calculations, summary is made below.

- BOD in the inflow of Dok Krai Reservoir after receiving water from Huai Phu Sai, which contains effluent from the project, is similar to the current level, with minor decrease. In the dry season, BOD decreases from 3.2 mg/l to 3.17 mg/l while in the rainy season, it reduces from 3.2 mg/l to 3.04 mg/l **(Table 5.1.4-2).** As for water quality, it can be used for utilization and consumption.
- TDS in the inflow of Dok Krai Reservoir after receiving water from Huai Phu Sai, which contains effluent from the project, in the dry season, is 206 mg/l In the rainy season, the combination of effluent from Pluak Daeng Power Plant and that of Pluak Daeng Industrial Park results in TDS of 211.81 mg/l **(Table 5.1.4-2)**. This level still falls within the standard of water use for irrigation which determines TDS in water shall not exceed 450 mg/l so that the growth of plant is not affected. As TDS in water did not exceed 1,000 mg/l, there was no need to remove it for water treatment.

TABLE 5.1.4-2

SUMMARY OF BOD AND TDS LEVELS IN DOK KRAI RESERVOIR AFTER RECEIVING WATER FROM HUAI PHU SAI

Seasons	BOD mg/l	TDS mg/l
1. In the dry season		
- Water from Huai Phu Sai (with the project)	2.16	445.26
- The average BOD and TDS in the existing condition of reservoir.	3.2	198
- The combination of water from Huai Phu Sai (with the project) and water in the existing condition of reservoir.	3.17	206
2. In the rainy season		
- The combination of water from Huai Phu Sai (with the project) and the effluent from Pluak Daeng Industrial Park	2.2	286.50
- The average BOD and TDS in the existing condition of reservoir.	3.2	198
- The combination of water from Huai Phu Sai (with the project) and water in the existing condition of reservoir	3.04	211.81

Remarks : In case TDS in water does not exceed 450 mg/l, the water will be suitable for all kinds of plants in all types of soil. However, the maximum standard level of TDS in water is 1,500 mg/l, which can still be used for plants but in a highly permeable soil (Direk Thong A-ram et al., 2002: Design and Plant Watering Technology)

- TDS accumulation will not take place (**Figure 5.1.4-5**) because Dok Krai Reservoir is not a closed system. The inflow and outflow data of Dok Krai Reservoir prepared by the Royal Irrigation Department and Eastern Water Resources Development and Management PLC. were adopted by the project for the analysis of BOD and TDS impacts on Dok Krai Reservoir. (1) The reservoir inflow means water from Huai Phu Sai and other canals. (2) The reservoir outflow means water pumped for industrial use, water discharged into the existing water body, downstream from the reservoir, for agricultural use and water discharged through the spillway of the reservoir. In the dry season, the monthly average of 6.9 million m^3 water volume from Dok Krai Reservoir will be used for various activities. Furthermore, in the dry season, the monthly average of 3.59 million m^3 water volume will be released into downstream of Dok Krai Reservoir. In the rainy season, the monthly average water use will be 7.32 million m^3 while the monthly average water released into downstream of Dok Krai Reservoir will be 6.87 million m^3 Thus, a total water volume in Dok Krai Reservoir, from which TDS will be removed, equals to 148.08 million m^3/year. Nonetheless, TDS from Huai Phu Sai in the inflow of Dok Krai reservoir in the dry and the rainy season is 68.46 million m^3/year. In summary, TDS will be removed based on the reservoir outflow rather than the reservoir inflow.

The analysis of BOD and TDS generated from the project and Pluak Daeng Industrial Park shows that (BOD and TDS are important parameters for the effluent quality of the power plant.)there will be no accumulation of BOD and TDS. However, TDS in the reservoir may increase slightly (new balance of TDS after the existence of the project), i.e. from 198 mg/l to 206 mg/l in the dry season and 211.81 mg/l in the rainy season (**Figure 5.1.4-5**). This level of TDS is lower than the level of brackwish water (5,000 mg/l). It is also lower than 1,000 ml/l. Therefore, it is suitable for water treatment. Furthermore, TDS in the reservoir is less than 450 mg/l which means it is suitable for agricultural use for all kinds of plants according to the Royal Irrigation Department.

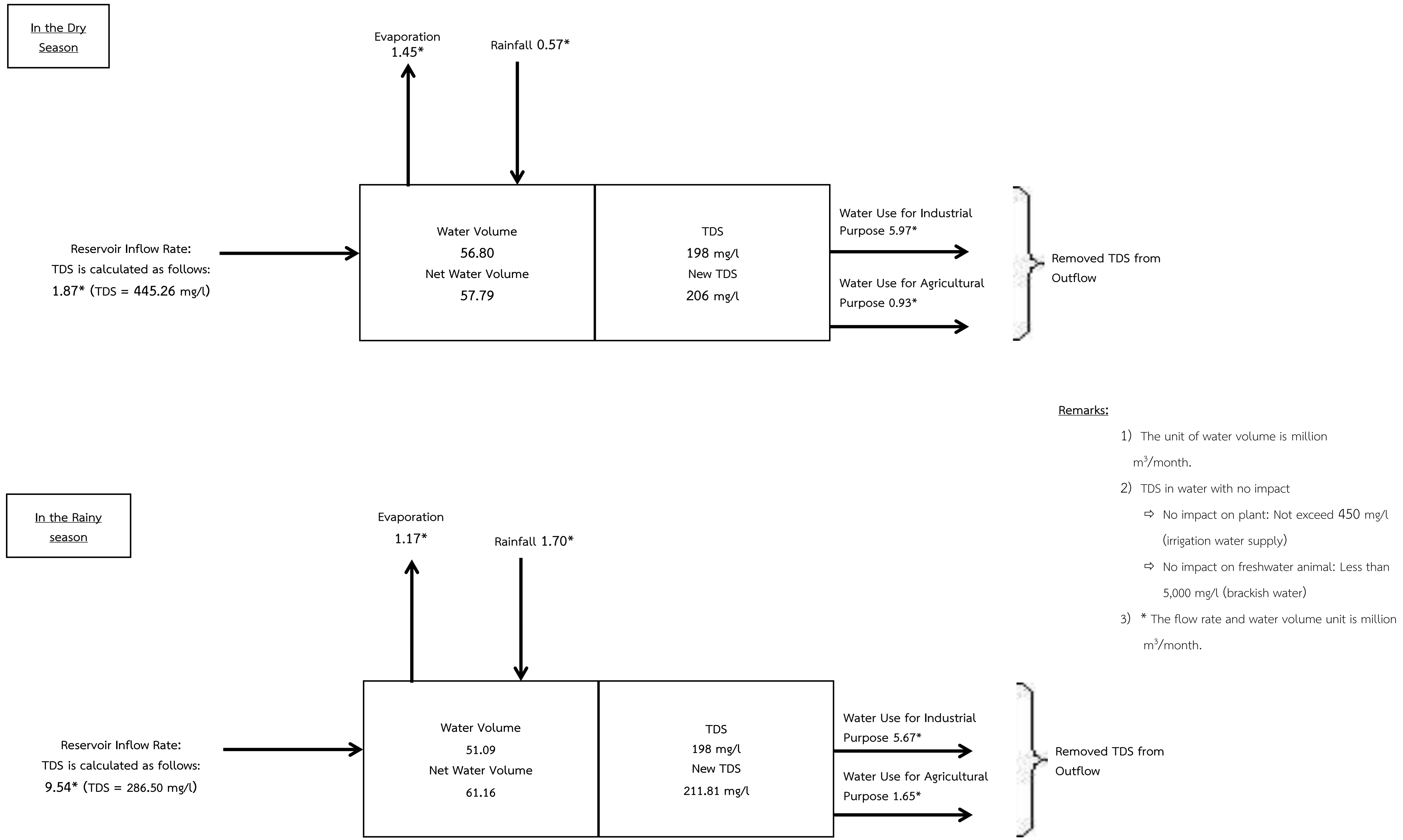
1) Analysis of SAR in all types of effluents released by the project

Study of sodium impacts from effluent of project

In case Na in the effluent is at a high level, it may affect water utilization, such as plant watering, etc. Typically, SAR (Sodium Absorbtion Ratio) is analyzed for the impacts. The ratio of Na: square root of the sum of Ca and Mg (unit: mmol/l).

Use of chemical substance that contains sodium composition (Na) by project

A chemical substance which contains sodium composition, i.e. sodium hydroxide, sodium metabisulphite, sodium chlorite and trisodium phosphate, will be used by the project.



Source : The Analysis Report of Impacts from Cooling Water from Power Plant Project in Pluak Daeng Industrial Park, 2015

FIGURE 5.1.4-5 : DIAGRAM OF CHANGES IN TDS AND TDS BALANCE IN DOK KRAI RESERVOIR DUE TO RELEASE OF EFFLUENT FROM POWER PLANT PROJECT IN PLUAK DAENG INDUSTRIAL PARK

- Sodium Hydroxide 50% Solution of 2,217.42 kg/day will be used to recover an anion resin. Hydroxide ion (OH^-) will binds to an anion resin and Na will remove negative ions, namely Cl^- NO^-_2 PO^{3-}_4 from anion resin. Regarding 2,217.42 kg of Sodium Hydroxide 50% Solution, it consists of 1,108.71 kg of sodium hydroxide content and 637.51 kg of sodium (Na).

- Sodium Metabisulphite 1% Solution will used for the removal of residual chlorine in water to be treated for demineralized water of 15 m^3/year, or 0.04 m^3/day on average, containing 0.4 kg of content and 0.098 kg of sodium.

- Microorganism and slime mold removal agents in power generation activity and cooling water of 2,058 and 60,560 m^3/day, respectively. A total water volume will be 62,618 m^3/day. In case Sodium Chlorite ($NaClO_2$) 25% is applied for the interaction with HCl for the preparation of ClO_2, where $NaClO_2$ of approx. 67.12 kg/day, containing $NaClO_2$ content of 16.78 kg/day is used, and where 4.26 kg/day of sodium and 12.52 kg/day of ClO_2 are added in water before use as cooling water and use for power generation porcess. The highest water volume of 62,618 m^3/day will be used. The concentration of ClO_2 will be 0.2 mg/l (After use, 60,560 m^3/day of cooling water will be evaporated and the highest released volume will be 12,232 m^3/day; so, the remaining ClO_2 will not exceed 1 mg/l).

- Trisodium phosphate 10% solution used in a boiler. The effluent will be released with cooling water. One liter of the solution contains 100 g. of trisodium phosphate (Na_3PO_4) which contains 42.07 of sodium content. (The atomic weight of sodium is 23; The atomic weight of phosphorus is 31 and the atomic weight of oxygen is 16. That is, the weight of three atoms of sodium equals to a molecular weight of 69 and Na_3PO_4 equals to 164.). The maximum utilization rate will be 30 m^3/year or 0.08 m^3/day. Thus, Na_3PO_4 solution of 0.08 m^3 contains 3,365,600 mg. of sodium (42.07 x 0.08 x 1,000 x 1,000).

Evaluation of potential impact of sodium content in the worst case scenario

- Wastewater from power generation process contains sodium content from sodium hydroxide, sodium metabisulphite and sodium chlorite (2,058 m^3/day of water which causes 792 m^3/day of wastewater) of 641.86 kg/day in total. In the worst case scenario, the least wastewater will be 792 m^3/day (High concentration of sodium usually exists in a very low level of wastewater). The concentration of sodium (Na) in the wastewater pond will be 810.31 mg/l.

- Chlorite will be applied to cooling water.The amount of sodium from Na_3PO_4 solution in the boiler and blowdown equal to 3,365,600 mg. Approx. 12,232 m^3/day of sodium will be in the effluent from the cooling tower with the concentration of 0.275 mg/l.

Total concentration of sodium content from two sources is as follows:

$$\text{Mixture value} = \frac{(810.43 \times 792) + (0.275 \times 12{,}232)}{(792 + 12{,}232)}$$

$$= 49.54 \quad \text{mg/l}$$

According to the water quality data from 2011-2016 of Eastern Water Resources Development and Management PLC., water used for the industry sector and the project contains the highest levels of sodium (Na), calcium (Ca) and magnesium (Mg) at 24.03, 72 and 28.2 mg/l, respectively. In case of use in the cooling system, the evaporation of water will cause 5 times increase (60,562/12,232) in the concentration of Na, Ca and Mg in the effluent from the cooling system. Hence, Na, Ca and Mg levels will be 120.15, 360 and 141 mg/l, respectively. Combined with 49.54 mg/l of Na from the applied chemical substance, there will be 169.69 mg/l of Na, 360 mg/l of Ca and 141 mg/l of Mg in the effluent from the cooling system.

- According to the measurement of water quality in Huai Phu Sai in front of the project location, the levels of Na, Ca and Mg are 12.9, 30 and 2.27 mg/l, respectively (**Table 4.1.8-5**).

The formula to calculate SAR is given below.

$$\text{SAR} = \frac{\text{Na}}{\sqrt{(\text{Ca}+\text{Mg})}}$$

The weight per unit (mmol/l) of each element

$$= \frac{\text{Weight of element (mg/l)}}{\text{Atomic Weight}}$$

The atomic weight: Na = 23, Ca = 40, Mg = 24

Calculation of total concentration of the effluents directly released from the project and Huai Phu Sai

Na = 182.59 mg/l

Ca = 390 mg/l

Mg = 143.27 mg/l

Calculation of the weight: mmol/l

$$\text{Na} = \frac{182.59}{23} = 7.94 \quad \text{mmol/l}$$

$$\text{Ca} = \frac{390}{40} = 9.75 \quad \text{mmol/l}$$

$$\text{Mg} = \frac{143.27}{24} = 5.97 \quad \text{mmol/l}$$

$$\text{SAR} = \frac{7.94}{\sqrt{(9.75+5.97)}}$$

$$= 2.00$$

Calculation of SAR in the effluent from Pluak Daeng Power Plant, which is not released into Huai Phu Sai

Calculation of the weight: mmol/l

$$Na = \frac{169.69}{23} = 7.38 \quad mmol/l$$

$$Ca = \frac{360}{40} = 9.00 \quad mmol/l$$

$$Mg = \frac{141}{24} = 5.87 \quad mmol/l$$

$$SAR = \frac{7.38}{\sqrt{(9.00+5.87)}}$$

$$= 1.91$$

Comparison of SAR according to irrigation water quality standards of the Royal Irrigation Department

Level 1: SAR 0-10 can be used for general soil and plants.

Level 2: SAR 10-18 is suitable for plants and coarse loamy textured soil or soil which is rich in organic matter.

Level 3: SAR 18-26 is suitable for a highly permeable soil which is rich in organic matter. Poor permeability will be dangerous for plants.

Level 4: SAR is greater than 26, which is unsuitable for soil. This is exceptional for soil with low salinity. However, it is required to add gypsum.

Based on the results of SAR calculation, in case the effluent from Pluak Daeng Industrial Park and the one from the power plant project are released into Huai Phu Sai and prior to being released into Huai Phu Sai, these effluents have the range of SAR from 0-10, they can be used for all kinds of plants and general soil (**Figure 5.1.4-6**). Therefore, effluent from the project can be used for tree watering. Furthermore, water from Huai Phu Sai can be used as an irrigation water. The effluent will not affect the aquatic ecology of Huai Phu Sai as the concentration of sodium is lower than 5,000 mg/l (salinity that affects living creature in freshwater = 5,000 mg/l).

Additionally, an electrical conductivity (EC) analysis was made for the effluent from the project by evaluating TDS in the effluent released into Huai Phu Sai in the dry season, which equals to 445.26 mg/l and in the rainy season, which equals to 301.5 mg/l Then these values are converted into EC by dividing with Factor (0.64). The resulting EC equals to 695.7 and 471.09 µmho/cm, respectively. Compared with irrigation water quality standards of the Royal Irrigation Department, determining EC in an irrigation water at 2,000 µmho/cm at maximum. Thus, the quality of water in Huai Phu Sai after receiving the effluent from the project is suitable for agricultural use.

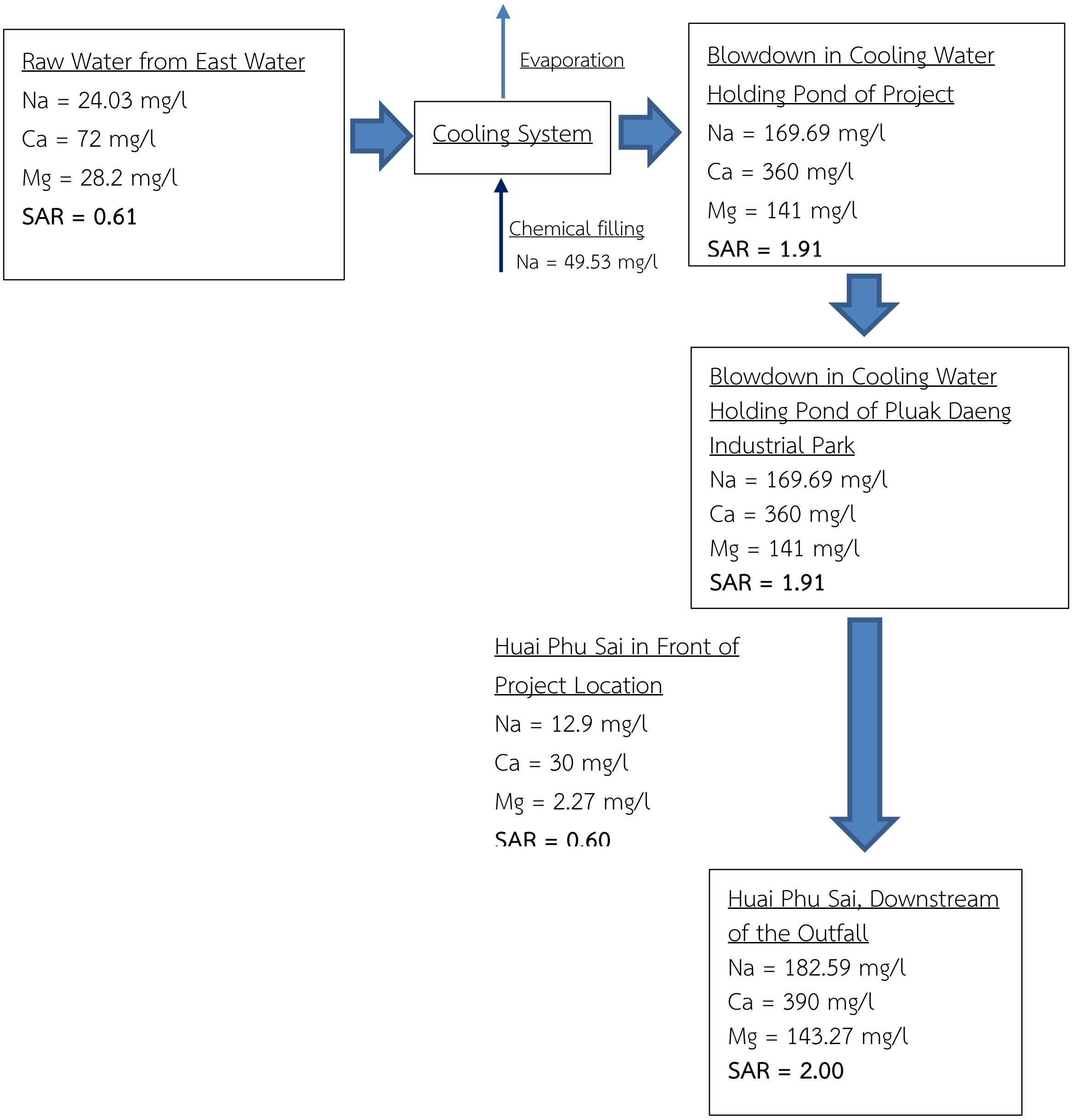


FIGURE 5.1.4-6 : CHANGES IN SAR VALUE IN HUAI PHU SAI (WITH THE PROJECT)

Apart from this, cooling water management was performed by the project, making it consistent with the management measures of the effluent from the cooling system of the power plant in Pluak Daeng Industrial Park and the management measures of the effluent from the cooling system. According to the additional study and control for compliance with the Notification of Ministry of Industry, No.2 (B.E.2539) on determination quality of wastewater discharged from factories. This is exceptional for total dissolved solids which shall meet the standards of wastewater quality, Royal Irrigation Department. The project's cooling water management methods are detailed below.

1) In case the effluent from the cooling tower and the boiler effluent of the power plant meet the setting standards of water quality, it will be released into the cooling water holding pond of Pluak Daeng Industrial Park. The management of the effluent from the cooling tower from the power plant will comply with environmental impact prevention and mitigation measures of Pluak Daeng Industrial Park as illustrated in **Appendix 3T**.

2) In case the effluent from the cooling tower and the boiler effluent of the power plant do not meet the setting standards of Pluak Daeng Industrial Park, they will be re-treated. Details are given below.

2.1) In case the effluent from the cooling tower and the boiler effluent of the power plant do not meet the setting standards of Pluak Daeng Industrial Park, water quality monitors will signal and the 1st valve will be shut off shortly. This is to prevent the effluent from flowing into cooling water holding ponds. The power plant will provide cooling water holding pond that can hold the effluent from the cooling tower and the boiler effluent for one day at minimum, which is sufficient for problem solving whether the abnormalities of pH or electrical conductivity. By this, the power plant can proceed eventhough no effluent is released from the cooling system and the boiler. For example, in case the effluent in the cooling system contains lower pH compared with the standard, it will receive neutralization in the cooling water holding pond of the power plant. In case an electrical conductivity in the effluent from the power plant exceeds the standard, it will be managed by several ways, such as changing a chemical substance to prevent sedimentation, or increasing coolant to reduce the concentration in the system, etc. The power plant operation without discharging the effluent shall last for 1 day at minimum.

2.2) In case it is impossible to perform the above management after one day passes, the power plant will prepare the cooling water holding ponds 2 and 3. Either of them will become the cooling water holding pond for the poor quality effluent or an emergency pond; the other will hold the typical effluent or the quality effluent. For example, if the wastewater holding pond 2 is provided to hold the poor quality effluent or an emergency pond. The effluent from the cooling tower will be released into this pond. Meanwhile, water from the cooling system will be released into this pond through the 2nd valve. At that time, the 3rd valve will be shut off so that the cooling water holding pond 3 is available for the quality effluent that meets the standards and ready for release. If the cooling water holding pond 3 is chosen for holding the poor quality effluent, 3 the cooling water holding pond 2 will be managed to store the quality effluent. There are several ways to manage the effluent, depending on the root cause, such as carrying it to the neutralization systems or sending it for disposal by the authorized company.

In addition, to this, the power plant will establish additional preventive measures to monitor water quality at the location where the effluent is released from the cooling water holding pond 2 or 3. In case it is detected that water quality at location 1 does not meet the standards, the 7th valve will be shut off and the 6th valve will be turned on to convey the effluent that exceeds the standards back to the cooling water holding pond for re-treatment and improvement.

- **Wastewater from power generation process**

Wastewater from power generation process, such as about 13 m^3/day of wastewater from the water treatment system, 5 m^3/day of wastewater from the laboratory and 30 m^3/day of sanitary wastewater, etc. Wastewater generated from each source will receive pre-treatment before being carried to the wastewater holding pond so as to control the effluent quality for compliance with the requirements of Pluak Daeng Industrial Park **(Table 3.11-5)**. The online monitoring system will be installed in the wastewater holding pond of the project to measure temperature, pH and conductivity prior to carrying to the sanitary sewer and the central wastewater treatment system of Pluak Daeng Industrial Park (Negative impact level = 1).

(b) Wastewater from stormwater drainage system of project

Wastewater from the stormwater drainage system will be collected and managed as follows:

- Uncontaminated stormwater from the uncontaminated area or a roof will be drained into the stormwater drainage system of Pluak Daeng Industrial Park.
- Oil contaminated stormwater from the oil contaminated area, such as a concrete dike surrounding a diesel oil drum/tank, etc. The rain falls into the concrete dike will be collected there. After that, the stormwater will be gradually conveyed to an oil separator to separate oil before pumping water for the central wastewater treatment system.

(c) Wastewater holding capacity of central wastewater treatment system

After being treated, about 48 m^3/day of the treated wastewater will be sent for treatment at the central wastewater treatment system of Pluak Daeng Industrial Park. According to the Environmental Impact Assessment Report of Pluak Daeng Industrial Park Project (First Extension Phase) (February 2016), the central wastewater treatment system is capable of storing 2,000 m^3/day of the wastewater. That is the central wastewater treatment system of Pluak Daeng Industrial Park accounts for 2.4% of wastewater from the project, which is sufficient (No impact).

(d) Capacity of Pluak Daeng Industrial Park to hold the effluent from the cooling tower

There will be about 12,232 m^3/day of the effluent from the cooling tower that needs inspection for the effluent from the cooling tower characteristics for compliance with the Notification of Ministry of Industry, No.2 (B.E.2539) on determination quality of wastewater discharged from factories. However, total dissolved solids (TDS) shall meet the standards of wastewater quality, Royal Irrigation Department prior to being discharged outside the power plant through the collection pipe to the cooling water holding pond with the capacity of at least 15,000 m^3 of Pluak Daeng Industrial Park. As a result, the effluent from the cooling tower of the project accouts for 81.55% of the cooling water holding pond of the Industrial Park. It is apparent that the cooling water holding pond of Pluak Daeng Industrial Park **is sufficiently capable of holding the effluent from the cooling tower from Pluak Daeng Power Plant. There will be no problem of effluent control** (No impact).

Although wastewater generated from the project is not directly discharged into surface water sources, the project determined the locations of surface water quality monitoring stations to measure the effluent released from Pluak Daeng Industrial Park in water sources. This is to monitor impacts from the project operation on Huai Phu Sai and Dok Krai Reservoir. Determination of monitoring stations is (**Figure 5.1.4-7**) is as follows:

1) Location of Monitoring Station 1: It is located about 4 km upstream in the north from Pluak Daeng Power Plant location before the outfall of Amata City Industrial Estate (Rayong). The data of water quality before it flowed through Amata City Industrial Estate (Rayong), which is close to the project area, was obtained. According to the measurement, water was uncontaminated from the industrial effluent or very slightly contaminated. As a result, water quality from this area is the representative of water which is not affected by Amata City Industrial Estate (Rayong).

2) Location of Monitoring Station 2: It is located before the outfall of the cooling water holding pond of Pluak Daeng Industrial Park. Water sample was collected from Wang Tan Mon weir before it reaches the crest of overflow weir. According to the measurement results, water quality from this area is the representative of water which flowed past Amata City Industrial Estate (Rayong), but was not affected yet by effluent from the project. The quality of water that flowed past Amata City Industrial Estate (Rayong) is used to compare with the quality of water from Monitoring Station 1.

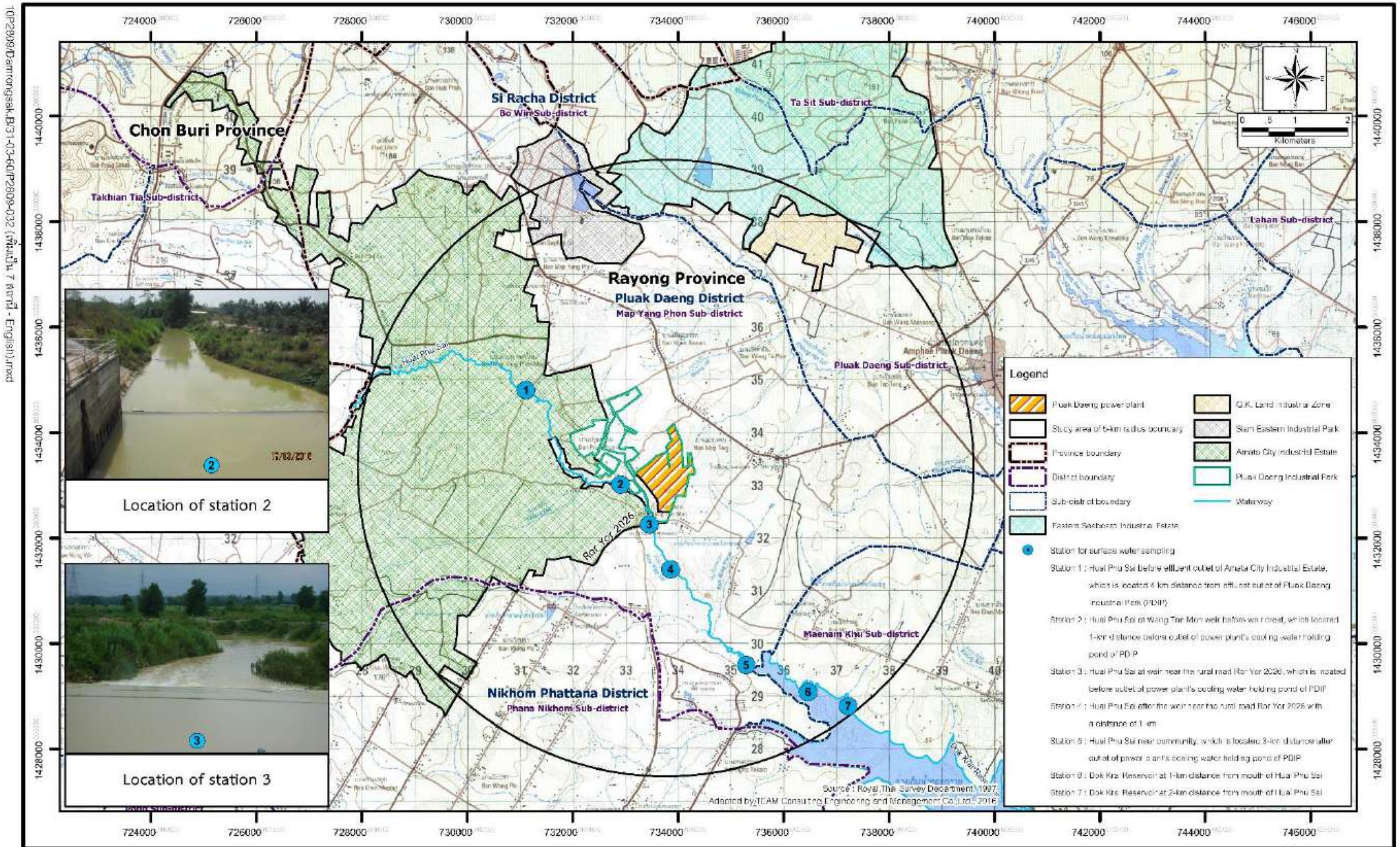


FIGURE 5.1.4-7 : MONITORING STATIONS OF SURFACE WATER QUALITY DURING THE CONSTRUCTION AND OPERATION PHASES

TEAM

3) Location of Monitoring Station 3: It is located at the outfall of the cooling water holding pond of Pluak Daeng Industrial Park. Water sample was collected at the overflow weir on Ror. Yor. 2026 roadside before it reaches crest of the overflow weir. According to the measurement result, water in this area was affected by the project operation. Comparison of water quality at this monitoring station and those at Monitoring Station 1 and Monitoring Station 3 will clearly show the impacts of the project operation on the quality of water in Huai Phu Sai.

4) Location of Monitoring Station 4: It is located at Huai Phu Sai, downstream of the weir crest, about 1 km from Ror. Yor. 2026 roadside. The purpose of measurement is to compare the quality of water in front of the weir (Monitoring Station 3) and behind the weir (Monitoring Station 4).

5) Location of Monitoring Station 5: It is located downstream about 3 km from Pluak Daeng Power Plant. This location is adjacent to communities. Measurement results of water quality in this area is used as the representative of impact from the project operation on communities. Measurement result will indicate whether effluent from the project affects communities.

6) Location of Monitoring Station 6: It is located in Dok Krai Reservoir, 1 km. from the entrance of Huai Phu Sai. This is the area where the reservoir does not receive water from other sources in addition to Huai Phu Sai (including the branches of Huai Phu Sai). Measurement result of water quality in this area is used as the representative of water quality in Dok Krai Reservoir, which is affected by water flowing from Huai Phu Sai.

7) Location of Monitoring Station 7: It is located in Dok Krai Reservoir, 2 km. from the entrance of Huai Phu Sai. This is the area where the reservoir receives water from canal and other water bodies, which is not Huai Phu Sai. This includes water mass from Huai Phu Sai, which may flow from Monitoring Station 5. Compared with measurement result of water quality at Monitoring Station 5, water quality at this station could clearly indicate the impacts from other water bodies combined with water in Dok Krai Reservoir.

Mitigation Measures

(a) Construction Phase

Stormwater management measures

- Temporary drainage ditches and sedimentation pond shall be provided for stormwater storage and sedimentation in the project area. Solids will be separated from stormwater while clear water will be used to spray the project area to alleviate dust diffusion. The remaining water will be drained into the storm drains of Pluak Daeng Industrial Park.
- If material scrap falls into the drainage ditches and block or obstruct the water flow, it should be removed.
- Material scrap and dirt shall not be dumped into the drainage ditch.

Wastewater management measures: wastewater from construction workers and construction activities

- Sanitary toilets shall be adequately provided for construction workers as required by law. Additionally, a septic tank or prefabricated wastewater treatment tank shall be constructed to treat wastewater from water use and consumption by construction workers so that treated effluents meet the effluent standards. The responsible agency shall be contacted to pump out sewage in the prefabricated wastewater treatment tank for further disposal. The prefabricated wastewater treatment tank will be always maintained to ensure its efficiency throughout the construction phase. The plant shall treat wastewater from bathrooms and toilets of construction workers to meet the effluent quality standards of Building Type C according to the Notification of the Ministry of Natural Resources and Environment on Establishment of Building Effluents Standards for some Building Types and Sizes. Effluent parameters include pH, BOD, suspended solids, sulfide, Total Dissolved Solids, settleable solids, oil and grease, and TKN. A monitoring pond shall be provided for effluent storage for at least 1 day for inspection once a month before contacting the responsible agency for further disposal.
- The drainage ditch and wastewater holding pond shall be provided at the construction site to hold uncontaminated wastewater from construction activities. The uncontaminated wastewater quality shall be inspected for compliance with the requirements of Pluak Daeng Industrial Park prior to being drained into the central wastewater treatment system of Pluak Daeng Industrial Park.
- Contaminated wastewater e.g. wastewater from changing engine oil, shall be controlled, and will be kept in a drum and delivered to the agency authorized by government agencies for disposal.
- Regular maintenance shall be performed for vehicles and all types of machinery to prevent oil leakage. The maintenance shall be performed in the designated area or on solid surface with a pad to prevent oil leakage into Huai Phu Sai.

Wastewater management measures: wastewater from workers' camp

- Sanitary toilets shall be adequately provided for construction workers as required by law. Additionally, a septic tank or prefabricated wastewater treatment tank shall be constructed to treat wastewater from water use and consumption by construction workers so that treated effluents meet the effluent standards. The responsible agency shall be contacted to pump out sewage in the prefabricated wastewater treatment tank for further disposal. The prefabricated wastewater treatment tank will be always maintained to ensure its efficiency throughout the construction phase. The plant shall treat wastewater from bathrooms and toilets of construction workers to meet the effluent quality standards of Building Type C according to the Notification of the Ministry of Natural Resources and Environment on Establishment of Building Effluents Standards for some

Building Types and Sizes. Effluent parameters include pH, BOD, suspended solids, sulfide, Total Dissolved Solids, settleable solids, oil and grease, and TKN. A monitoring pond shall be provided for effluent storage for at least 1 day for inspection once a month before contacting the responsible agency for further disposal.

Wastewater management measures for Discharges from the Power Plant and Hydrostatic Test

- Screens shall be installed at the drain pipe to trap garbage and solids in water discharges after hydrostatic tests.
- The characteristics of hydrostatic test water discharges, i.e. pH, temperature, total suspended solids, oil and grease, shall be checked to strictly comply with the requirements of Pluak Daeng Industrial Park
- In the event that the effluent quality does not comply with the one required by Pluak Daeng Industrial Park, it will be sent for disposal by the agency authorized by government agencies.

(2) Operation Phase

Cooling water management measures

- Two cooling water holding ponds shall be provided with the holding capacity of 19,000 cu.m. each for at least one (1) day discharge volume. These two cooling water holding ponds will hold the blowdown from a cooling tower. The ponds shall be paved with high density polyethylene (HDPE) or concrete to prevent leakage.
- The online monitoring system shall be installed at the water holding ponds to check the temperature, pH, conductivity and dissolved oxygen. The monitoring results shall be reported to the display in front of the project area and wastewater control center of Pluak Daeng Industrial Park.
- The Project shall control the quality of effluent discharged from a cooling tower to be in compliance with the measures of Pluak Daeng Industrial Park. The Industrial Park requires that the quality of cooling water shall meet the Notification of Ministry of Industry, No.2 (B.E.2539) on determination quality of wastewater discharged from factories, except total dissolved solid shall be complied with RID's standard of effluent quality discharge into irrigation system (TDS shall not exceed 1,300 mg/l) and temperature shall not exceed 34 °C.
- One emergency pond with the capacity of 19,000 cu.m. shall be provided with the holding capacity of at least one (1) day discharge volume. The emergency pond will hold the blowdown from a cooling tower. In case the monitoring results show that the quality of effluent from a cooling water does not comply with the measures of Pluak Daeng Industrial Park, which is based on the Notification of Ministry of Industry, No.2 (B.E.2539) on determination quality of wastewater discharged from factories. This is exceptional for total dissolved solids which shall comply with RID is standard of

effluent quality discharge into irrigation system (TDS shall not exceed 1,300 mg/l) and temperature shall not exceed 34 °C (In normal working conditions, the emergency pond shall be dry.)

- An aerator shall be installed in cooling water holding ponds to increase dissolved oxygen in the effluent.
- The aerator shall be run when dissolved oxygen in the effluent is lower than 4 mg/l and shall be run until dissolved oxygen is higher than 4 mg/l.
- Chlorite in blowdown from the cooling tower shall not exceed 1 mg/l. If chlorite exceeds the criteria, the effluent shall not be discharged from the project.
- In the event that blowdown from the cooling tower will be used for watering plant within the project area, SAR shall be control in the range 0-10. Conductivity shall not exceed 2,000 micromho/cm. and TDS shall not exceed 1,300 mg/l. if these effluent parameters do not comply with the criteria, they shall be improved prior to watering plant within the project area.
- Management of blowdown from the cooling tower (**Figure 9-2**)
  - **Cooling water holding pond and emergency pond:** Before being discharged from the power plant, cooling water will be held in the cooling water holding pond 1, which is capable of managing water at least for 1 day. The cooling water holding ponds 2 and 3 are capable of holding the effluent for 1 day each. The cooling water holding ponds will be paved with HDPE or of concrete type to prevent leakage. Typically, either the cooling water holding pond 2 or 3 will be used. The one that is not in use will be kept dry as an emergency pond.
  - **Control valve**: The system consists of the 1st valve which will be closed when the quality of water at the cooling tower exceeds the standards. The 2nd valve and the 3rd valve manage to convey blowdown water to the cooling water holding ponds 2 and 3, respectively. The 6th valve and the 7th valve manage blowdown from the cooling tower before it is drained into the cooling tower holding pond of Pluak Daeng Industrial Park for the increase in effluent management.
  - **Water pump**: The effluent from the cooling water holding pond 2 or 3 will be pumped by the water pump and conveyed outside the power plant. The size of water pump will be designed for pumping capacity that makes the basin dry within a short period of time and ready to used as an emergency pond
  - **Water quality and control at cooling tower, blowdown and blowdown management:** Water in the cooling system will be checked and improved all the time to control the quality of recirculated water and the water released from the cooling system, such as control of pH, concentration, water filling and partial drainage of water, etc. Measurements will be made for the temperature, pH, dissolved oxygen and conductivity. This is a continuous monitoring. The control signal will be sent to a valve/water

pump. Furthermore, the values of continuous monitoring will be displayed at a control room. The characteristics of blowdown from the cooling tower shall comply with the requirements of Pluak Daeng Industrial Park. Blowdown management can be performed in various ways, depending on causes of problems. For example, the blowdown may be sent to the pH neutralization system within the power plant, or it may be sent for disposal by the authorized agency.

- Regular check and maintenance shall be performed for condenser and cooling towers so as to control the quality of effluent from the cooling tower prior to discharging out of the project.

Management measures for effluent from the process

- The quality of effluent to be carried to the central wastewater treatment system of Pluak Daeng Industrial Park shall comply with the requirements of Pluak Daeng Industrial Park.
- An oil separator shall be provided to separate oil from oil contaminated effluent. Then the contaminated effluent shall be carried to a wastewater holding pond for quality check prior to being discharged to the central wastewater treatment system of Pluak Daeng Industrial Park.
- Adequate sanitary toilets shall be prepared for staff as required by law. In addition, a septic tank or prefabricated wastewater treatment tank shall be constructed to treat wastewater generated by utilization and consumption of staff before being discharged to the wastewater holding pond of the project and carried to the central wastewater treatment system of Pluak Daeng Industrial Park.
- A neutralization pit shall be provided for pH neutralization before draining the effluent into the wastewater holding pond of the project and the central wastewater treatment system of Pluak Daeng Industrial Park.
- The wastewater holding pond of the project, which can hold the effluent for 24 hours at minimum, shall be provided so that the quality of effluent is checked before being discharged to the central wastewater treatment system of Pluak Daeng Industrial Park.
- The online monitoring system shall be installed at the wastewater holding pond to check the temperature, pH and conductivity. The monitoring results shall be reported to the wastewater control center of Pluak Daeng Industrial Park.
- The effluent that passes quality check from the wastewater holding pond shall be carried through the drain pipe for treatment at the central wastewater treatment system of Pluak Daeng Industrial Park.

5.1.5 Soil Resource

(1) Construction phase

Land levelling is to be executed by Pluak Daeng Industrial Estate before the area is entrusted to Pluak Daeng Power Plant Project. In this way the land in the project area will already be levelled before the construction of the project starts. The only activity that might have impacts on the soil resources is topsoil excavation to lay the foundation of the buildings and dig ponds. Possible impacts to the soil resources are as follows:

(a) Soil erosion

Because of land levelling but with no cover cropping, and topsoil excavation; there is more likelihood of natural soil erosion. Assessment of soil erosion in the project area in the construction phase is conducted by employing the Universal Soil Loss Equation (USLE), in which the cropping factor (C) = 0.80 (for unused land and developed land, as shown in **Table 4.1.3-7**) and the conservation practice factor (P) = 1.0. As there is no practice to prevent soil erosion such as contour cultivation and terrace cropping, etc., prediction of the average soil loss according to the USLE is as follows:

Average annual soil loss (A) = $237.93 \times 0.09 \times 0.567 \times 0.80 \times 1.0$
= 9.71 tons/hectare/year (1.55 tonne/rai/year)

The average soil loss due to erosion in the project site in the construction phase during the excavating operation at 1.55 tonne/rai/year, when put into comparison with the Soil Tolerance Goal with reference to the Land Development Department (2002) at 2 tons/rai/year, shows that soil erosion caused by the excavating operation in the construction of the project is less than that caused by natural circumstances. Therefore, the impact on soil loss in the project area is considered low (no impact).

(b) Soil fertility

As land levelling is to be executed by Pluak Daeng Industrial Estate before the area is entrusted to Pluak Daeng Power Plant Project and the construction is to be executed only in the project site, there is no impact to the soil fertility (no impact).

(2) Operation phase

(a) Soil fertility

In the operation phase, pollutants are to be emitted from the electricity generation process through the emission stacks. Sulfur dioxide, the main cause of acid rain, is produced in the project’s electricity generation, in which the main fuel used is natural gas, less than when other fuel fossils are used.

According to the Pollution Control Department's website, Thailand is a member of the Acid Deposition Monitoring Network in East Asia (EANET). Under the charge of the Pollution Control Department, the Acid Deposition Monitoring Network in Thailand has been established comprising relevant government agencies and authorities from various academic institutes with a view to monitoring acid deposition including both wet and dry precipitation and assessing risk impacts of this problem through the investigation of changes in the ecology and environment, including the ecological condition of the water, soil, and forest resources affected. The surveillance is aimed to cover extensive areas in all the regions in Thailand and is still in progress in many areas. **Table 5.1.5-1** shows the urban, industrial and nature reserve areas which have been continuously monitored since the end of 1998. However, there is no surveillance of the project area by the said network.

Also, according to the report on the investigation of rainwater quality during August-September 2015 by the Regional Environmental Office 1-16, in which the pH of rainwater is measured in the rural, urban and industrial areas in Mueang Rayong District (the capital district) and Klaeng District, Rayong Province by the Regional Environmental Office 13. It is found that the pH of the three rainwater samples are above 5.6 (rainwater having a pH of less than 5.6 is considered to be acid rain - **Appendix 5C**). Nevertheless, only three samples are not enough to generalize on the pH of rainwater in the entire Rayong Province. Moreover, the three samples are not collected in the project area. All in all, no agency yet has monitored acid precipitation deposition in the project area.

TABLE 5.1.5-1

ACID DEPOSITION SAMPLE COLLECTION POINTS IN THAILAND

Samples Collected	Sample Collection Point
1. Samples of wet acid precipitation deposition	1. Khao Laem Dam, Kanchanaburi Province 2. Office of Natural Resources and Environmental Policy and Planning (ONEP) 3. Meteorological Department, Bangkok 4. Environmental Research and Training Centre, Pathum Thani Province
2. Samples of dry acid precipitation deposition • gas • aerosol	1. Khao Laem Dam, Kanchanaburi Province 2. Office of Natural Resources and Environmental Policy and Planning (ONEP)
3. Samples of acid deposition in soil and plants	1. Khao Laem Dam, Kanchanaburi Province
4. Samples of acid deposition in water bodies and deposits of soil particles	1. Khao Laem Dam, Kanchanaburi Province

Source: http://www.pcd.go.th/info_serv/air_aciddeposition.html#s6 (retrieved on 12 October 2016)

The review of the data on soil properties in the project area according to the Land Development Department's soil survey report in Rayong Province (1985) **(Table 4.1.3-2)** reveals that the pH of the topsoil of each soil series fall into the range of 5.2-6.5 (highly acidic to mildly acidic soil) - except in the case of Thai Muang series, the pH of which is 7.5 (mildly alkaline soil). In addition, the laboratory analysis of four soil samples collected from the project site and the area under study in the project reveals the pH in the range of 5.13-6.17 (highly acidic to mildly acidic soil), as shown in **Appendix 4B**). All in all, the soils in the area under study in the project range from highly acidic to mildly alkaline.

However, if there is acid rain in Rayong Province, especially in the area under study in the project; agriculture, the activity that utilizes the said area most, will be negatively affected. Despite its natural acidity, the acidity level in the soil will be increased. The impacts of highly acidic soil with respect to nutrient deficiency and toxicity in soil are as follows:

- In soil with pH level lower than 5.0, phosphate can be less utilized by the plant as it is fixed in the forms of iron and aluminum phosphate. Furthermore, iron and manganese become increasingly soluble, and potentially toxic to the plant if their amounts are large enough.
- In soil with pH level lower than 5.5, the plant may suffer from deficiency of potassium, calcium, and magnesium.

In addition, the data from the investigation on acid deposition in Songkhla Province[2] are referred to. The findings are as follows:

The concentration of sulphate (SO_4^{2-}) in the rainwater is higher than that of nitrate (NO_3^-). The ratio of NO_3^- SO_4^{2-} is 0.58, which is less than 1 means that the acidity of the rainwater is more attributable to sulfur compounds than to nitrogen compounds. The deposition of wet acid precipitation is 2.5 times higher than the deposition of dry acid precipitation. Also, the amount of SO_4^{2-} and NO_3^- in the deposition of wet acid is 21.8 and 11.2 microgram per square meter a year. These show that the majority of acid deposition is caused by Sulphate, not Nitrate.

As a result, in the operation phase, pollutants are to be emitted from the electricity generation process through the emission stacks. In spite of the facts that Sulfur Dioxide, the main cause of acid rain, is produced in the project's electricity generation, in which the main fuel used is natural gas, less than when other fuel fossils are used; and that the project prescribes that the amounts of air pollutant emitted must be lower than those established in the Ambient Air Quality Standards; because of pollutants already

[2] Naowarat Raksakan, Acid Deposition in the Southern Region of Thailand, Master's Degree Thesis, Department of Environmental Technology, School of Energy, Environment and Materials, 2001.

released into the air by the plants in the vicinity, the pH of rainwater and acid deposition acid in soil are monitored all through the project from its pre-construction and construction phases to the operation phase, as discussed in the Environmental Action Plan in Chapter 7. For this, Sulphate radical and Nitrate radical in the soil samples are analyzed. The samples are collected from the project area at the depth level of 0-15 cm and also from the agricultural area around Khao Song Phi Nong Mountain in the north-west of the project (the area around Khao Song Phi Nong Mountain is the worst case in terms of the highest concentration of Sulfur Dioxide and Nitrogen Dioxide resulting from the execution of the project). All in all, the impact to the soil fertility is considered low (negative impact level = 1).

5.1.6 Earthquake

(1) Construction Phase

The project site is located far away from seismic risk zones and faults capable of producing earthquakes. Up to the present no earthquake, has ever been reported. Also, there is no record of any damage resulting from an earthquake nor detection of seismic waves in the project area and in the vicinity. Therefore, there is no seismic impact on the project's construction activity (no impact).

(2) Operation Phase

The project area is located in seismic zone IV according to the Mercalli scale, with moderate intensity of shaking (can be felt by passers-by). The structure of the buildings in the project is designed in compliance with construction standards with respect to the capacity to withstand the said seismic intensity. Also, no earthquake, has ever been reported in the project area. Therefore, there is no seismic impact on the project operation (no impact).

5.1.7 Electromagnetic Field

Electricity Generating of Thailand (EGAT) is responsible for transmission line (TL). Design and construction of TL will be in accordance with EGAT Operation Code for Transmission Line System. In addition, there is no specific regulation on EIA for transmission line in Thailand. There is requirement of electric field and magnetic field of international commission on non-ionizing radiation protection (ICNIRP) on electromagnetic radiation (**Table 5.1.7-1**). To check the compliance with the requirement, EGAT has designed the value of electric field, magnetic field, radio interference, audible noise and short circuit current density by selecting type and clearance of transmission line. The expected results of impact are as shown in **Table 5.1.7-2** that calculated by BVCORONA program. All quantities are not exceeded the standard. It can be assured that the construction of transmission line by EGAT will not pose impact of electric field and magnetic field to people living near the line.

TABLE 5.1.7-1

REQUIREMENT OF ELECTRIC FIELD AND MAGNETIC FIELD OF INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION (ICNIRP) ON ELECTROMAGNETIC RADIATION

Exposure	Electric Field (kV/m)	Magnetic Field (mG)
Working related to magnetic field		
- All day exposure	10	5000
- Short time exposure	30	50000
- Only arms and legs exposing to magnetic field	-	250000
People		
- 24 hrs/day	5	1000
- 2 - 3 hrs/day	10	10000

Remark: Summation of electric field should not exceed 80 kV/m for all day work.

TABLE 5.1.7-2

RESULTS CALCULATED BY BVCORONA PROGRAM

Quantity	Unit	Quantity at the boundary of R.O.W.	
		Standard	Calculated value
Electric Field	kV/m	2	1.125
Magnetic Field	mG	200	112.68
Radio Interference	dB	40	28.8
Audible Noise	dBA	55	35.8

Source: Electricity Generating Authority of Thailand, 2012

5.2 BIOLOGICAL RESOURCES

5.2.1 Aquatic Ecology

(1) Construction phase

During the construction phase, the construction waste, such as dirt, rubble, sand, etc., if leached by the rain to water bodies, may affect aquatic ecology. Impact mitigation measures are, therefore, established. Truck wheels shall be washed before the trucks leave the construction site or construction-related areas to prevent dirt and sand from falling onto the roads, both inside and outside the project area, and water bodies. Uncontaminated wastewater from construction activities shall be collected to the wastewater holding pond for quality check for compliance with the requirements of Pluak Daeng Industrial Park prior to being discharged to the central wastewater treatment system of Pluak Daeng Industrial Park. Meanwhile, wastewater from utilization and consumption by construction workers shall be collected to the septic tank or the prefabricated wastewater treatment plant for standard treatment. Regarding rainfall within the project area, storm drains shall be provided to collect stormwater and send it to the temporary sedimentation pond. The temporary sedimentation pond will store and allow sedimentation of stormwater within the power plant project area. Furthermore, Settleable Solids shall be separated from stormwater. Clear water will be used to spray in the project area to reduce the diffusion of dust. The remaining water shall be released into the storm drain of Pluak Daeng Industrial Park. It is forecast that the project construction will affect the aquatic ecology at a low level (Negative impact level = 1).

(2) Operation Phase

As the project is located in Pluak Daeng Industrial Park, wastewater management shall comply with environmental impact prevention and mitigation measures of the Industrial Park. According to the measures, the power plant located in Pluak Daeng Industrial Park shall separate wastewater into 2 parts: Wastewater from power generation process (consisting of wastewater from the water treatment plant, laboratory wastewater, and sanitary wastewater). Each type of wastewater will be treated with suitable method. After that, the treated wastewater shall be compiled and sent to the wastewater holding pond of the project for quality check for compliance with the standards of Pluak Daeng Industrial Park. Then it shall be drained into the central wastewater treatment system of Pluak Daeng Industrial Park. The effluent from the cooling tower of the power plant will be held at the cooling water holding ponds of the project for quality check for compliance with the standards of Pluak Daeng Industrial Park before being carried to the cooling water holding pond of the Industrial Park. Since the project and Pluak Daeng Industrial Park strictly controls the effluent from the cooling tower quality, it is predicted that the effluent discharged will have a low impact on Huai Phu Sai.

Based on the analysis report of impacts from the discharge of BOD and TDS in the effluent from the power plant project in Pluak Daeng Industrial Park in the dry and the rainy seasons (December 2015), as shown under **Section 5.1.4 Surface Water Quality**, includes the following details.

1) Scoping study

- The study of impacts from BOD, TDS and ammonia effluent from the cooling tower of the project in Pluak Daeng Industrial Park on aquatic ecology and fisheries and aquatic animal production in Huai Phu Sai and Dok Krai Reservoir. Regarding ClO_2, consideration was made including effluent from power generation activity.
- The study of use of phosphate that may cause eutrophication and impact on Huai Phu Sai and Dok Krai Reservoir

2) Source of data

Measurement results of BOD and DO levels in Huai Phu Sai and Dok Krai Reservoir, August 2015.

3) Physical characteristics of studied surface water

- **Huai Phu Sai**

The average width of Huai Phu Sai or the canal (the section that flows past the location of Pluak Daeng Power Plant) is 20 m. The average depth of the canal from the riverbed to the bank is 2.5 m In the rainy season, the canal flows fast, with flooding, while in the dry season, the riverbed contains silt and pubble. Both sides of the canal are covered with papyrus, grass, and reed alternating with rubber orchard. Furthermore, high-density communities and agriculture area were found along the canal. Huai Phu Sai holds the effluent from Pluak Daeng Industrial Park which will flow into Dok Krai Reservoir, about 3.3 km from Pluak Daeng Power Plant Location. Huai Phu Sai flow in front of Pluak Daeng Industrial Park is illustrated in **Photo 5.2.1-1**.

PHOTO 5.2.1-1 : HUAI PHU SAI FLOW IN FRONT OF PLUAK DAENG INDUSTRIAL PARK

- **Dok Krai Reservoir**

Dok Krai Reservoir is the large water source, holding waterflow from Huai Phu Sai. Also, water from this reservoir will be used for industrial and agricultural purposes, as well as utilization and consumption. Furthermore, it serves as the fishery source. The reservoir is characterized by lateritic soil, sandy and skeleton soil. The average water retention in Dok Krai Reservoir is 53.95 million m^3 **Photo 5.2.1-2** illustrates the appearance of Dok Krai Reservoir, 1 km from the entrance of Huai Phu Sai.

4) Fishery and aquatic animal production in Huai Phu Sai and Dok Krai Reservoir

The following summary is made from survey on area condition and the compilation of documents related to fishery and aquatic animal production in the study area.

- **Huai Phu Sai**: People in this area do not earn a living by fisheries or aquatic animal production; they catch aquatic animals by using fishhook and fishnet for consumption in the household or selling them for supplement income. Types of fish found in Huai Phu Sai include Nile Tilapia, Mystus nigriceps, carp, minnows, tiny freshwater shrimp, etc. Each type of fish is not abundant.

PHOTO 5.2.1-2: APPEARANCE OF DOK KRAI RESERVOIR, 1 KM FROM ENTRANCE OF HUAI PHU SAI

- **Dok Krai Reservoir:** Fisheries are made for 3 purposes.
  - earning a living
  - consumption in a household
  - sporting and recreation

The abundant aquatic animals include carp, pangasius sutchi, Nile Tilapia, giant freshwater prown, followed by Probabus jullieni and climbing perch. Fishing tackle includes fishhook, net and fishnet. Those who catch aquatic animals to earn a living have the income between 500 baht to 1,000 baht per day per person.

5) Evaluation of BOD and TDS impacts from effluent released from project on aquatic ecology

5.1 Evaluation of BOD impact on surface water quality

- BOD level in Huai Phu Sai at the location of Pluak Daeng Power Plant location, without project and with project: Huai Phu Sai is categorized as surface water source, Class 4. This water source is capable of holding the effluent and useable for industrial purpose. However, utilization and consumption require special water treatment as BOD exceeds 2 mg/l but not exceeds 4 mg/l both in the dry and the rainy seasons. Since dissolved oxygen (DO) in Huai Phu Sai is relatively high compared with BOD, that is, the average DO in front of the power plant location and downstream of the power plant location exceeds 7 mg/l This level is sufficient for BOD degradation. As a result, water will not polluted and living things in Huai Phu Sai will survive.
- BOD level in Dok Krai Reservoir at the location of Pluak Daeng Power Plant location, without project and with project: It is categorized as surface water source, Class 4. The average BOD, without project, equals to 3.2 mg/l With the project, the average BOD in the dry season equals to 3.17 mg/l and in the rainy season, it equals to 3.04 mg/l Nontheless, the average DO in Dok Krai Reservoir equals to 8.85 mg/l This level will be sufficient for BOD degradation with sufficient DO left for aquatic living things.

5.2 Evaluation of TDS on surface water quality

- Huai Phu Sai: Without project, TDS will be about 236 mg/l With project, The average TDS in the dry season will be 445.26 mg/l and in the rainy season, it will be 286.50 mg/l, which are less than 5,000 mg/l to 15,000 mg/l (brackish water criteria). Hence, with project, TDS in Huai Phu Sai will be higher. However, it will not lead to brackwish water, which is harmful to aquatic living things.
- Dok Krai Reservoir: Without project, in the dry season and the rainy season, TDS will be 198 mg/l With project, TDS in the dry season will be 206 mg/l and in the rainy season, it will be 211.81 mg/l These levels are lower than the range of brackish water from 5,000 mg/l to 15,000 mg/l Therefore, it is summarized that with project, TDS in Dok Krai Reservoir will be higher but it does not cause brackish water, which is harmful to aquatic living things.

6) Evaluation of cholorine dioxide (ClO_2) impacts on aquatic ecology

- **Impacts on Huai Phu Sai**

Chlorine dioxide (ClO_2) is chosen to eliminate slime mold and microorganisms in cooling water. As there is no reaction between ClO_2 and an organic substance, it will not result in trihalomethane (THMs) (Petrucci and Rosellini, 2005). Trihalomethane (THMs) are chemical compounds (carcinogen) in case of exposure or intake for a long period of time. Apart from this, there is no reaction between ClO_2 and ammonia, so, it will not result in chloramine. According to these properties, ClO_2 has been employed for water treatment and cooling water in the power plants in several countries in Europe and America to reduce the occurrence of trihalomethane. Other benefits of ClO_2 are given below.

- ClO_2 eliminates biofilms which are adhered by legionella. (M.J. Turvey. Ashland Chemicals, UK. "THE USE OF CHLORINE DIOXIDE FOR CONTROLLING LEGIONNAIRES DISEASE" Published by Ashland / Drew Ameroid, 2nd International Conference on Chlorine Dioxide in Paris)
- ClO_2 inhibits the growth of microorganisms better than chlorine (Cl_2). It also takes shorter time to disinfect microorganisms.
- ClO_2 eliminates inorganic matters, such as iron, manganese, etc while chlorine does not have this property.

Use of ClO_2 will not cause trihalomethane, which is a carcinogen. As a result, it is not required to measure trihalomethane. Nontheless, ClO_2 is likely to affect an aquatic ecology and aquatic living animals because ClO_2 is converted into ClO^-_2. Effluent from the project will be released into the wastewater holding pond of the project. The concentration of chloride shall not exceed 1 mg/l (Calculation is shown in **Section 5.1.4: Surface Water Quality**) The discharge rate of effluent from the cooling tower including wastewater from power generation process will be 12,280 m^3/day, or equals to 0.142 m^3/sec. (The effluent shall not be discharged from Pluak Daeng Industrial Park in the dry season.) The waterflow rate in Huai Phu Sai will be 0.58 m^3/sec.

The effluent from the cooling tower and wastewater from the project will not directly discharged into Huai Phu Sai, but they will be stored in the coling water holding pond for at least 1 day. (The power plant's cooling water holding pond can hold cooling water for at least 1 day) The Material Safety Data Sheet of Vulcon Chemical (2002) describes that when used in water, sodium chlorite ($NaClO_2$) will change into chloride. The concentration of chlorine dioxide (ClO_2) in the effluent will not exceed 1 mg/l Calculation is shown in **Section 5.1.4: Surface Water Quality**.) This concentration is lower than the salinity of brackwish water (5,000 mg/l). According to the evaluation of chlorite from the effluent from the cooling tower of the power plant, it will not change into the form of chloride (worst case scenario). The concentration of chlorite is 1 mg/l

$$\text{Total concentration in water} = \frac{C_1Q_1+C_2Q_2}{Q_1+Q_2}$$

C_1	Chlorite concentration in effluent	1	mg/l
C_2	Chlorite concentration in Huai Phu Sai	0	mg/l
Q_1	Effluent flow rate	0.142	m^3/sec
Q_2	Flow rate of Huai Phu Sai	0.58	m^3/sec

$$\text{Total concentration} = \frac{(1\times0.142)+(0\times0.58)}{0.142+0.58}$$

$$= 0.2 \quad \text{mg/l}$$

Based on U.S. EPA. (in Copes, Chastaganer, and Hummel, 2004), chlorine dioxide impacts on living things, when used, chlorine dioxide will be in the ionized form of chlorite (ClO_2^-). The concentration of ClO_2^- will affect fish species and inverterbrates as follows:

- Bluegill Sunfish: LC_{50} ranges from 244-420 ppm (mg/l).
- Rainbow Trout: LC_{50} ranges from 203-360 ppm (mg/l).
- Mysid Shrimp: EC_{50} (96 hrs.) equals to 576 ppb (0.576 mg/l).

According to the review of paper belonging to AWWA Research Foundation Tailored Collaboration about the Impact of Chlorine Dioxide on Transmission, Treatment, and Distribution System Performance (Source: https://books.google.co.th/books?Isbn = 1583213937), toxicity of chlorine dioxide to phytoplankton is as follows:

- Green algae *(Cladophora* sp.): When the concentration of ClO_2 is 2.6 mg/l, chlorophyll-a will change within 24 hours.
- *Microcytis pyrifera*: When exposed to ClO_2 at the concentration of 5.2 mg/l for 4 days, the cell shape will change.

Moreover, the above AWWS's paper mentions the concentration of chlorite (ClO_2^-) (produced by ClO_2), which affects phytoplankton species

- Green algae *(Selenastrum capricornutum):* EC_{50} within 4 days ranges has the concentration of 1.32 mg/l (Study of impacts while phytoplankton population grow fully) and the concentration that leads to EC_{50} within 96 hours (studied while the population is increasing and nitrate is required for growth) is 0.835 mg/l
- Brown algae *(Ectocarpus variabillis*): The lowest concentration that affects phytoplankton (LOEC) within 14 days is 250 mg/l

Based on such concentration, potential impacts of chlorine dioxide (ClO_2) in the form of chlorite (ClO_2^-) is evaluated. The resulting concentration when the effluent is discharged into Huai Phu Sai in the worst case scenario is as follows: In the dry season, chlorite in Huai Phu Sai will be about 0.2 mg/l, which is lower than the level from the study of impacts on sensitive aquatic living things, such as mysid shrimp. It is also more than 50% (EC_{50}) lower than the concentration that affects phytoplankton cells. It is very low compared with C_{50} of the studied fish. Hence, it is evaluated that impacts of the project's effluent on living things in Huai Phu Sai is at a low level.

In addition, the review of the Material Safety Data Sheet of sodium chlorite solution, Vulcan Chemicals (2002) found that regarding fish toxicity, LC_{50} for 48 hours that affects crustacea *(Daphnia magna*) equals to 0.29 mg/l Based on the reference value of $LC_{50,}$ it is evaluated that chlorite from the effluent released from the project into Huai Phu Sai will not affect fish or other aquatic animals and phytoplankton. Also, it has minimal impact on zooplankton (taking into account LC_{50} of *Daphnia magna*).

- **Impacts on Dok Krai Reservoir**

Evaluation ctiteria are given below.

- The minimum flow rate of Huai Phu Sai in Dok Krai Reservoir in the dry season is used to evaluate the impacts.
- ClO_2 that is released into Huai Phu Sai will be in the form of chlorite (ClO_2^-). Evaluation consists of:

Analysis of ClO_2^- from Huai Phu Sai into Dok Krai Reservoir.

$$CT = \frac{C_1Q_1 + C_2Q_2}{Q_1 + Q_2}$$

C_T = Total ClO_2^-

C_1 = ClO_2^- in Huai Phu Sai

C_2 = ClO_2^- in Dok Krai Reservoir

Q_1 = Flow Rate in Huai Phu Sai in the dry season

Q_2 = Water volume rate in Dok Krai Reservoir per second

$$C_T = \frac{(0.2 \times 0.58) + (0 \times 775.46)}{(0.58 + 775.46)}$$

$$= 0.0001 \text{ mg/l}$$

Compared with the above reference document about toxicity level, the minimum value of ClO_2^- in water from Huai Phu Sai, flowing into Dok Krai Reservoir that affects aquatic living things is 0.29 mg/l (LC_{50} within 48 hours of *Daphnia magna*). The minimum value of ClO_2^- in water from Huai Phu Sai, flowing into Dok Krai Reservoir that affects phytoplankton is 0.835 mg/l It is apparent that ClO_2^- in Dok Krai Reservoir is lower than the one which is harmful to phytoplankton, zooplankton, and aquatic animal, such as fish, etc. As a result, the overall impact on aquatic ecology in Dok Krai Reservoir is at a low level. Meanwhile, there will be no impact on fisheries because ClO_2^- is very low and it is not harmful to fishing resources (fish, shrimp). Moreover, ClO_2^- in water will be converted into chloride, which is not dangerous to aquatic living things (The value is lower than brackish water criteria.) However, aquatic ecology, fisheries and aquatic animal production measures are established by the project, such as releasing aquatic animal species into Huai Phu Sai and Dok Krai Reservoir, etc.

7) Evaluation of ammonia impacts from effluent from the cooling tower

The project will employ ammonia for 2 purposes.

(1) Aqueous Ammonia 25% of 6,900 m^3 per year will be used to control nitrogen dioxide from the combustion of fuel involved in power generation. nitrogen dioxide will be emitted to the air instead of water bodies.

(2) Aqueous Ammonia 25% of: 45 m^3 per year will be used to control water quality in a boiler/the pipe system of boiler, which will later become the effluent combined with cooling water of about 60,560 m^3/day. After evaporation, the effluent will be 12,232 m^3/day.

- Ammonia solution 25%: This means one liter of the solution contains 250 grams of ammonia. The amount of 45 m^3/year, or 0.12 m^3/day of this solution will be employed. Ammonia content will be 30,000,000 milligrams per the cooling water of 60,560 m^3/day. However, the cooling water will be evaporated by the cooling tower 4.95 times (60,560 ÷ 12,232). Therefore, the remaining ammonia will be 6,060,606 milligrams.

- The concentration of ammonia in the effluent from the cooling system is 0.49 mg/l (6,060,606 ÷ (12,232 x 1,000)).

The effluent from the cooling system of the project will be released into Huai Phu Sai with the following details.

- The discharge rate of effluent from the project will be 0.142 m^3/sec. and the concentration of ammonia will be 0.49 mg/l
- The average flow rate in Huai Phu Sai in the dry season will be 0.58 m^3/sec. and the concentration of ammonia in Huai Phu Sai will be 0.1 mg/l
- The average ammonia in water in Huai Phu Sai combined with the effluent from the cooling system of the project will be 0.18 mg/l According to surface water quality standards from the Announcement of the National Environment Board, No. 8 (November, B.E. 2537), the ammonia level in water bodies, Class 1, Class 2 and Class 3, which are clean water bodies suitable for living things, shall not exceed 0.5 mg/l Therefore, when the effluent from the cooling system is discharged into Huai Phu Sai, the total ammonia in Huai Phu Sai will still meet the standards. This will not affect aquatic ecology. As ammonia evaporates from water body, ammonia level will reduce. Aditionally, ammonia will not accumulate in Dok Krai Reservoir as water is pumped from the reservoir and ammonia can evaporate from water.

8) Evaluation of use of phosphate in boiler that leads to eutrophication

Phosphate will be used in the boiler of the power plant to prevent slag. The remaining water in the boiler will become the effluent that is combined with the effluent from cooling system at the discharge rate of 12,232 m^3/day.

The 10% phosphate concentration will be applied in the project (One liter of solution contains 100 grams of Na_3PO_4.). Each year, 30 m^3 of phosphate will be required, or 0.08 m^3/day on average. Based on Na_3PO_4 formula, phosphate content will be as follows: 164 grams of Na_3PO_4 contain 95 grams of phosphate content, or 0.579. Phosphate content before use in the bolier is 4,632,000 mg/day (100 g x 0.579 x 0.08 m^3 x 1,000 l x 1,000 mg) If the entire 0.08 m^3 of phosphate solution is used in the boiler (Not the entire phosphate solution is employed in the project operation) without thermal degradation, when combined with the effluent from the cooling tower, the concentration of phosphate released into the outside will be 0.38 mg/l (4,632,000 ÷ (12,232 x 1,000)) and the phosphorus content will be 0.12 mg/l

The study of phosphate level that causes eutrophication in freshwater in Ecological Toxicology (Maliwan Boonsanue, 2012) reveals that phosphate content that lead to eutrophication is 1.3 mg/l with approx. 9.1 mg/l of TKN in water. (The production of phytoplankton and algae cells needs the ratio of phosphorus to nitrogen 7:1.) The released value has the concentration of 0.12 mg/l The data of water quality in Huai Phu Sai show that TKN equals to 0.2 mg/l and phosphorus (calculated from the phosphate level of 1.01 mg/l) equals to 0.33 mg/l The concentration of phosphorus in Huai Phu Sai in front of the project location combined with the effluent from the project will decrease (When the average flow rate in Huai Phu Sai in the dry season is 0.58 m^3/sec) to 0.29 mg/l and TKN in Huai Phu Sai equals to 0.2 mg/l Hence, the ratio of nitrogen to phosphorus is 0.69:1, which is less than 7:1, so, it will not cause eutrophication. Phosphate will be swept away by water mass of Dok Krai Reservoir, or bonded to calcium in water or suspended sediment and some will be pumped together with water mass, resulting in low eutrophication. Nontheless, according to the review of technical documents, monitoring of eutrophication can be performed through the measurement of chlorophyll a. Therefore, chlorophyll a and phosphate monitoring are included in the surface water quality monitoring measures of the project.

9) Evaluation of impacts from benthos after the project is implemented

According to the measures of Pluak Daeng Industrial Park in the EIA report, the IPP in the Industrial Park has to separate wastewater into 2 parts.

(a.) Wastewater from power generation process consists of wastewater from water treatment system, laboratory wastewater and sanitary wastewater. After receiving treatment and quality check, <u>it shall be carried to the central wastewater treatment system of Pluak Daeng Industrial Park.</u>

(b.) The effluent from the cooling water system of the power plant, which will be held in the cooling water holding pond for quality check and <u>shall be carried to the cooling water holding pond of Pluak Daeng Industrial Park</u>.

Hence, wastewater will not be directly discharged into natural water bodies; it will receive treatment according to the requirements of Pluak Daeng Industrial Park with quality check before being conveyed to the Industrial Park. The online monitoring system will be installed at the cooling water holding ponds and the wastewater holding pond of the project. In case the effluent does not meet the standards, it will be carried to the emergency pond for treatment prior to carrying to the Industrial Park.

BOD Impacts on benthos: Before and after the project operation, in the dry and the rainy seasons, BOD in Huai Phu Sai is not much different (Before and after the project operation in the dry season, BOD equals to 2.2 and 2.16 mg/l, respectively; meanwhile in the rainy season, BOD equals to 2.2 mg/l). Additionally, the measurement result of dissolved oxygen at the monitoring station in Huai Phu Sai is relatively high (8.2

mg/l) and sufficient for BOD degradation. Therefore, water is not polluted and it affects benthos and aquatic living animals at a low level.

TDS from the cooling system will be discharged into the cooling water holding pond of the project before releasing into the cooling water holding pond of Pluak Daeng Industrial Park and Huai Phu Sai. As a result, The average TDS in Huai Phu Sai will be about 445.26 and 286.50 mg/l in the dry and the rainy seasons, respectively. These TDS values are lower than 5,000-15,000 mg/l It is concluded that the project operation will cause the slight increase in TDS in Huai Phu Sai. Furthermore, it will not cause brackish water. Thus, the impacts on survival of benthos and aquatic living things are at the low level.

Chlorine dioxide will be used to eliminate slime mold and micro-organism in the cooling system. The coling blowdown will be collected and carried to the cooling water holding pond of the project for at least 1 day before being released into the cooling water holding pond of Pluak Daeng Industrial Park and the effluent will be drained into Huai Phu Sai. Chlorine dioxide will be converted into chlorite which may affect aquatic living organisms, especially sessile benthos which move slowly. However, the concentration of chlorite in the effluent from the cooling system will not exceed 1 mg/l, or about 0.2 mg/l for the maximum discharge rate of 12,280 m^3/day, or 0.142 m^3/sec (natural gas as fuel scenario and 100% Load/Full load) (no discharge from the central wastewater treatment system of Pluak Daeng Industrial Park in the dry season, except the effluent from the cooling water holding pond of the power plant) The average flow rate of Huai Phu Sai is 0.58 m^3/sec. According to the evaluation of impact from chlorine dioxide, which is in the form of chlorite, on Huai Phu Sai in case the discharge is done in the dry season, it will be very low. Chlorite from the project operation in Huai Phu Sai will be about 0.2 mg/l, which is less than the value from the study of impacts on sensitive aquatic living things, such as mysid shrimp (EC_{50} (96 hrs) = 0.576 mg/l), etc. Apart from this, the stronger current in Huai Phu Sai will dilute the concentration of chlorite. Therefore, it is forecast that the effluent from the project will have low impacts on living things in Huai Phu Sai.

5.2.2 Terrestrial Ecology

5.2.2.1 Forest Resources

(1) Construction Phase

Pluak Daeng Power Plant Project is located in Pluak Daeng Industrial Park, Map Yang Phon sub-district, Pluak Daeng district, Rayong province. Pluak Daeng Industrial Park shall complete land leveling before making the hand-over to the project. Currently, land leveling is undertaken partially, as illustrated in **Photo 5.2.2-1.** Due to no forest resource in the project area, the construction of Pluak Daeng Power Plant Project will not affect forest resources. As a result, no impact will arise (No impact).

(2) Operation Phase

The power plant project will use natural gas as a primary fuel. Potential major impacts from the project operation include air quality and surface water quality. Environmental impact prevention and mitigation measures are established as detailed below.

- Air quality: Air pollutant emission rates from emission stacks shall not exceed the setting standards in the EIA report. Dry Low NO_x (DLN) combustion shall be applied to control NO_x during combustion in case of natural gas as fuel scenario. Water Injection NO_x combustion shall be applied to control NO_x during combustion in case of diesel oil as fuel scenario.

PHOTO 5.2.2-1 : EXISTING CONDITION IN PLUAK DAENG INDUSTRIAL PARK

- Surface water quality: The cooling water effluent quality shall be controlled for compliance with the measures of Pluak Daeng Industrial Park. The Industrial Park requires that the quality of cooling water shall meet the Notification of Ministry of Industry, No.2 (B.E.2539) on determination quality of wastewater discharged from factories. Total dissolved solids (TDS) shall meet standard quality of water discharge to irrigation canal. The online monitoring system shall be installed to measure the temperature, pH, conductivity and dissolved oxygen at the cooling water holding ponds of the power plant. The monitoring results shall be reported to the display in front of the project area and wastewater control center of Pluak Daeng Industrial Park.

According to the field survey results, forest resources were not found in the 5 km radius of the study area from the boundary of the project area. Plants scattered only on the roadside. Land use comprises community area, government compound, industrial estate, reservoir and agriculture area, etc. Hence, it will affect terrestrial ecology at a low level (Negative impact level = 1).

5.2.2.2 Wildlife Resources

(1) Construction phase

Pluak Daeng Power Plant Project is located in Pluak Daeng Industrial Park, Map Yang Phon sub-district, Pluak Daeng district, Rayong province. The Industrial Park shall complete land leveling before delivering the land to the project. Currently, part of the area is leveled, as shown in **Photo 5.2.2-1.** The construction of Pluak Daeng Power Plant Project will not affect wildlife resources as the area is not the shelter and foraging habitat of wild animals (No impact).

(2) Operation Phase

During the operation phase, there will be power generation activity only within the project area. Air pollutant emission control measures and the project's effluent characteristics are established. Therefore, the project operation will not disturb or affect wildlife resources. It is expected that certain species of wild animals, such as pigeons, that are able to adapt to the environment will live in the project area. Overall, the project operation will not affect wildlife resources (No impact).

5.3 HUMAN USE VALUES

5.3.1 Transportation

(1) Construction phase

The project development during the construction phase comprises transportation of equipment, machinery, construction workers and construction materials for the project construction. The activities will affect traffic volume in the area. Traffic volume on highways and roads around the project area and nearby areas are employed to evaluate transportation impacts. Moreover, the increased traffic volume due to the project development is adopted for the evaluation of the proportion of traffic volume to highway capacity and other related road capacity. The v/c ratio is taken into account for evaluation of traffic flow in the area at present and during the project development. Details are given below.

- Vehicles are categorized into 8 types. The Passenger Car Unit (PCU) is calculated from Passenger Car Equivalents (PCE) as shown in **Table 5.3.1-1.**
- Where V is the traffic volume (from PCU peak hour), the v/c ratio is calculated for comparison with the standard of the Traffic Engineering Division, which shall not exceed 0.8 (80%). Highway capacity by type is shown in **Table 5.3.1-2**.

TABLE 5.3.1-1
WEIGHTED VALUE OF EACH TYPE OF VEHICLE

Vehicles	Passenger Car Equivalents Factor (PCE)
Passenger car and taxi	1.00
Light bus	1.25
Heavy bus	2.00
Light truck	1.50
Medium truck	1.75
Heavy truck	2.00
Motorcycle	0.33
Two-wheelers, tricycle	0.20

Source : Phaophong, 1997 and Department of Highways, 2001

TABLE 5.3.1-2

HIGHWAY CAPACITY BY TYPE

Type of Highway	Traffic Carrying Capacity (vehicle/hr.)
Multi-lane highway	2,000 (per 1 lane)
Bidirectional 2 lanes	2,000 (bidirectional)
Bidirectional 3 lanes	4,000 (bidirectional)

Source : Paopong, 2540

The comparison of v/c ratio standard for future traffic flow conditions is made as shown in **Table 5.3.1-3.**

- The v/c ratio is calculated to evaluate impacts on traffic flow on highways and roads in the project area and vicinities. Traffic volumes on highways and roads **(Table 4.3.2-1** to **Table 4.3.2-3)** are applied to calculate PCU as shown in **Table 4.3.2-7.**

According to the evaluation, the existing v/c ration before the project development was 0.16-0.33 (2015). This means highways and roads adjacent to the project area has a very high traffic flow as shown in **Table 5.3.1-3**.

TABLE 5.3.1-3

V/C RATIO STANDARD FOR FUTURE TRAFFIC FLOW CONDITIONS

V/C Ratio	Future Traffic Flow Conditions
0.89-1.00 hr	Severe traffic flow
0.68-0.88 hr	Very high traffic congestion
0.53-0.67 hr	Medium traffic flow
0.37-0.52 hr	Good traffic flow
0.20-0.36 hr	Excellent traffic flow

Source : Improved from the study of Phaopong, 1997

The following formula is used to calculate v/c ratio

$$\text{V/C ratio} = \frac{\text{Increased traffic volume due to project development + existing traffic volume}}{\text{Carrying capacity of each highway}}$$

During the construction phase, traffic volume will increase from the transportation of equipment, machinery, construction workers and construction materials for the project construction. The calculation of v/c ratio during the construction phase is shown in **Table 5.3.1-4.**

TABLE 5.3.1-4

MAXIMUM VEHICLES TO BE USED DURING CONSTRUCTION PHASE

Transportation	Types of Vehicle	Trips (Trip/Day)	Safety Factor (10%)
Equipment and machinery	Trailer	20	22
Construction workers	Van/light truck	96	106
Construction materials	Trailer	60	66
Total		**176**	**194**

Transportation of equipment and machinery

The transportation of equipment and machinery requires 10 trailers. There will be 20 trips/day (round trip).

- A 10% safety factor (20×1.1) = 22 trips/day
- In case of 1 day of 8 working hours

Therefore, traffic volume from transportation of machinery = 3 trips/hr

- Traffic volume due to project operation in PCU = 3×2.0 PCU/hr
  = 6 PCU/hr

Transportation of construction workers

The transportation of total 3,200 construction workers requires 48 vans/light trucks. There will be 96 trips/day (round trip).

- A 10% safety factor (96×1.1) = 106 trips/day
- In case of 1 day for 2-hour travelling (in the morning and in the evening)

Therefore, traffic volume from transportation of construction workers = 53 trips/hr.

- Traffic volume due to project operation in PCU = 53×1.5 PCU/hr
  = 79.5 PCU/hr

Transportation of construction materials

The transportation of construction materials requires 30 trailers. There will be 60 trips/day (round trip).

- A 10% safety factor (60×1.1) = 66 trips/day
- In case of 1 day of 8 working hours

Therefore, traffic volume from transportation of construction materials = 9 trips/hr

- Traffic volume due to project operation in PCU = 9×2.0 PCU/hr
  = 18 PCU/ hr

Transportation of construction workers will be in the morning and in the evening only. However, the evaluation is made in the worst case scenario. That is equipment and machinery, construction workers and construction materials are transported concurrently. The increased traffic volume will be as follows:

Trailers for transportation of equipment and machinery =6 PCU/ hr

Vans/ light trucks for transportation of construction workers = 79.5 PCU/hr

Trailers for transportation of construction materials = 18PCU/ hr

Thus, A total incremental traffic volume due to the transportation of equipment and machinery, construction workers and construction materials will be (6+79.5+18 PCU/hr) = 103.5 PCU/hr

A total incremental traffic volume due to the transportation of equipment and machinery, construction workers and construction materials will be 194 trips/day, or 103.5 PCU/hr. The v/c ratio of traffic on highways and roads will be from 0.17 hr-0.38 hr. This means activities during the construction phase will not affect traffic flow on each transportation route (**Table 5.3.1-5**). Details are given below.

- **National Highway No. 331:** At the count station at km 68+900, the existing v/c ratio is 0.16. In case of construction activities, the v/c ratio will increase to 0.17, with a very high traffic flow. Hence, impacts on the traffic condition on the National Highway No.331 will be at a low level (Negative impact level = 1).
- **National Highway No. 36:** At the count station at km 2+000, the existing v/c ratio is 0.23. In case of construction activities, the v/c ratio will increase to 0.25, with a very high traffic flow. Thus, impacts on the traffic condition on the National Highway No. 36 will be at a low level (Negative impact level = 1).
- Rural Highway No. **Ro. Yor. 2026**: At the count station at km12+300, the existing v/c ratio is 0.31. In case of construction activities, the v/c ratio will increase to 0.36, with a very high traffic flow. Therefore, impacts on the traffic condition on the Rural Road No. Ro. Yor. 2026 will be at a low level (Negative impact level = 1).
- Rural Highway No. **Ro. Yor. 3013:** At the count station at km14+250, the existing v/c ratio is 0.33. In case of construction activities, the v/c ratio will increase to 0.38, with a good traffic flow. Therefore, impacts on the traffic condition on the Rural Road No. Ro. Yor. 3013 will be at a low level (Negative impact level = 1).

TABLE 5.3.1-5

V/C RATIO ON HIGHWAYS RELATING TO PROJECT AT PRESENT AND DURING CONSTRUCTION PHASE

Locations	Traffic Volume[3/] on Road at Present (PCU/hr)	Increased Traffic volume during Construction Phase (PCU/hr)	Total traffic Volume on Road at Present and during Construction Phase (PCU/hr)	Number of Lanes	Carrying Capacity (PCU/hr)	V/C ratio	
						At Present	During Construction Phase
National Highway No. 331[1/] at Km 68+900	1,294	103.5	1,397.5	4	8,000	0.16	0.17
National Highway No. 36[1/] at Km 2+000	1,869	103.5	1,972.5	4	8,000	0.23	0.25
Rural Road No. Ro.Yor. 2026[2/] at Km 12+300	611	103.5	714.5	2	2,000	0.31	0.36
Rural Road No. Ro.Yor. 3013[2/] at Km 14+250	665	103.5	768.5	2	2,000	0.33	0.38

Remark : v/c ratio : 0.89-1.00 = Severe traffic flow 0.68-0.88 = Very high traffic congestion
0.53-0.67 = Medium traffic flow 0.37-0.52 = Good traffic flow
0.20-0.36 = Excellent traffic flow

Sources : 1/ Traffic Volume on Highways Report 2011-2015 (Department of Highways, Ministry of Transport), 2016

2/ Field traffic count results by Team Consulting Engineering and Management Co., Ltd., March 13th-14th, 2016 (The day with maximum traffic count will be applied.).

3/ Reference is traffic volume in the latest year (PCU/hr) only (existing condition).

(2) Operation phase

During the operation phase, traffic volume will increase from passenger cars, visitors' vehicles, garbage, sludge and chemical substance transport vehicles. Thus, the highest number of transport vehicles during the operation phase will be 8 7 vehicles/day, or 174 trips/day (**Table 5.3.1-6**). Details are given below.

TABLE 5.3.1-6

HIGHEST NUMBERS OF VEHICLES TO BE USED DURING OPERATION PHASE

Transportation Activities	Types of Vehicle	Numbers of Vehicle (vehicle/day)	Numbers of Trip (trips/day)
Travel of power plant staff and visitors	Passenger car	84	168
Garbage transportation	Garbage transport vehicle	1	2
Sludge generated from water treatment	Ten-wheeled truck	1	2
Transportation of chemical substance	Trailer	1	2
Total		**87**	**174**

Source : Implementation Results of Environmental Measures of Uthai Power Plant Project Report (January-June 2016) by Gulf JP UT Co., Ltd.

Travel of power plant staff and visitors

There will be 84 passenger cars/day, or 168 trips/day (round trip) of power plant staff and visitors

- A 10% safety factor (168×1.1) = 185 trips/day
- In case of 1 day for 2-hour travelling (In the morning and in the evening)

Therefore, traffic volume from transportation of staff = 93 trips/hr

- Traffic volume due to project operation in PCU = 93×1.0 PCU/hr
  = 93 PCU/hr

Garbage transportation

There will be 51 kg/day of garbage from utilization-consumption of staff. A garbage transport vehicle will collect garbage for disposal every 2 days. In the worst case scenario, the garbage shall be transported every day. There will be 1 garbage transport vehicle, or 2 trips/day (round trip).

- A 10% safety factor (2×1.1) = 3 trips/day
- In case of 1 day for 8 working hours

Therefore, traffic volume from garbage transportation = 1 trips/hr

- Traffic volume due to project operation in PCU = 1×2.0 PCU/hr
  = 2 PCU/hr

Transportation of sludge from water treatment

There will be 5 tons/day of sludge from water treatment. A 10-wheeled truck will collect it for disposal 3 times per week. In the worst case scenario, sludge shall be sent for disposal every day. There will be one 10-wheeled truck, or 2 trips/day round trip).

–	A 10% safety factor (2×1.1)	=	3	trips/day
–	In case of 1 day for 8 working hours			
	Therefore, traffic volume from sludge transportation	=	1	trip/hr
–	Traffic volume due to project operation in PCU	=	1×2.0	PCU/hr
		=	2	PCU/hr

Transportation of chemical substance

Chemical substances used in the power plant will be transported about 140 trips/year, or 3 trips/week on average by trailers. In the worst case scenario, chemical substances shall be transported every day. There will be 1 trailer, or 2 trips/day (round trip).

–	A 10% safety factor (2×1.1)	=	3	trips/day
–	In case of 1 day for 8 working hours			
	Therefore, traffic volume from chemical substance transportation			
		=	1	trip/hr
–	Traffic volume due to project operation in PCU	=	1×2.0	PCU/hr
		=	2	PCU/hr

As a result, during the operation phase, 99 PCU/hr of traffic volume will increase from the travel of the power plant staff/visitors, transportation garbage, sludge from water treatment and chemical substances. The v/c ratio will be in the range of 0.17-0.38. This will not affect traffic flow on each transportation route (**Table 5.3.1-7**). Details are given below.

- **National Highway No. 331:** At the count station at Km 68+900, the existing v/c ratio is 0.16. During the operation phase, the v/c ratio will increase to 0.17, with a very high traffic flow. Hence, impacts on the traffic condition on the National Highway No. 331 will be at a low level (Negative impact level = 1).
- **National Highway No. 36:** At the count station at Km 2+000, the existing v/c ratio is 0.23. During the operation phase, the v/c ratio will increase to 0.25, with a very high traffic flow Thus, impacts on the traffic condition on the National Highway No. 36 will be at a low level (Negative impact level = 1).

- **Rural Road No. Ro.Yor. 2026**: At the count station at Km 12+300, the existing v/c ratio is 0.31. During the operation phase, the v/c ratio will increase to 0.36 with a very high traffic flow. Therefore, impacts on the traffic condition on the Rural Road No. Ro. Yor. 2026 will be at a low level (Negative impact level = 1).

- **Rural Road No. Ro.Yor. 3013:** At the count station at Km 14+250, the existing v/c ratio is 0.33. During the operation phase, the v/c ratio will increase to 0.38, with good traffic flow. Therefore, impacts on the traffic condition on the Rural Road No. Ro. Yor. 3013 will be at a low level (Negative impact level = 1).

TABLE 5.3.1-7

V/C RATIO ON HIGHWAYS RELATING TO PROJECT AT PRESENT AND DURING OPERATION PHASE

Locations	Traffic Volume[3/] on Road at Present (PCU/hr)	Increased Traffic Volume during Operation Phase (PCU/hr)	Total Traffic Volume on Road at Present and during Operation Phase (PCU/hr)	Numbers of Lanes	Carrying Capacity (PCU/hr)	V/C Ratio	
						At Present	During Operation Phase
National Highway No. 331[1/] at Km 68+900	1,294	99	1,393	4	8,000	0.16	0.17
National Highway No. 36[1/] at Km 2+000	1,869	99	1,968	4	8,000	0.23	0.25
Rural Road No. Ro.Yor. 2026[2/] at Km 12+300	611	99	710	2	2,000	0.31	0.36
Rural Road No. Ro.Yor. 3013[2/] at Km 14+250	665	99	764	2	2,000	0.33	0.38

Remark : v/c ratio : 0.89-1.00 = Severe traffic flow 0.68-0.88 = Very high traffic congestion
0.53-0.67 = Medium traffic flow 0.37-0.52 = Good traffic flow
0.20-0.36 = Excellent traffic flow

Sources : 1/ Traffic Volume on Highways Report 2011-2015 (Department of Highways, Ministry of Transport), 2016
2/ Field traffic count results by Team Consulting Engineering and Management Co., Ltd., March 13th-14th, 2016 (The day with maximum traffic count will be applied.).
3/ Reference is traffic volume in the latest year (PCU/hr) only (existing condition).

Mitigation Measures

(1) Construction Period

- Transportation routes of construction materials and equipment shall be planned to avoid traffic problems.
- Regular review and modification of Transportation routes of construction materials and equipment shall be performed so as to be in line with current situation.
- Transport of construction materials during rush hours, i.e. from 07.30-08.30 hr and 16.00-17.00 hr, shall be avoided to reduce traffic congestion. If it is necessary to transport construction materials during rush hours, prior permission or approval shall be obtained from relevant agencies. Additionally, communities shall be notified 2 weeks in advance
- Trucks shall be covered with tarpaulin sheets to prevent materials from falling onto the road.
- Contractors shall supervise drivers to strictly follow traffic rules.
- Truck weight limits shall be controlled to comply with law.
- Drivers shall be trained and supervised to strictly follow traffic rules.
- Regular check and maintenance shall be performed for vehicles used in the project.
- Coordination with traffic police regarding transport of materials and equipment.
- Truck speed limits shall be 80 kilometers/ hour for the highway according to the Land Transport Act, B.E.2522 and the Highway Act, Volume 2 and Volume 3, B.E.2542. Also, speed limits shall not exceed 40 kilometers/hour in communities.
- A warning sign shall be installed and speed shall not exceed 20 kilometers per hour at the construction site.
- A telephone number of the responsible person shall be posted on transportation trucks as a channel for complaints to the project.
- Security guards shall be provided for facilitation at the access road.

(2) Operation Period

- Drivers shall strictly follow traffic rules.
- Transport and safety regulations shall be established for vehicles coming in and out of the Project so as to prevent accidents.
- Sufficient parking space shall be provided in a suitable area. Also, traffic signs shall be installed within the project area and the access road.
- A warning sign shall be installed and speed shall not exceed 20 kilometers per hour in the project area.

- The number of vehicles coming in the generation unit shall be limited to reduce accidents in that area.
- Types and volume of vehicles coming in the project area shall be recorded. The obtained information shall be used for traffic management in the project area, especially in the parking space, where parking outside the designated area within the Project area shall be prohibited.
- The condition of transportation vehicles shall be checked regularly.
- A telephone number of the responsible person shall be posted on transportation trucks as a channel for complaints to the project.
- Hazardous chemicals or waste transporter companies shall be supervised to strictly adhere to relevant laws. (such as the manual for transport of hazardous objects of Pollution Control Department, September 2011, the manual for hazardous chemical management and handling in the place of business, July 2013, and the Notification of Department of Industrial Works on manual for storage of hazardous chemicals and objects, B.E. 2550 and the Notification of Ministry of Industry on transportation of hazardous substances responsible by Department of Industrial Works, B.E.2558, etc.)
- Chemical substance and waste transporting vehicles shall have the clear and easy to understand warning sign. The warning sign shall contain name of chemical substance and details according to international standards, such as UN Recommendations and HAZCHEM code, etc

5.3.2 Water Use

(1) Construction phase

During the construction phase, contractors will provide construction workers water for utilization and consumption as well as construction activities.

(a) Water use for construction activities, utilization and consumption by construction workers accounts for 224 m^3/day. (calculated from 70 l/person/day (Kriangsak, 1996) with 3,200 construction workers in total) Contractors will provide water. As for drinking water, contractors will purchase bottled drinking water.

(b) About 55 m^3/day of water will be used for construction activities.

(c) Water use for spraying the project area to reduce the diffusion of dust during the construction phase will be 1,182 m^3/day. (calculated from single spraying/round = 0.75 l/sq.m, at least 2 times/day in the area of 492 rai)

Hydrostatic test water of 250 m^3 will be provided by Pluak Daeng Industrial Park.

A total water use during the construction phase of Pluak Daeng Power Project will be 1,711 m^3/day. Consequently, it will not affect water use of people in nearby communities (No impact).

(2) Operation phase

During the operation phase, there will be cooling water and water use in the process (wastewater from water treatment system, laboratory wastewater, and sanitary wastewater) with a total water use of 63,000 m^3/day. Water will be supplied by Eastern Water Resources Development and Management PLC. (East Water). The power plant will not use water from Pluak Daeng Industrial Park. East Water has a confirmation letter that it is capable of supplying adequate water for the project, as shown in **Appendix 3J**. Therefore, it will not affect water use of other business premises in Pluak Daeng Industrial Park. Furthermore, the source of water for the project is different from the one for communities, it will not affect people living in nearby communities (No impact).

Mitigation Measures

(1) Construction Period

- Contractors shall provide sufficient water for construction activities.
- Contractors shall provide sufficient and safe drinking water for construction workers.
- Contractors shall coordinate with Pluak Daeng Industrial Park for water allocation regarding hydrostatic test for natural gas transmission pipeline and fuel pipeline within the project.

(2) Operation Period

- Efficient water use shall be considered, such as reduction in water drainage from the cooling system or recirculation of water within the project, etc.
- Water pipes shall be checked. Leaking pipes shall be fixed immediately to prevent water loss.
- In the event of water shortage and Eastern Water Resources Development and Management PLC. is unable to convey water to the project, the project shall reduce power generation capacity or stop the operation.

5.3.3 Water Drainage and Flood Control

5.3.3.1 Methedology

(1) Study Method

The rational formula (Thongchai, 1991) is adopted to calculate flood in the sub-retention area and the run-off. As the water retention area of the project is less than 25 sq.km as shown in **Table 5.3.3-1,** the equation is given as follows:

$$Q = 0.278 \times 10^{-6} CIA \quad \text{................. (1)}$$

Where Q = Maximum flow rate (m^3/sec)

C = Run-off coefficient

I = Rainfall intensity (mm/sec)

A = Stormwater retention area (sq.m)

The detail of each variable is given below.

- **Run-off coefficient (C)**

The calculation of run-off coefficient (C) is adhered to the Environmental Engineering Association of Thailand (2003), which collected and determined the run-off coefficient based on the surface of the drainage area and land use pattern (**Table 5.3.3-2** and **Table 5.3.3-3**).

- **Area before the project development**

A total area before the project development is 787,682 sq.m. At present, it is an open space with land leveling and no building. This area is less developed or not developed. The run-off coefficient is 0.30 (Undeveloped area).

- **Area after the project development**

After the project development, there will be uncontaminated and contaminated run-off areas.

(a) Uncontaminated run-off area

- **Area of buildings, power block, road and green area** encompass 668,649 sq.m. After the project development, The main part of this area will become concrete lining, asphalt or roofting while part of it will be improved to serve as a green area. It is categorized as the light industry area. The average run-off coefficient is 0.70 (industrial area).

- **Storm water pond area** encompasses 46,266 sq.m. It is the stormwater holding pond. The run-off coefficient is 1.00 (pond area). However, as the rain falls directly into the pond, the uncontaminated run-off is not included in the calculation of the storm drain size. Only water volume to be retained will be considered.

TABLE 5.3.3-1
STORMWATER RETENTION AREA OF PROJECT

Components within Project Area	Approx. Area (sq.m)
(1) Uncontaminated stormwater retention area	
Concrete lining area/Roofting	
– Power block	111,318
– Gas Metering Station	6,122
– Gas compressor	2,400
– Cooling water area	33,118
– Control building	1,000
– Workshop & Warehouse Building	1,200
– Administration Building and guardhouse	800
– Water treatment and wastewater treatment area	34,108
– Power transformer area (uncontaminated area)	1,170
– Other areas, such as road, ditch, piping work area, etc.	432,413
Non-concrete lining area/non-roof area	
– Green area	45,000
Pond area	
– Raw water pond	45,358
– Stormwater pond	46,266
Total (1)	**760,273**
(2) Contaminated stormwater retention area	
Concrete lining area/Roofting	
– Diesel storage tank area	6,726
– Power transformer area	390
Pond area	
– Cooling water holding pond	20,221
– Wastewater holding pond	72
Total (2)	**27,409**
Grand Total Area (sq.m)	**787,682**

Source : Gulf PD Co., Ltd, 2016

TABLE 5.3.3-2
RUN-OFF COEFFICIENT BASED ON SURFACE OF DRAINAGE AREA

Surface	Run-off Coefficient
Paving Material	
– Asphalt or concrete	0.70-0.95
– Brick or worm concrete paving block	0.70-0.85
Roof	0.75-0.95
Field (Sandy soil)	
– 2% plain-slope	0.05-0.10
– 2-7% slope	0.10-0.15
– 7% slope or more	0.15-0.20
Field (compacted soil)	
– 2% plain-slope	0.13-0.17
– 2-7% slope	0.18-0.22
– 7% slope or more	0.25-0.35

Source : Environmental Engineering Association of Thailand, 2003

TABLE 5.3.3-3
RUN-OFF COEFFICIENT BASED ON LAND USE PATTERN

Land Use Pattern	Run-off Coefficient
Business zone	
– High-density	0.70-0.95
– Around business	0.50-0.70
Residential zone	
– Nuclear family	0.30-0.50
– Extended family (separate)	0.40-0.60
– Extended family (adjacent)	0.60-0.75
Residential zone (suburban)	0.25-0.40
Apartment zone	0.50-0.70
Industrial zone	
– Light	0.50-0.80
– Heavy	0.60-0.90
Public park	0.10-0.25
Playground	0.20-0.35
Railway station and railway junction	0.20-0.35
Waste land	0.10-0.30

Source : Environmental Engineering Association of Thailand, 2003

- **Raw water pond** encompasses 45,358 sq.m. The pond stores water for the production process of the project and holds rainwater falling in the pond area. The run-off coefficient is 1.00 (pond area). However, as the rain falls directly into the pond, the uncontaminated run-off is not included in the calculation of the storm drain size, or water volume to be retained.

(b) Contaminated run-off area

- Dike to prevent the leak from the diesel storage tank area covers 6,726 sq.m. The dike is similar to a dam or a reservoir that is likely to be oil-contaminated. The run-off coefficient is 1.00 (pond area). However, the potential oil-contaminated run-off shall be carried to the oil separator. Therefore, the contaminated run-off is not included in the calculation of the storm drain size or water volume to be retained in the storm water pond.

- **Transformer area** covers 390 sq.m and is likely to be oil-contaminated. The run-off coefficient is 0.9 (concrete lined floor). However, the potential oil-contaminated run-off shall be carried to the oil separator. Therefore, the contaminated run-off is not included in the calculation of the storm drain size or water volume to be retained in the storm water pond.

- **Wastewater holding pond and cooling water holding pond areas** cover 20,293 sq.m. These ponds hold the effluents before they are released into the outside. The run-off coefficient is 1.00 (pond area). However, as the rain falls directly into the pond, the contaminated run-off is not included in the calculation of the storm drain size, or water volume to be retained.

- **Return period**

Based on the criteria for designing the drainage channel of the Royal Irrigation Department, a 10-year return period of equal rainfall or greater will be used for the calculation of hydrological conditions of the area before and after the project development and the design of the stormwater collection and drainage systems of the project as the project is located in the industrial park and land leveling is undertaken.

- **Time of Concentration (Tc)**

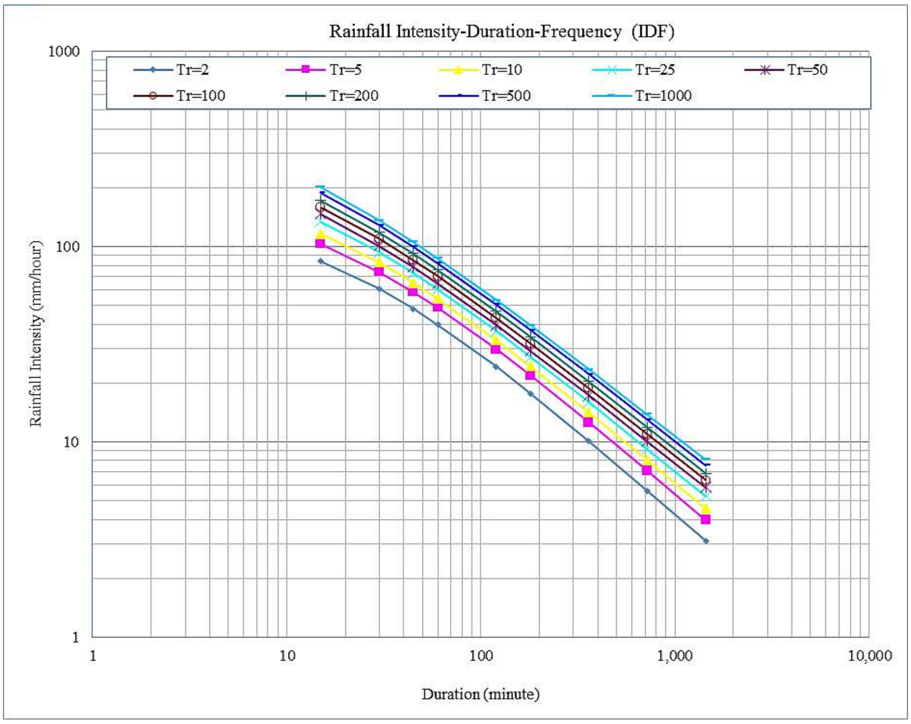
Time of Concentration (Tc) for the design of storm water pond and the storm drain system of the area after the project development according to the approach of the Environmental Engineering Association of Thailand (2003) is determined below.

- **Area before project development:** The entire wasteland with land leveling and no building is less developed. The area is plain with minimum slope. Time of Concentration (Tc) is 20-30 minutes. As a result, time of Concentration (Tc) to the outfall during the pre-development phase is 30 minutes or 0.50 hour.

- **Area after project development:** Mainly, the area will be developed to the concrete lined or roof area, such as building, access road, etc. Hence, the run-off cannot percolate to soil. It is considered the highly developed area, which is flat with minimum slope. Time of Concentration (Tc) is 10-15 minutes. As a result, time of Concentration (Tc) during the development phase is 15 minutes or 0.25 hour.

- **Rainfall Intensity (I)**

According to the survey, the nearest rainfall station to the project location is Rainfall Station Z.4 in Pluak Daeng district, Rayong province. As Pluak Daeng Rainfall Station measured and collected the rainfall data up to 1988 (1967-1988), the project applied Gumbel distribution to analyze the rainfall data from Rayong Rainfall Station from 1990-2011 (Meteorological Department, 2014). The analyzed rainfall data will be the representative of Pluak Daeng Rainfall Station **(Figure 5.3.3-1)**. Taking into account the return period and time of concentration (TC) to the outfall (storm drain), rainfall intensity (I) will be as follows:



Source : Data from Meteorological Department, Rayong Rainfall Station 1990-2008
Analyzed by Team Consulting Engineering and Management Co., Ltd., 2014

FIGURE 5.3.3-1 : RAINFALL DURATION FREQUENCY CURVE OF PLUAK DAENG RAINFALL STATION

- **Area before project development:** With the 10-year return period and and time of concentration (Tc) of 0.50 hour, rainfall intensity (I) will be 82.85 mm/hr.
- **Area after project development:** With the 10-year return period and and time of concentration (Tc) to the storm drain is 0.25 hour, rainfall intensity (I) will be 116.22 mm/hr.

However, to make the evaluation and the design of the storm drain of the project comprehensive, rainfall intensity (I) of 116.22 mm/hr. will be applied both in the pre-development and development phases.

5.3.3.2 Study Results

(1) Construction phase

A total area before the project development is 787,682 sq.m. It is an industrial area with land leveling and no building. This area is less developed. The run-off coefficient is 0.30. Mostly, rainfall in this area is permeable to the soil. The maximum flow rate is 7.63 m^3/sec. During the construction phase, the existing condition of the area is concrete lining or roof area. So, soil permeability will be more difficult. Run-off coefficient will be higher than the existing condition and the run-off increases according to the construction schedule of the project. When the construction is completed, it will increase from 7.63 m^3/sec to 15.12 m^3/sec.

Temporary storm drains are designed along the edge of the road or buildings during the construction phase. The storm drain system separates contaminated run-off and uncontaminated run-off. The uncontaminated run-off will be collected and conveyed to the 99,797 m^3 storm water pond of the project which can hold water for 3 hours. The duration of time allows sedimentation before releasing clear water into the storm drain of Pluak Daeng Industrial Park, as depicted in **Figure 3.11-1.** The stormwater pond will be constructed at the beginning of the project construction. The storm drain system will be improved to be the permanent re-inforced one during the operation phase.

Furthermore, the storm drain and the storm water pond of Pluak Daeng Industrial Park are designed to accommodate the maximum flow rate of 51 m3/sec, which is highly sufficient for the potential run-off due to the project development. Therefore, the project development will not affect nearby areas (No impact).

(2) Operation phase

(a) Uncontaminated run-off

<u>Run-off volume before project development</u>

Before being developed, the area of leveled land which covers 787,682 sq.m has no building. It is less developed. The run-off coefficient is 0.30. Rainfall intensity (I) is 116.22 mm/hr. The formula to calculate the run-off is given below.

Maximum flow rate = $0.278 \times 10^{-6} \times 0.30 \times 116.22 \times 787{,}682$
= 7.63 m^3/sec
= 27,485 m^3/hr

<u>Run-off volume after project development</u>

- **Area of buildings, power block, road and green area** encompass 668,649 sq.m. After the project development, The main part of this area will become concrete lining, asphalt or roofting while part of it will be improved to serve as a green area. The average run-off coefficient is 0.70. Rainfall intensity (I) is 116.22 mm/hr. The formula to calculate the run-off is given below.

Maximum flow rate = $0.278 \times 10^{-6} \times 0.70 \times 116.22 \times 668{,}649$
= 15.12 m^3/sec
= 54,441 m^3/hr

- **Storm water pond area** encompasses 46,266 sq.m. It is the stormwater holding pond. The run-off coefficient is 1.00. Rainfall intensity (I) is 116.22 mm/hr

Maximum flow rate = $0.278 \times 10^{-6} \times 1.00 \times 116.22 \times 46{,}266$
= 1.49 m^3/sec
= 5,381 m^3/hr

However, as the rain falls directly into the pond, the uncontaminated run-off is not included in the calculation of the storm drain size. Only water volume to be retained will be considered.

- **Raw water pond** encompasses 45,358 sq.m. The pond stores water for the production process of the project and holds rainwater falling in the pond area. The run-off coefficient is 1.00. Rainfall intensity (I) is 116.22 mm/hr. The formula to calculate the run-off is given below.

Maximum flow rate = $0.278 \times 10^{-6} \times 1.00 \times 116.22 \times 45{,}358$
= 1.47 m^3/sec
= 5,276 m^3/hr

However, as the rain falls directly into the pond and water is used for the production process, it is not included in the calculation of the storm drain size, or water volume to be retained.

So, the maximum flow rate for the design of the storm drain system will be 15.12 m^3/sec, or 54,441 m^3/hr (excluding the run-off of storm water pond and raw water pond).

Change in run-off volume before and after project development

Taking into account the change in uncontaminated run-off before and after the project development, the run-off will increase from 7.63 to 16.59 m^3/sec after the project development, or 8.95 m^3/sec (32,231 m^3/hr). Therefore, water retention is required to reduce hydrological impacts on the outside area. Stormwater shall be retained for at least 3 hours. The formula to calculate the pond size is given below.

$$v = Qt \qquad \text{................. (2)}$$

Where v =Volume needed for storm water pond, m^3/hr

Q = Run-off volume to be retained, m^3/hr (32,231 m^3/hr)

t = Time needed for water retention, hr (3 hr)

Thus,

$$v = 32{,}231 \ m^3/hr. \times 3 \ hrs$$

$$= 96{,}694 \ m^3$$

The two storm water ponds with the total capacity of 99,797 m^3 of the project can retain the entire incremental run-off, with no overflow outside. In addition, the drainage system of Pluak Daeng Industrial Park is capable of holding the maximum rainfall of 51 m^3/sec. **(Appendix 3Z).** Therefore, it is capable of holding the entire run-off in the project area and will not affect nearby areas (No impact).

(b) Contaminated run-off

Run-off volume before project development

Before being developed, there is no building in this area of leveled land. It is expected that no oil-contaminated activity is performed. Therefore, the run-off is not contaminated.

Run-off volume after project development

Contaminated run-off area

- **Dike to prevent the leak from the diesel storage tank area** covers 6,726 m^2. The dike is similar to a dam or a reservoir that is likely to be oil-contaminated. The run-off coefficient is 1.00. Rainfall intensity (I) is 116.22 mm/hr. The formula to calculate run-off volume is given below.

$$\text{Maximum flow rate} = 0.278 \times 10^{-6} \times 1.00 \times 116.22 \times 6{,}726$$

$$= 0.22 \ m^3/sec$$

$$= 782 \ m^3/hr$$

- **Transformer area**: This concrete lined area is likely to be oil-contaminated for 390 m^2. The run-off coefficient is 0.90. Rainfall intensity (I) is 116.22 mm/hr. The formula to calculate run-off volume is given below.

Maximum flow rate = $0.278 \times 10^{-6} \times 0.90 \times 116.22 \times 390$
= 0.01 m^3/sec
= 41 m^3/hr

- **Wastewater holding pond and cooling water holding pond areas** cover 20,293 m^2. These ponds hold the effluents before they are released into the outside. The run-off coefficient is 1.00. Rainfall intensity (I) is 116.22 millimeters/hour. The formula to calculate run-off volume is given below.

Maximum flow rate = $0.278 \times 10^{-6} \times 1.00 \times 116.22 \times 20{,}293$
= 0.66 m^3/sec
= 2,360 m^3/hr

However, as the rain falls directly into the pond, it is not included in the calculation for design of the drainage system of the project.

As a result, the contaminated run-off of the project, namely, run-off volumes from the diesel storage tank area and the transformer area are 0.23 m^3/sec, or 823 m^3/hour. This volume is less than maximum capacity of 11,116 m^3 of dike to prevent the leak. This capacity can hold water for more than 24 hours (Calculation details are shown in **Appendix 2S**). The contaminated stormwater will be conveyed to an oil separator. As a result, it will not affect nearby areas (No impact).

From the calculation above showed that stormwater management of the Pluak Deang Power Plant Project complies with EHS guidelines.

Mitigation Measures

(1) Construction Phase

- Debris and waste generated from construction activities shall be collected and sorted before sending to the authorized agency for proper disposal so as to prevent bebris and construction waste from clogging the drainage ditch of the project.
- The storm drainage system of the project shall be designed to prevent blockage of existing waterway and flooding in adjacent areas.
- Construction waste and construction debris shall not be dumped into the drainage ditch.
- Regular maintenance shall be performed for the drainage ditch to prevent clogging.

(2) Operation Phase

- Storm drains shall be provided in the project area and connected with the stormwater drainage system of Pluak Daeng Industrial Park.
- The storm water ponds of at least 99,797 cu.m. shall be provided. The storm water ponds shall hold stormwater for 3 hours for appropriate drainage rates and flood prevention in the project area.

- Contaminated stormwater shall be discharged to the oil separator to separate oil before releasing to the wastewater holding pond for quality check based on effluent standards established by Pluak Daeng Industrial Park. The effluent will then be drained into the central wastewater treatment system of Pluak Daeng Industrial Park.
- The storm drains shall be checked continuously and regularly to prevent clog.
- Drainage ditches shall be cleaned in the dry season each year to increase the efficiency of drainage in the project area.
- The responsible agencies for Huai Phu Sai shall be supported for dredging activity.
-

5.3.4 Solid Waste Management

(1) Construction phase

During the construction phase, there will be about 3,200 construction workers. About 2,720 kg/day (calculated from solid waste of 0.85 kg/person/day, Kriangsak Udomsinrot, 1994) of general waste will include plastic, waste paper, glass bottle, plastic bottle, etc. Contractors shall provide 200-liter covered waste bins. At least, the number of 46 covered waste bins is required (0.3 kg of waste density/l) to hold the solid waste within the project area and around the field office. It shall be specified in the contract that the contractor deals with solid waste management.

Solid waste/ construction waste will include material scrap from soil excavation, such as dirt and sand, broken brick, etc.; construction waste, such as structural scrap or material scrap, etc. and hazardous waste, such as battery, used lubricant oil, hydraulic oil, filter, mineral oil, detergent or used solvent, coatings, poor quality paint, ect. The project will provide special areas for the storage of each type of solid waste. Also, suitable containers will be used to collect the solid waste. The recycled waste will be kept or sold to buyers. Hazardous waste will be collected and disposed of by the agency authorized by Department of Industrial Works.

As a result, during the construction phase, solid waste management will not affect communities (No impact).

(2) Operation phase

There will be 2 types of waste generated from the project operation: waste not required permission for removal from the factory and waste required permission for removal from the factory according to Notification of Ministry of Industry on industrial waste disposal, B.E.2548.

(a) industrial waste not required permission for removal from the factory according to Notification of Ministry of Industry on industrial waste disposal, B.E.2548

General waste according to the Public Health Act, B.E.2535 includes waste paper, material scrap, and food scraps. There will be 60 project staff. It is predicted that 51 kg of solid waste/day will be generated (calculated from 0.85 kg of solid waste/person/day, Kriangsak Udomsinrot, 1994). General waste will be placed in covered waste bins and sent for disposal to the local agency or the authorized company.

(b) industrial waste required permission for removal from the factory according to Notification of Ministry of Industry on industrial waste disposal, B.E.2548

- **Used lubricant oil and oil from an oil separator:** About 800 liters/month of deteriorated oil will be stored in a 200-liter covered steel tank. The tanks will be placed in the hazardous waste storage area of the project. After that, they will be sent for disposal to the company authorized by Department of Industrial Works.
- **Used resin:** About 1 m^3/year of resin will be replaced. Used resins will be returned to the distributors or stored in a 200-liter tank, collected and placed in plastic bags and sent for disposal to the company authorized by Department of Industrial Works.
- **Used air filter:** This device prevents dust from sticking in a gas turbine. This is because dust will reduce the effectiveness of the gas turbine. Air filters will be replaced every 1.5 years. Air filters of approx. 47,040 kg/1.5 years will be used. Used air filters will be compiled and stored in the gas turbine building and sent for disposal to the company authorized by Department of Industrial Works.
- **Sludge generated from water treatment:** About 5 tons/day of sludge will be separated from raw water in the water treatment system. Sludge will be stored in a sludge hopper, which is located in the water treatment plant. It will be sent for disposal 3 times per week by the company authorized by Department of Industrial Works.

During the operation phase, solid waste management will comply with the Notification of Ministry of Industry on industrial waste disposal, B.E.2548 or other government agencies. Solid waste will be collected, stored and transported for disposal by the company authorized by Department of Industrial Works. Therefore, it is predicted that the impact caused by the project's solid waste management will be at a low level (Negative impact level = 1).

Mitigation Measures

(1) Construction Phase

- Responsible workers shall be assigned to collect solid waste in the designated area at least once a day.
- Hazardous waste shall be sent for disposal to the agency authorized by government agencies according to the Notification of Ministry of Industry on disposal of waste or unusable materials, B.E. 2548.
- Adequate covered waste bins shall be provided in the areas at the construction site. Coordination shall be made with the agency authorized by government agencies for waste collection and disposal. Waste disposal shall be made at the disposal sites.
- Scraps of materials, dirt and construction waste shall be compiled, packed and disposed in an appropriate way.
- Oil management, such as oil change, construction materials, etc. shall be controlled. The oil shall be contained in a drum and carried for disposal by the agency authorized by government agencies.
- Construction workers shall be supervised to throw solid waste in a waste bin. Waste shall be disposed regularly.
- Stackpiles shall be place in the designated area.
- Waste shall not be incinerated at the construction site.
- The collected recyclable waste of the project, such as scraps of wood, scrap iron, rubble, paint tin, paint brush, spray can, etc. should be sorted for reuse or sale to waste purchasing companies.
- Contractors shall coordinate with the Sub- district Administrative Organization or the agency authorized by local government agencies for collection so that the solid waste is not left in the project area, which will be the carrier of diseases and the source of unpleasant smell.

(2) Operation Period

- Adequate covered waste bins shall be provided for solid waste collection. Collected waste shall be carried for disposal by the agency authorized by government agencies. Waste disposal shall be made by means required by law.
- A storage place for solid waste shall be provided. The storage place shall be roofted and floored with concrete. Waste shall be sorted and labelled.
- The collected recyclable solid waste should be sorted and utilized as much as possible or sold to waste purchasing companies. The remaining waste shall be collected for disposal by the agency authorized by government agencies. Appropriate disposal shall be made according to the Notification of Ministry of Industry on disposal of waste or unusable materials, B.E.2548.

- Solid waste that have characteristics and properties defined in the Notification of Ministry of Industry on disposal of waste or unusable materials, B.E. 2548, such as lubricant oil and cleaning solutions for devices, etc. shall be separated from general waste and collected for disposal by the agency authorized by government agencies.
- Drums/tanks shall be provided to collect solid waste, such as resin, oil, etc. from power generation process before sending for disposal by the the agency authorized by government agencies. Alternatively, the collected solid waste may be sold to solid waste disposal companies authorized by government agencies.
- Types and volume of solid waste and transportation out of the project area shall be recorded. Purchasing companies or disposal sites shall be identified.

5.4 QUALITY OF LIFE

5.4.1 Socio-Economics

The social impact assessment (SIA) was applied for assessment of socio-economics impacts of the project. Focus is made on human use values (quality of life) and concerns of people. Considerations were made from secondary data compiled from government agencies and other reference documents, interview of target community leaders and household members. Furthermore, review of community way of life was made. Additionally, potential impacts on society, the way of life of people, occupation and daily life were evaluated. Environmental impact prevention and mitigation measures and monitoring measures, which are consistent with the community context were proposed.

All phases of project development will cause both positive and negative impacts on communities. According to the compilation of the studies, the overall social impacts during the pre-construction, construction and operation phases are summarized below (**Table 5.4.1-1**).

(1) Pre-construction phase

(a) Positive impacts (community relations activities)

The community relations plan is established for implementation during the preparation of EIA report. Community relations activities aim at making familiar to communities and good relationship with local people as the importance of public participation in the long run is realized. Community relations activities will be performed regularly, such as support for community activities in the district/sub-district/village, etc. (Details are in **Chapter 9** Mitigation Action Plan).

TABLE 5.4.1-1

SUMMARY OF OVERALL IMPACTS DURING PROJECT DEVELOPMENT

Social Impacts	Impacts from Project Development			
	Construction Phase		Operation Phase	
	Positive	Negative	Positive	Negative
• **Environment Impacts**				
- Air/noise pollution		✓		✓
- Water/aquatic ecology		✓		✓
- Water use		✓		✓
- Solid waste management		✓		✓
- Transportation/traffic		✓		
• **Social Impacts (way of life/quality of life)**				
- Social and cultural conflicts				
➢ Increase/ reduction in population, migration, or change in population structure		✓		
➢ Social relation, social problems-crimes or others; community development, such as community expansion, social service or degree of urbanization		✓		
➢ Culture, livelihood or change in way of life, belief, or others		✓		
- Community economy (employment/local income)	✓		✓	
- Health and safety		✓		✓
- Benefits for communities (power development fund)	✓		✓	
- Promotion of knowledge to communities (power plant visit)			✓	
• **Public Participation (role/channel)**				
- People policy (community relations)				
➢ Quality of life development plan for change and/or development of people's quality of life			✓	
• **Mental impact**				
- Concern/stress		✓		✓

In addition, to this, the development plan for the quality of life of people living in communities near the power plant is established, such as support for education, promotion for religious understanding, culture and tradition, sport, public health and the environment, etc. This policy is in accordance with the community relations plan of the project from the pre-construction phase (Details are in **Chapter 9** Mitigation Action Plan), which shows social responsibilities through continuous promotion/support for community activities.

(b) Negative impacts

- **Mental impact**
  - **Concern**

During the enquiry/interview, the project staff explained the interviewees the project information. It was found that the project information were recognized by community leaders. Almost all of the community leaders have known about the project before. Meanwhile the household members who live within the radius of 0-3 km from the project boundary have acknowledged the project information more than those living within the radius of 3-5 km from the project boundary. Compared with the household members, acknowledgement of the project information by community leaders are apparently better. However, the interview results reveal that most of the community leaders and household members expressed no concern about the project development, especially, those living within 3-5 km from the project boundary.

Most reasons given by the interviewees are as follows: The project area is remote from residential area. The project is not developed yet. These people are confident in the implementation of environmental impact prevention and mitigation measures of the project. Concerns about the project development include air pollution, effluent from the project, sufficiency of water use in communities, etc. It could be said distance from the project location and the reliability in environmental impact prevention and mitigation measures of the project are the variables that make the interviewees, who know about the project information for the first time, express no concern about the project developmen. Therefore, if community people understand potential impacts from the project development, prevention and mitigation measures and are reliable in the measures, their concerns will be reduced.

However, modern technologies and communication enable fast acknowledgement, especially negative impacts of the power plants in various areas in the past. To disseminate the project information to local people, public relations campaign is be made to promote the understanding of the power plant operation, power plant impacts and prevention and mitigation measures. These activities are performed in the district/sub-district/village level at the same time of EIA report preparation (Details are in **Chapter 9**).

In addition, public relations campaign is performed to promote the understanding of people regularly and continuously from the pre-construction, construction and operation phases (Details are in **Chapter 9,** Mitigation Action Plan). People will be more reliable on the project operation. Therefore, the impacts will be at a low level (Negative impact level = 1).

(2) Construction phase

(a) Positive impacts

(a.1) Social impacts

- **Community economy**
  - **Increase in local employment**

Even though the highest number of construction workers during the construction phase is approximately 3,200 persons, the employment of local people will be at a low level. This is because the employment during the construction phase will depond on contractors, who practically will employ construction workers from their suppliers (Positive impact level = 1).

Nontheless, the environmental impact prevention and mitigation measures determine that local people will have the priority for employment to mitigate impacts from migrant labours and increase benefits for communities.

- **Promotion of local economy**

During the construction phase, there will be more cash flow from approximately 3,200 the staff and workers. Daily expenses of these people will increase community income, especially food stalls and sellers in the area. Taking into account the minimum wage rate of Rayong province, which is 300 baht/day/person (Notification of Wage Committee on minimum wage rate (No.7), October 17, 2011) and 25 working days/month of labours, there will be 24,000,000 baht/month of cash flow, or 288,000,000 baht/year. During the construction phase (48 months), approx. cash flow will be 152,000,000 baht. This is the positive impact on local economy (calculated from 88.2% of income for consumption expenditures, Source: National Statistical Office, Summary Results of Survey on Socio-Economics of Households in the First 6 Months of Year, 2013, http://service.nso.go.th/nso/nsopublish/themes/files/ socioSum56-6.pdf. Retrival: March 9, 2015.) (Positive impact level = 1).

- **Employment opportunity**

According to the survey on socio-economics, some household members work for wages. Therefore, it is an opportunity for them to be hired by the project for the positions that do not need high skills since qualified local people will be the first priority for employment (Positive impact level = 1).

- **Benefits of power development fund for communities**

During the construction phase (from the starting day of power plant construction according to the construction contract to the commercial operation date (COD). Money shall be transferred by the project to the power development fund in the rate of 50,000 baht/megawatt/year based on the installed capacity of the power plant. As the installed capacity of the power plant is 2,920 megawatt s, approximately 146,000,000 baht/year shall be transferred to the power development fund (according to Notification of the Energy Regulatory Commission on money transfer to power development fund for Electricity Operation Operator, Electricity Generation License, B.E.2553) throughout the construction phase for 48 months. The power development fund will be allocated for community development (Positive impact level = 2).

(a.2) Community relations activities

The complaint receiving channel and opportunity of people to be involved in the project development in the form of the Environmental Monitoring Committee show monitoring transparency. Furthermore, the continuously allocated budget for community development activities will contribute to better quality of life of people based on the social plan for communities nearby the project (Positive impact level = 2).

Furthermore, the power plant establishes people policy under "Social Activity in a Proactive and Consistent Manner" strategy. Community activities will be supported as appropriate for good relationship and benefit to community/society. (Details are in **Chapter 9** Mitigation Action Plan).

(b) Negative impacts

(b.1) Mental impact

According to the interview, most of the interviewees viewed that they would not affected by the project during the construction phase. However, some of the interviewees thought that they would be affected from dust due to construction activities and contruction material transportation, traffic congestion due to material transportation, theft due to migrant labours, inadequacy of water supply and electricity, etc. Construction activities that may cause impacts on communities will not be undertaken all the time. In addition, comprehensive prevention and mitigation measures are established. Moreover, a complaint receiving center is established to receive complaints from community people who suffer from construction activities. Remedial action will be taken immediately. As a result, the impact will be at a low level (Negative impact level = 1).

(b.2) Physical impacts

- **Air quality**

During the construction phase, the construction site will be water sprayed at least 2 times per day to reduce the diffusion of dust. The 24-hour average total suspended particulate (TSP) will increase to 92.77 micrograms./cubic meter. Combined with the highest measurement value from field survey, the total suspended particulate will be 198.77 micrograms./cubic meter, or 60.23% of the standard value of ambient air quality. According to the standard value of ambient air quality, total suspended particulate shall not exceed 330 micrograms/cubic meters. Therefore, the measured ambient air quality at the construction site still meets the standard value of ambient air quality and the impact from increased total suspended particulate will be at a low level (Negative impact level = 1).

- **Noise Annoyance**

During the construction phase, calculated noise annoyance in the sensitive receptor will be higher than the standard. However, environmental impact prevention and mitigation measures are established. Contractors are required to use the machinery and equipment that generate low noise. In addition, temporary barriers will be installed in the pile driving areas in the west, the south and the north of the project. Preliminarily, a metal sheet of 1.27 millimeters thick onwards (Steel 18 ga) is chosen. Alternatively, other materials with sound transmission loss of 25 decibers (A) can be used. The height of three sidewalls in the west, the south and the north will be 5 m from the ground so that nose level in the sensitive receptor will not increase from the existing noise level. Therefore, it is expected that noise generated from construction activities will temporarily affect the livelihood of people at a low level (Negative impact level = 1).

- **Water use**

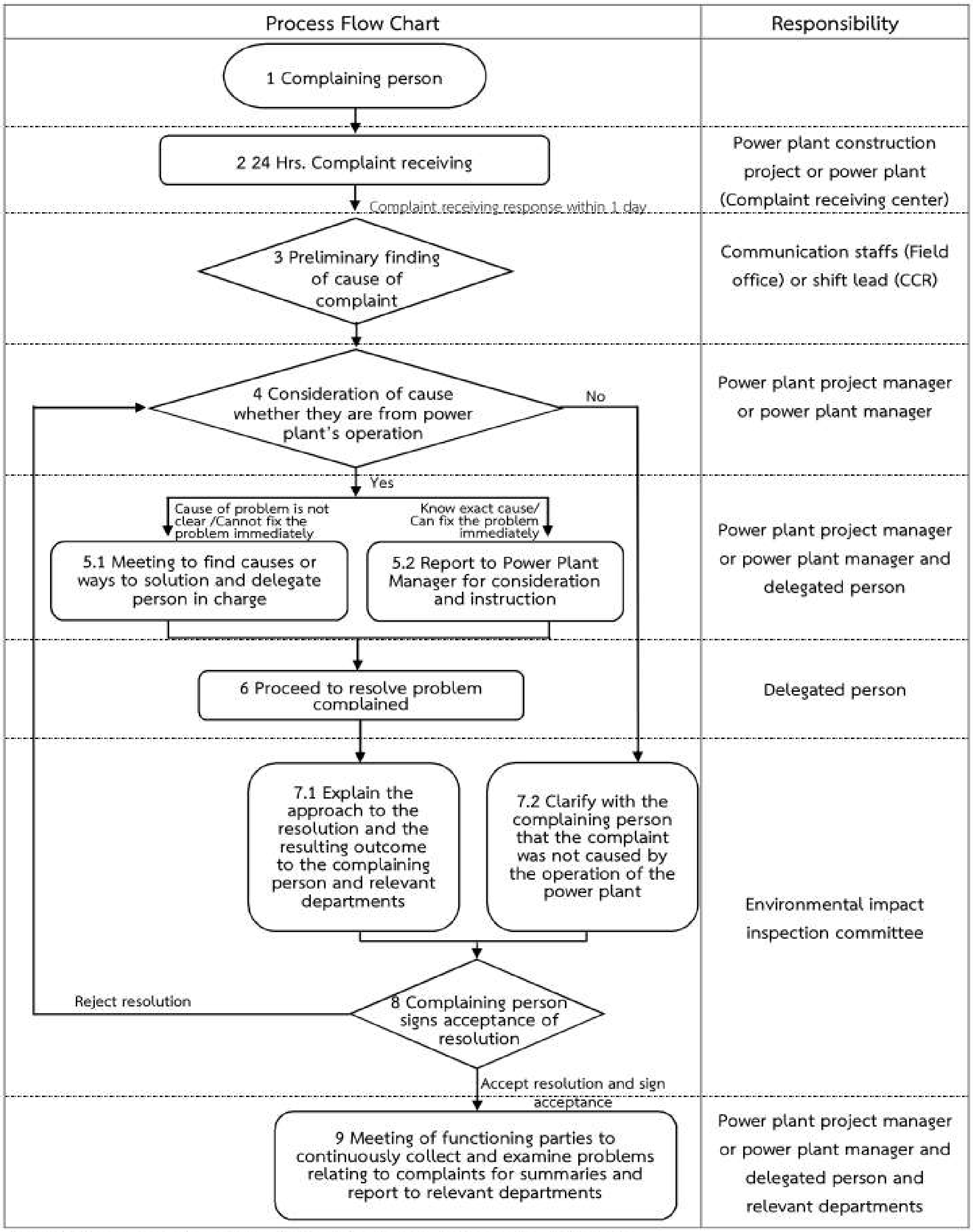
During the construction phase, there will be about 3,200 construction workers. All of them will stay outside the project area. The demand for an average water supply will be 224 m^3/day (calculated from the water use rate of 70 L./person/day). Water for consumption will be adequately provided by contractors. Bottled water will be provided for drinking. Therefore, during the construction phase, water use of the project will not affect water use of local people (No impact).

- **Solid waste management**

During the construction phase, solid waste will be generated from construction workers and a temporary site office. It is forecast that 3,200 construction workers will generate solid waste of 2,720 kg/day (calculated from the solid waste generation rate of 0.85 kg/person/day). The storage area for solid waste or each type of waste will be separated. Suitable containers will be used to collect solid waste. Waste will be recycled or sold to buyers. Hazardous waste will be collected and sent for disposal by the company authorized by Department of Industrial Works. Therefore, the impact will be at a low level (Negative impact level = 1).

(b.3) Social impacts

- Social and cultural changes may cause conflicts between migrant labours and community people or migrant labours and local labours. Other problems include change in population structure, quarrel, theft, narcotics, and difference in livelihood. However, currently, a large number of migrant labours live in Pluak Daeng district and nearby areas, the above social and cultural changes may affect the project area at a low level. Moreover, the policy to hire local people as the first priority according to the socio-economics action plan enables low impacts (Negative impact level = 1).
- During the construction phase, community people may have conflicts due to concerns and lack of understanding about the project operation and impacts. Dissemination of the project information, such as the construction schedule, the environmental measurement action plan shall be made. Public relations campaign shall be made urgently in case of conflicts between the project and communities. In addition the complaint receiving channel shall be provided during the construction phase so that affected persons can make the project staff informed as shown in **Figure 5.4.1-1.** People involvement in the form of the Environmental Impact Monitoring Committee will contribute to transparency and affect community people at a low level (Negative impact level =1).
- Construction activities may affect the physical environment near the project area and health of people in nearby communities. Local public facilities will have more burden to treat migrant labours. As most of the migrant labours are non-registered population, local public facilities could not request additional budget or medical personnel. Moreover, construction workers may cause unsafety in life and asset of people living around the project area. Therefore, construction worker monitoring measures are established to strictly control the behavior of construction workers. In case of a minor illness, construction workers will be treated within the project area to lessen the burden of the local public facilities. Hence, the impacts will be at a low level (Negative impact level = 1).



Note: 1. Report causes/resolutions/solving time to complaining party within 5 days.

2. Report progress in resolving problems to the complaining party every 7 days or as agreed.

FIGURE 5.4.1-1: LAYOUT OF COMPLAINT RECEIVING STEPS OF PLUAK DAENG POWER PLANT PROJECT

(3) Operation phase

(a) Positive impacts

(a.1) Social impact

- The revenue of the Local Administation Organization, i.e. Map Yang Phon Sub-District Administrative Organization will raise. The benefit will come from collection of property tax. The calculation of property tax will depend on each Sub-District Administrative Organization. Moreover, the continuous development as a result of the existence of the power plant enables the Sub-District Administrative Organization to collect other taxes, such as land tax, property tax, wheeled vehicle tax and signboard tax, etc. These contribute to the increased budget for local development (Positive impact level = 1).
- Communities will receive benefits from power generation from the commercial operation date (COD) onwards. The revenue from power generation using natural gas as fuel will be allocated to the power development fund in the rate of 1 satang/power units generated for sale each month. This excludes the payment for energy used in power generation process in the power plant throughout the project life (about 25 years) (Positive impact level = 2).
- The project development will contribute to the increase in power generation of the country so that people have adequate power supply. Also, it support other manufacturing fields, especially the industry sector. This is because the electricity is the main factor for industrial expansion, which leads to employment and the increase in Gross Domestic Product (GDP) in the provincial and national levels (Positive impact level = 2).
- Community people will be trained for the understanding of the project development. They will be supported by the project in several ways, such as occupational training, scholoarship for students, etc. These supports will be made throughout the project operation for the development of community people. The trained people are important for future development of communities (Positive impact level = 1).

(a.2) Community relations activities

Community relations activities will be organized by Gulf PD Co., Ltd., which is the project owner. These activities aim at enhancing the understanding of community people in the district/sub-district/village level. Community activities, such as occupational training, support for education, promotion for religious understanding, culture and tradition, sport and music, public health and the environment, etc. Community relations activities are also the channels for idea sharing and recommendations between the project and communities, enhancement of understanding and alleviation of concerns, which are beneficial for the co-existence of communities and the project.

However, to make activities according to the community development plan sustainable, the activities/programs should be based on the understanding and recognition that community development needs the ideas and implementation by community people. Communities need to be responsible for such activities/programs, such as the quality of life development program to change/improve the quality of life of people in terms of basic social services, public facilities, natural resources and the environment, occupational development promotion and income, educational support, public health and personal hygiene, etc. (Positive impact level = 1) (Details are in **Chapter 7, Section 7.2.10**: Public Relations Campaign and Public Participation Action Plan).

(b) Negative impacts

(b.1) Mental impact

According to the interview, most of the community leaders and household members viewed that they would not be affected during the operation phase. The proportion of community leaders who stated that the project operation may not have impacts on communities are higher than that of the household members. This may be because community leaders acknowledge more project information than the household members.

The sample viewed that potential impacts include air quality due to fuel combustion, effluent quality in public water bodies, noise from the power plant operation, solid waste/waste from the project operation, insufficient water use for people due to water consumption by the project, agricultural impacts, etc. Environmental issues are the main concerns of the sample. Therefore, environmental prevention and mitigation measures and monitoring measures, which are comprehensive, are established. (Details are in **Chapter 9**: **Environmental Action Plans**).

To reduce anxiety about impacts from the project operation, the Environmental Monitoring Committee will be appointed since the pre-construction phase. the Environmental Monitoring Committee consists of representatives from communities within 5 km radius from the project boundary, representatives from the government agencies, experts and the power plant representative. The committee will comment or give recommendations for improvements or changes in the project operation so that they will be in line with the EIA report. Also, the Committee will recommend the government agencies to temporarily stop the project operation if it does not comply with the EIA report.

Moreover, the project staff will be provided to receive complaints and make a good relationship with local people through regular visits and remedial actions when problems arise from the project. These methods make people less anxious. Therefore, the impacts will be at a low level (Negative impact level = 1).

(b.2) Physical impacts

- **Air quality**

The AERMOD model was adopted to forecast impacts on ambient air quality in the study area and the sensitive receptor. It was found that the concentration of air pollutants, i.e. nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and total suspended particulate (TSP) in 6 cases within 15 km radius from the project location were lower than the standard values. Meanwhile, the results combining the current measurement results with the concentration from the model show that the concentration of pollutants in 31 sensitive receptors meet the setting standard. This indicates that the study area has a potential for future development of Pluak Daeng Power Project. Hence, the project operation will affect the air quality at a moderate level.

Air quality impacts can be reduced through the establishment of environmental prevention and mitigation measures and monitoring measures. These measures shall be strictly complied with. This will affect the air quality at a low level (Negative impact level= 1).

- **Noise**

The calculated noise levels generated from the machinery and equipment during the operation phase do not exceed the noise level standards. Taking into account noise annoyance in the 3 sensitive receptors, the combined noise levels (noise levels from sources and current noise levels) do not increase from the current levels. Measures are established to reduce noise levels in nearby communities. For example, a silencer shall be installed at the end of pipe of the noisy machinery to reduce noise. The cover structure shall be built for the machinery at the combustion of gas turbine and the gas turbine generator. Furthermore, continuous noise monitoring will be performed throughout the operation phase. Thus, noise impacts will be at a low level (Negative impact level = 1).

- **Water pollution/Aquatic ecology**

The effluent from the project can be divided into 2 types as follows:

1. Cooling water blowdown (12,232 m^3/day) will be conveyed to a cooling water holding pond. The two cooling water holding ponds with the capacity of 19,000 m^3 each will hold the effluent and serve as an emergency pond. After that, the effluent will be drained into the cooling water holding pond of Pluak Daeng Industrial Park, which is capable of holding the effluent for 1 day. The effluent temperature will meet the standards of Pluak Daeng Industrial Park. The online monitoring system will be installed at the cooling water holding pond to measure the temperature, pH, dissolved oxygen (DO)

and electric conductivity (EC) of the discharged effluent for compliance with such standards.

2. Wastewater from process: 48 m^3/day

- Wastewater from water treatment system (demineralization system) and wastewater from mixed bed regeneration (13 m^3/day) which will be carried to the neutralization pond for pH neutralization before releasing into the wastewater pond of the project
- Laboratory wastewater (5 m^3/day) which will be carried to the neutralization pond for pH neutralization before releasing into the wastewater pond of the project
- Wastewater from utilization and consumption (30 m^3/day) which will be treated in the septic tank before being conveyed to the wastewater pond of the project

Wastewater from process in Item 2 will be stored in the wastewater holding pond. The two wastewater holding ponds with the holding capacity of 75 m^3 (for 3 days in total) will be equipped with the online monitoring system to measure the temperature, pH and electrical conductivity (EC) of the discharged effluent for compliance with such standards before discharging into the central wastewater treatment system of Pluak Daeng Industrial Park.

The wastewater holding pond's floor is designed to prevent leakage of water to the underground (such as lining). Inspection and maintenance will always be performed for the wastewater holding pond. In case of damage, the wastewater holding pond will be repaired shortly.

The uncontaminated stormwater from storm drains will be collected and released into the drainage system of the project. It is apparent that wastewater from the power generation process will be treated by the wastewater treatment system of the project. The effluent will be controlled for compliance with the standards of Pluak Daeng Industrial Park. Also, environmental impact prevention and mitigation measures proposed in the EIA report will be strictly complied with. Thus, the impacts will be at a low level (Negative impact level = 1).

- **Soid waste management**
  - **General waste:** About 51 kg/day of general waste (calculated from 60 staff and the waste generation rate of 0.85 kg/person/day, Kriangsak Udomsinrot, 1994) will be generated from the office. General waste consisting of food scraps, plastic bag, scrap paper will be compiled and sent for disposal to the waste disposal section of Pluak Daeng Industrial Park or the authorized agency.

➢ **Air filter:** The air filter prevents dust and scraps of material in the air from moving into the power generation system. It is a synthetic fiber designed for single use only. As the dust sticking to the fiber of the air filter is thick and moist, it is impossible to blow or wash it. When used over a period of time, it will be damaged and needs to be replaced. About 47,040 kg/1.5 years of an air filter will be used. Used filters will be sent for disposal to the company authorized by Department of Industrial Works.

➢ **Used lubricant oil and oil from an oil separator:** About 800 liters/month of deteriorated oil and oil from an oil separator will be stored in a 200-liter covered steel tank. They will be sent for disposal to the company authorized by Department of Industrial Works.

➢ **Used resin:** About 1 m^3/year of resin will be replaced. Used resins will be returned to the distributors or collected and placed in plastic bags, stored in a 200-liter tank and sent for disposal to the company authorized by Department of Industrial Works.

➢ **Sludge generated from water treatment:** About 5 tons/day of sludge will be separated from raw water in the water treatment system. Sludge will be stored in a sludge hopper, which is located in the water treatment plant. It will be sent for disposal 3 times per week. Sludge disposal will be in accordance with the Notification of Ministry of Industry on industrial waste disposal, B.E.2548.

Considering solid waste and waste disposal method during the operation phase, impacts are expected to be at a low level (Negative impact level = 1).

(b.3) Social impact (health and safety)

During the operation phase, there will be 60 staff. However, the first priority for employment will be given to local people. Staff/workers monitoring measures are established to strictly control the behavior of these people. In addition, measures to reduce the risk of of communicable diseases and environmental sanitation are established. Also, the Environmental Monitoring Committee will be involved in mitigating the environmental impacts so that people are confident in the project operation and transparency. Thus, the impacts will be at a low level (Negative impact level = 1).

Mitigation measures

(a) Pre-construction Period

General Measures

- The project staff shall build good relationship with local officials and people.
- The information of Pluak Daeng Power Plant Project shall be continuously publicized throughout the construction phase. The information to be provided include: construction schedule, environmental monitoring action plan, etc.,

through media. Optionally, any of the following methods may be adopted: local radio, installation of signboards at important places, e.g. office of community leaders, in front of the the Sub-district Administrative Organization (SAO) or other methods which are consistent with the objectives of the measures, one month in advance before the construction begins.

- Support will be provided for community activities as appropriate to build good relationship with communities, and return to community and society.
- In case of conflicts between the power plant and communities, the project information shall be urgently disseminated to people through channels or media so that people acknowledge facts. This means the project is responsible for communities and aware of people's concerns.

Public relations campaign measure

1) Objectives of Public relations campaign

- To provide people living in the project vicinities an opportunity to acknowledge the project information continuously from the pre-construction, construction and operation phases, to serve as a communication channel between people living in the project vicinities and the project, to hear the opinions and recommendations of people who may be affected by the project operation.

2) At least one of the following channels for public relations campaign/dissemination of project information or other activities which are consistent with the objectives, i.e.

- **Through local media**: such as wire broadcasting from local government agency and community or local cable media, as appropriate
- **Through notice board/signboard of local government agency, community or in public place that is visible**: such as signboard of the district involved with the project, signboard of municipality/Sub-district Administrative Organization involved with the project, signboard of public health facility in the study area and the project location.
- **Through public relations material/leaflet**: to disseminate the project details, progression (during each phase), safety data and emergency prevention, communication channel in case of emergency, complaint receiving channel and communication channel of the project, etc. The public relations material/leaflet should be placed at the public relations unit of the government agency, community or the place where people can access.

- **Through meeting**:

  - The project's details/ progress shall be explained in the meeting through local government agencies (provincial and district levels), at least once before the construction or within the first month of construction.

  - The project's details/ progress shall be explained in the meeting for the involved villages/ communities/ sub- districts. The meeting shall be organized once before the commencement of construction or within the first month of construction.

- **Through community participation committee**: throughout the duration that the committee serves as the community participation committee

- **Through other methods of public relations, as appropriate**: such as personal visit, public address, etc.

Public relations campaign shall include the project details and progress during the construction phase, environmental impacts, and environmental impact prevention and mitigation measures, communication channel and complaint receiving channel as well as contact in case of emergency.

(b) Construction Period

Environmental impact prevention and mitigation measures

- A "Complaint Center" shall be established to disseminate the project information, hear people's opinion, recommendations and complaints. Affected persons can make complaints or raise problems through any channels, as appropriate, such as verbal communication, telephone, memo, letter, electronic mail, fax, etc., as shown in **Figure 9-1**
- Environmental impact prevention and mitigation measures shall be strictly adhered to.
- Complaints and sufferings of people in communities due to construction activities shall be received and solved urgently.

Life and asset safety measures

- Qualified local people shall be given priority to be hired for any vacancy.
- A register of migrant labour and foreign labour shall be established.
- A project supervisor shall be assigned to supervise construction workers. Moreover, staff shall be provided to strictly supervise the entrance and exit to the construction site.
- Construction activities and construction workers' behavior shall be supervised to prevent impacts on local people.

- The boundaries of temporary workers' camp and construction site shall be clearly demarcated.
- Working regulations shall be explicitly established. Construction workers shall be supervised strictly.
- In the event that workers' camp is close to a community, workers' behavior shall be closely supervised to prevent disturbance and annoyance.
- In case of conflicts between the power plant and community people, the project information shall be disseminated urgently through channels or media to show the responsibility and care for people's concerns.
- If it is proven that the power plant is the cause of any impact, the problem shall be solved urgently. The database of an affected person or affected group shall be created. The impact prevention measures shall be established.
- A resgister of affected persons shall be established. Complaints or incidence shall be registered. Facts, remedial action and negitiations shall be compliled and registered to be used as evidence of the power plant operation.

Public relations campaign measures

1) Objectives of Public relations campaign

- To continuously provide the project information during the pre-construction, construction and operation phases for people living in the project vicinities.
- To serve as a communication channel between communities nearby and the project, listen to the comments of affected persons and receive recommendations from people.

2) At least one of the following channels for public relations campaign/dissemination of project information or other activities which are consistent with the objectives, i.e.

- **Through local media:** such as wire broadcasting from local government agency and community or local cable media, as appropriate
- **Through notice board/signboard of local government agency, community or in public place that is visible**: such as signboard of the district involved with the project, signboard of municipality/sub-district administrative organization involved with the project, signboard of public health facility in the study area and the project location.
- **Through public relations material/leaflet:** to disseminate the project details, progression (during the operation phase), safety data and emergency prevention, communication channel in case of emergency, complaint receiving channel and communication channel of the project, etc. The public relations material/leaflet should be placed at the public relations unit of the government agency, community or the place where people can access.

- **Through other methods of public relations, as appropriate**: such as personal visit, public address, etc.

Public relations campaign shall include the project details and progress during the construction phase, advantages and disadvantages, communication channel and complaint receiving channel as well as contact in case of emergency.

(c) Operation Period

General Measures

- Qualified local people shall have the priority to be hired for any vacancy in order to mitigate the impact of relationship between the Project and people and communities. Local people should be always notified for any vacancy every time.
- Measures for benefit return for communities shall be established, such as maintenance of Huai Phu Sai with Pluak Daeng Industrial Park, other factories or involved agencies, support for local educational institutes or public health facilities, promotion of religious maintenance, contribution to public health benefit, etc.
- Responsible persons shall be assigned for receiving complaints, hearing comments and suggestions. Affected persons can complain via channels like verbal communication, telephone, memo, letter, electronic mail, fax, etc. to the power plant as shown in Figure 9.1.
- People in nearby communities shall have an opportunity to visit the power plant to ease their concern.
- The quality of life improvement policy shall be set up. Community businesses shall be supported and promoted for sustainable economic and social development.
- Project's action plan shall be implemented and strictly adhered to so as to reduce accidents and impacts on the Project and communities.
- If it is proven that the power plant is the cause of any impact, the problem shall be solved urgently. The database of an affected person or affected group shall be created. The impact prevention measures shall be established.
- A register of affected persons shall be established. Complaints or incidence shall be registered. Facts, remedial action and negitiations shall be compliled and registered to be used as evidence of the power plant operation.
- In case of conflicts between the power plant and communities, the project information shall be urgently disseminated to people through channels or media so that people acknowledge facts. This means the project is responsible for communities and aware of people's concerns.

Public relations campaign measures

1) Objectives of Public relations campaign

- To continuously provide the project information during the pre-construction, construction and operation phases for people living in the project vicinities.
- To serve as a communication channel between communities nearby and the project, listen to the comments of affected persons and receive recommendations from people.

2) At least one of the following channels for public relations campaign/dissemination of project information or other activities which are consistent with the objectives, i.e.

- **Through local media:** such as wire broadcasting from local government agency and community or local cable media, as appropriate
- **Through notice board/signboard of local government agency, community or in public place that is visible**: such as signboard of the district involved with the project, signboard of municipality/sub-district administrative organization involved with the project, signboard of public health facility in the study area and the project location.
- **Through public relations material/leaflet:** to disseminate the project details, progression (during the operation phase), safety data and emergency prevention, communication channel in case of emergency, complaint receiving channel and communication channel of the project, etc. The public relations material/leaflet should be placed at the public relations unit of the government agency, community or the place where people can access.
- **Through other methods of public relations, as appropriate**: such as personal visit, public address, etc.

Public relations campaign shall include the project details and progress during the construction phase, advantages and disadvantages, communication channel and complaint receiving channel as well as contact in case of emergency.

5.4.2 Health impact assessment

(1) Construction Phase

Construction activities may lead to health threats to the staff and people living within 5 km radius of the project boundary. Health effects resulting from health threats include dust, noise, accidents from traffic and transportation as well as operation, stress and anxiety about impacts or activities. The health effect appraisal results using risk matrix during the construction phase are as follows:

(1) Air quality (dust)

The major air pollutant during the construction phase will be total suspended particle (TSP) generated from construction activities, such as foundation work and building construction, etc. and construction material, equipment transportation and construction waste, etc. Details are given below.

(a) Health effect characteristics

Health effects from particulate matter include irritation to eyes and the respiratory system in case of inhalation. Parts of the respiratory system will be irritated. Coarse particulate will be traped at nose hair while fine particulate can escape into the respiratory system, resulting in irritant symptoms, nasal inflammation, cough, sniff, wet cough or dust accumulation in pulmonary alveoli, which deteriorates pulmonary function. Moreover, particulate matter can cause visual impairment, dirtiness and annoyance. The study conducted by Chulalongkorn University reveals that students living in the area having particulate matter with a diameter less than 10 microns (PM-10) more than 100 μg/cu.m. had the higher rate of respiratory system diseases compared with those living in the area where PM-10 was lower than 50 μg/cu.m. Furthermore, severity of illness changed depending on concentrations of particulate matter (Collage of Public Health, 1998).

(b) Major activities leading to health effects

Major activities that are sources of particulate matter during the construction phase include construction work, transportation of construction materials and equipment and construction waste, which will be temporary and intermittent. An important health threat will be total suspended particulate (TSP) from construction activities and transportation of construction materials and equipment.

(c) Vulnerable groups to health effects

Vulnerable groups that are likely to be affected from air pollutant during the construction phase will be construction workers in case they do not wear personal protection equipment (PPE), or air quality prevention and mitigation measures are not implemented, as these people are exposed to total suspended particulate for 8 working hours (TWA). The secondary vulnerable group will be people living within 5 km radius from the project boundary. Likelihood and severity depend on the health status of people who are exposed to total suspended particulate during a particular period of time and the duration of exposure.

(d) Consideration of likelihood and severity of health effects

1. Consideration of Likelihood

- **Construction workers**

Construction workers at the construction site are likely to be affected at a high level as they have to work in the area for at least 8 hours. Therefore, the likelihood of exposure is at a high level (4 scores), i.e with support from available statistics for likelihood forecast in case of inadequate prevention measures.

- **People living within 5 km radius from the project boundary**

Taking into account TSP 24 hr from the first measurement during September 9th-16th, 2015 and the second measurement during February 13rd-20th, 2016 at 5 monitoring stations: (1) Pluak Daeng Power Plant Project area, (2) Nuen Sawan community, Village no. 2, Map Yang Phon sub-district, (3) Wat Prasittharam, (4) Ban Map Toie School and (5) community, west of the project, Village no. 2, Map Yang Phon sub-district. TSP 24 hr was measured 2 times at each station for 7 consecutive days, covering holidays and working days, the concentration of TSP 24 hr met the standard (not exceeding 330 μg/cu.m.). The forecast result of total suspended particulate during the construction phase will be 198.77 μg/cu.m., or 60.23% of the standard value.

According to morbidity statistics of outpatients in Rp. 504 from Tambon Health Promoting Hospitals in the study area during 2011-2015, the majority of people in the study area suffered from respiratory system diseases, symptoms, signs and abnormalities due to clinical examination and laboratory test that cannot be classified, digestive disorders and oral diseases, respectively.

According to morbidity statistics of inpatients in Rp. 505 during 2011-2015, respiratory system diseases were not the main causes of the illness of people in the study area. Major diseases were endocrinopathy, malnutrition and metabolism, delivery, signs, symptoms and abnormalities due to clinical examination and laboratory test that cannot be classified and other intestinal infections **(Details are included in Chapter 4, Collection of Public Health Baseline.)**

Based on air quality measurement results at present in the study area, the project vicinities can increasingly accommodate total suspended particulate (TSP) with close monitoring. Since vulnerable groups have lived in the study area and some household members suffered from respiratory system diseases, therefore, the likelihood of health effects will be at a moderate level (3 scores), i.e. support from available statistics for likelihood forecast.

2. **Consideration of severity of consequences**

- **Construction workers**

During the construction phase, severity of consequences is at a moderate level (2 scores). As land leveling was already undertaken for industrial development, the consequences from total suspended particulate will be at a low level. However, construction activities and transportation of construction materials and equipment may cause dust diffusion.

- **People living within 5 km radius from the project boundary**

As the construction site of the project which is located in Pluak Daeng Industrial Park is adjacent to the sensitive receptors, i.e. communities at Village no. 2 and Village no. 5 Map Yang Phon sub-district, the communities may be affected from dust generating activities, such as equipment transportation and construction worker travel, etc. However, land leveling is not undertaken, the severity of health effects will be at a moderate level (2 scores). Activities during the construction phase may lead to injuries, accumulation of vulnerable groups, strike and the impact on communities.

(e) Health risk assessment

- **Construction workers**

During the construction phase, construction workers will be affected at a moderate level. As these people have to work at the construction site for 8 working hours, the probability of exposure will be at a high level (4 scores). Impact severity level will be a moderate level (2 scores). Impact significant level, therefore, will be at a moderate level (8 scores). The health risk level is acceptable; however, health effect prevention and mitigation measures shall be established, or existing measures may be improved.

- **People living within 5 km radius from the project boundary**

Taking into account risk matrix, construction activities at the construction site in a short period of time and the concentration of total suspended particulate meets the standard. Nonetheless, potential health effects include eye and skin itrritation. The affected persons will recover if they are not exposed to total suspended particulate. This is a short-term health effect. Also, dust diffusion may be caused by transportation. Moreover, the sensitive receptors are adjacent to the project area, the impact severity level will be at a moderate level (2 scores). According to morbidity statistics of outpatients in Rp. 504, the majority of people living in the study area suffered from respiratory system diseases and local public health personnel viewed that these diseases were the main causes of illness. Therefore, the level of health effects will be at a moderate level (3 scores). Hence, health effect significance level from exposure to total suspended particulate will be at a moderate level (6 scores). Impact prevention and mitigation measures shall be checked for sufficiency. Additional, Impact prevention and mitigation measures may be established to be in line with health effects.

(2) Noise

(a) **Health effect characteristics**

The impacts of noise on physical health include destruction of auditory system efficiency and side effects, such as stress, headache, hypertension, fatigue, and heart disease, etc. Loud noise exposure may lead to 2-3 hours destruction of auditory system, having tinnitus, temporary deaf or permanent deaf. A prolonged exposure to loud sound will impair hearing ability, hypacusia or even deafness. The study of Department of Pollution Control reveals that exposure to noise of greater than 120 decibels (A) means a high risk of deafness. Moreover, exposure to an average noise level of 90 decibels (A) or higher for 8 hours/day or 70 decibels (A) onwards all the time, will lead to hearing loss and impair hearing ability. The impact of noise on mental health includes annoyance, and failure in communication and understanding. Furthermore, Noise obstructs people's concentration while working. Noise also affects people's emotion, relaxation and privacy (Crocker, 1998)

(b) **Main activities that result in health effects**

Main activities during the construction phase that will be noise sources are pile driving, foundation construction, structural or building construction, decoration and transportation of construction materials and equipment, etc.

(c) **Vulnerable groups to health effects**

Vulnerable groups to health effects consist of construction workers woring near the noisy engine and machinery as well as people living close to the construction site.

(d) **Consideration of likelihood of health effects and severity of consequences**

1. **Consideration of likelihood of health effects**

The power plant project is categorized as a factory of building and structure type. As a results, in the worst case scenario, at the distance of 15 m from the noise source which are the machinery or equipment employed concurrently while excavating for foundation construction, the noise level will be 89 decibels (A), which is the representative of noise level from construction activity.

- **Construction workers**

During the construction phase, construction workers will be exposed to 89.0 decibels (A) of the noise level. Combined with the maximum Leq 8 hr in the project area at present (51.0 decibels (A)), the noise level will be 89.0 decibels (A). This value falls within the standard of the ministerial regulation of Ministry of Labour, B.E. 2549 on determination of safety, occupational health, and work environment management of heat, lighting and nose. The standard determines that Leq 8 hr shall not exceed 90 decibels (A). In addition, to this, construction workers are required to wear personal protective equipment, such as ear muffs and earplugs while working in noisy areas. As a result, the likelihood of health effect mitigation will be at a moderate level (3 scores).

- **People living in the project vicinities**

According to noise measurement results in the sensitive receptors in the study area during February 3rd-18th, 2016 at 3 sampling stations: (1) Community, west of the project (Village no. 2 Map Yang Phon sub-district), (2) Community, south of the project (Village no. 5 Map Yang Phon sub-district), (3) Community, north of the project (Village no. 2 Map Yang Phon sub-district), Leq 24 hr ranged from 51.2-66.3 decibels (A). Maximum noise level measured at station in the community, west of the project (Village no. 2, Map Yang Phon sub-district), accounted for 73.1%-94.7% of general noise standard, which determines Leq 24 hr shall not exceed 70 decibels (A). L_{max} ranged from 84.4-100.0 decibels (A). Maximum measured value was at station in community, south of the project (Village no. 5 Map Yang Phon sub-district). It accounted for 73.4%-87.0% of general noise standard where L_{max} over a specific period of time shall not exceed 115 decibels (A).

In the worst case scenario, at the distance of 15 m from the noise source which are the machinery or equipment employed concurrently while excavating for foundation construction, the noise level will be 89 decibels (A), which is the representative of noise level from construction activity. According to forecast results of Leq 24 hr in the 3 sensitive receptors, i.e. community, west of the project, community, south of the project and community, north of the project, it was less than the standard. As a result, the impact of noise on communities and sensitive receptors will be at a low level.

Eventhough the forecast noise level falls within the standard, the maximum value is 95.0% of the standard value. Therefore, the likelihood of health effects during the construction phase will be at a moderate level (3 scores).

2. **Consideration of Severity of Consequences**

- **Construction workers**

As construction activities will be undertaken for a short period of time, severity of consequences will be at a moderate level (2 scores). Exposure to noise may result in temporary, permanent hearing loss, absence from work, and impacts on construction activities and power generation process.

- **People living in the project vicinities**

According to forecast results, noise levels in 3 sensitive receptors will exceed the standards, ranging from 1.7-31.5 decibels (A). However, contractors are required to employ the machinery and equipment that generate noise at a low level and install noise barriers in the areas where pil driving is undertaken, 10 m from noise sources in the west, the north (Village no. 2 Map Yang Phon sub-district) and the south (Village no. 5 Map Yang Phon sub-district). Preliminarily, a metal sheet of 1.27 mm thick (Steel 18 ga), with the transmission loss (TL) of 25 decibels (A) is selected. Furthermore, due to the 5 m high of noise barriers in the west, the south and the north, noise levels in all sensitive areas will be reduced. As a result, severity of consequences will be at a moderate level (2 scores). It is likely that communities in the project vicinities affected by Communities, west of the project (Village no. 2 Map Yang Phon sub-district), south of the project (Village no. 5 Map Yang Phon sub-district) and north of the project (Village no. 2 Map Yang Phon sub-district) will be exposed to noise (49.5-52.1 decibels (A)) from construction activities. Combined with the maximum Leq 24 hr (59.4-66.3 decibels (A), it will be 59.8-66.5 decibels (A), which fall within 70 decibels (A) of general noise standard.

(e) Health risk assessment

- **Construction phase**

Eventhough construction activities occur intermittently, construction workers may be injured and vulnerable groups may be accumulated. As a results, Health effects will be at a moderate level (2 scores). The likelihood will be at a moderate level (3 scores). As construction workers have to work in the area where the machinery operates throughout working hours. Thus, level of significance will be at a moderate level (6 scores), which is acceptable. However, health effect prevention and mitigation measures shall be established, or existing measures may be improved.

- **People living in the project vicinities**

There are people living in the project vicinities where have not much carrying capacity of the increased noise level. Therefore, noise from construction activities may affect communities. Severity of consequences will be at a moderate level (2 scores). The likelihood will be at a moderate level (3 scores). Thus, level of significance will be at a moderate level (6 scores), which is acceptable. However, health effect prevention and mitigation measures shall be established, or existing measures may be improved.

(3) Solid waste, construction waste and wastewater

(a) Health effect characteristics

Construction waste during the construction phase includes scraps of material from soil excavation, structural scraps, hazardous waste, such as battery and lubricant oil. Apart from this, there will be 2,720 kg/day of general waste from 3,200 construction workers. (Based on the setting criteria, general people will generate approx. 0.85 kg/person/day of solid waste (Kriangsak, 1994)). Contamination to the environment may result in the breeding source of vectors, odour and conflicts with communities.

There will be about 179.2 cu.m./day of wastewater from utilization-consumption by 3,200 persons (Approx. 80% of wastewater is based on 70 liters/person/day of water demand for utilization-consumption, (Kriangsak, 1996)) and approx. 250 cu.m. of water discharges from the hydrostatic test.

(b) Main activities that cause health effects

Waste from construction activities and utilization-consumption by construction workers will be causes of health effects.

(c) Vulnerable groups to health effects

Vulnerable groups to health effects include construction workers and people living in the project vicinities.

(d) Consideration of likelihood and severity of consequences

1. Consideration of likelihood

- **Construction workers**

Construction workers who collect general waste and waste are most likely to be affected. Nonetheless, waste are segregrated by type and suitably collected according to the Notification of Ministry of Industry on disposal of waste or unusable materials, B.E. 2548. Moreover, construction workers are required to wear personal protection equipment (PPE), such as rubber gloves, and protective clothing according to occupational health, safety and work environment. However, during the construction phase, there will be 3,200 construction workers and 2,720 kg/day of solid waste, it may affect solid waste management by local agencies and cause solid waste accumulation. Hence, the likelihood of construction worker health effects will be at a moderate level (3 scores).

- **People living within 5 km radius from the project boundary**

During the construction phase, the designated areas for general waste and each type of waste will be provided. Also, proper containers will be provided for the storage of each type of waste and for suitable disposal. General waste will be collected by local agencies. Industrial waste will be sent for disposal by the agency authorized by Department of Industrial Works.

About 179.2 cu.m./day of wastewater from construction workers utilization-consumption and wastewater from toilets will be collected and treated through the prefabricated wastewater treatment plant so as to comply with effluent standards. Meanwhile, approx. 250 cu.m. of water discharges from the hydrostatic test will be checked for compliance with the requirements of Pluak Daeng Industrial Park before being conveyed to the central wastewater treatment system of the Industrial Park.

As a result, the likelihood of people’s health effects will be at a moderate level (3 scores).

2. Consideration of severity of consequences

- **Constructionn workers**

Severity of consequences for construction workers will be at a moderate level (2 scores) because these people will be directly exposed to waste, which results in health effects.

- **People living within 5 km radius from the project boundary**

During the construction phase, generated solid waste, construction waste and wastewater will be as follows:

General waste: About 2,720 kg/day of general waste

Construction waste, such as broken brick, structural scrap, scraps of material, etc.

Waste, such as battery, lubricant oil, hydaulic oil, detergent, etc.

The designated areas for waste storage and sorting will be provided. Also, proper containers will be provided for the storage of each type of waste and for suitable disposal.

Therefore, severity of consequences will be at a moderate level (2 scores), i.e. the increased morbidity rate, injuries, accumulation of vulnerable groups, budgeting, strike, impacts on power generation and communities.

(e) Health risk assessment

- **Construction workers**

Construction workers who collect and transport general waste and waste will have health effects. The likelihood will be at a moderate level (3 scores) since these people are most likely to be exposed to waste. Nonetheless, waste are segregrated by type and suitably collected according to the Notification of Ministry of Industry on disposal of waste or unusable materials, B.E. 2548. Moreover, Construction workers are required to wear personal protection equipment (PPE), such as rubber gloves, and protective clothing according to occupational health, safety and work environment. Severity of consequences will be at a moderate level. (2 scores). Thus, significance level of construction worker health effects will be at a moderate level (6 scores). Health effect prevention and mitigation measures shall be checked for sufficiency. Additional measures may be established to be in line with health effects.

- **People living in the project vicinities**

The likelihood of impacts of general waste and waste on people living in the project vicinities will be at a moderate level (3 scores). Severity of consequences will be at a moderate level (2 scores). Thus, significance level of health effects on people living in the project vicinities will be at a moderate level (6 scores), which is acceptable. Health effects prevention and mitigation measures need to be established. Additional, measures may be established**.**

(4) Transportation

(a) Health effect characteristics

During the construction phase, transportation of construction materials, equipment and construction workers to the project area may affect traffic flow in the project area and vicinities. Apart from this, in case of accident, it may lead to injury or death.

According to an assessment of impacts on transportation, national highways that are transportation routes, i.e. the National Highway No. 331, the National Highway No. 36, the rural road Ro Yor 2026 and the rural road Ro Yor 3013 had a very high traffic flow. Transportation suring the construction phase will not affect traffic flow on roads related to the project. Also, contractors shall strictly adhere to traffic rules. Local involved agencies and persons, such as local police, community leaders, etc. will be notified in advance for facilitation when materials, equipment and heavy machinery are transported. Moreover, community people will be notified in advance every time for the safety of operators and road users.

(b) Activities that lead to health effects

Transportation of construction materials, equipment and construction workers.

(c) Vulnerable groups to health effects

Vulnerable groups to health effects due to road accidents during the construction phase include road users around the project area and construction workers who commute from camp site to work at the construction site.

(d) Consideration of likelihood of health effects and severity of consequences

1. **Consideration of likelihood**

- **Construction workers**

Since construction workers do not live at the construction site but they commute from camp site to work, sharing transportation routes with people living in the project area may cause road accidents. However, health effect prevention and mitigation measures contribute to a low level of health effects (2 scores), i.e. low likelihood, likely to impact, with the availability of prevention and mitigation measures.

- **People living in the project vicinities**

According to traffic forecast in **Section 5.12 Transportation,** traffic conditions will not be different from the existing ones, i.e. a very high traffic flow. The transportation routes will sufficiently accommodate the increased traffic. Nonetheless, based on the public health facilities database, traffic road accidents are the leading cause of illness in the study area. Hence, the likelihood of people's health effects will be at a low level (2 scores), i.e. low possibility with the availability of prevention and mitigation measures.

2. **Consideration of severity of consequences**

- **Construction workers**

Serious road accidents during the construction phase may result in death. Severity of consequences will be at a high level (3 scores), i.e. injury, strike, impact on work or even death.

- **People living in the project vicinities**

As construction activities will take up 51 months and as road accidents are the leading cause of death and the mortality rate in the study area, the travel of construction workers and transportation may lead to minor injuries, deformities, or death. Thus, severity of consequences on people's health effects will be at a high level (3 scores). That is severity of consequences may lead to injuries or even death of community people.

(e) Health risk assessment

- **Construction workers**

Eventhough health effects on construction workers will be over a short period of time, severity of consequences will be at a high level (3 scores) and the likelihood will be at a low level (2scores). Hence, significance level of health effects will be at a moderate level (6 scores), which is acceptable. However, health effect prevention and mitigation measures shall be established, or existing measures may be improved.

- **People living in the project vicinities**

Health effects on people who share transportation routes with the project staff will be over a short period of time but with a high level of severity of consequences (3 scores) and low likelihood (2 scores). Hence, significance level of health effects will be at a moderate level (6 scores), i.e. injuries and budgeting. Existing health effect prevention and mitigation measures shall be checked for adequacy and suitability.

(5) Socio-economics

The opportunity for local people employment is expected to be at a moderate level (3) because employment during the construction phase will be responsible by contractors. Therefore, this benefit will depend on the management of contractors. However, prevention and mitigation measures require that contractors hire local people as many as possible to reduce the impact from migrant labours and increase benefits for communities. Moreover, local people shall be given priority to be hired for any vacancy. The employment by this project will enhance liquidity of the community economy, decrease the unemployment rate, promote the quality of life of people for better healthcare with a choice to receive better health service. The benefit for local people employment will be at a moderate level (2). Thus, significance level of local employment will be at a moderate level (6), which acceptable. However, health effect prevention and mitigation measures shall be established, or existing measures may be improved.

(6) Occupational Health, Safety and work Environment

(a) Health effect characteristics

During the construction phase, the following construction activities are likely to lead to accidents and illness: welding, short circuiting of power tools, construction in a confined space, noisy areas, brightly lit areas or dim ones, high heat areas, exposure to chemical substances, unsuitable ergonomics in the workplace, etc. These may cause illness and death.

According to impact assessment, occupational Health, Safety and work Environment of construction workers are realized. Safety will be always checked. Training will be provided for operators prior to starting work. Also, occupational health, safety and work environment measures will be made for safety during working hours. The main goal of the project is making zero accident.

(b) Construction activities that cause health effects

Construction activities that cause health effects include:

- Dust from construction activities, removal of scraps of material from the construction site, transportation of construction workers, etc.
- Exhaust from vehicles used in the transportation of construction machines,/equipment and materials, relocation of construction materials/parts

- Noise and vibration from machine operation
- Work environment like heat, bright areas or dim ones, and work in a confined space, work at a high place, work in a noisy area, unsuitable ergonomics at work, etc.

(c) Vulnerable group to health effects

The vulnerable group to health effects will be construction workers, especially works that need special caution and prevention. For example, structural construction in a specific area where machine control is difficult and an experienced operator is required and machine maintenance, etc.

(d) Consideration of likelihood of health effects and severity of consequences

1. Consideration of likelihood of health effects

- **Construction workers**

During the construction phase, the following construction activities are likely to lead to accidents and illness: construction at a high place, construction in a confined space, noisy areas, brightly areas or dim ones, high heat areas, unsuitable ergonomics in the workplace, etc. These may cause illness and death.

Pluak Daeng Power Plant Project realizes occupational health, safety and work environment for maximum safety during working hours. The main goal of the project is zero accident. Hence, the likelihood of construction worker health effects will be at moderate level (3 scores), i.e. support from available statistics for likelihood forecast.

2. Consideration of severity of consequences

- **Construction workers**

If a contractor does not pay attention to or does not consider the safety of construction workers, accidents at work may occur. The severity of accident may lead to injury or death. As a result, severity of consequences will be at a high level (3 scores), i.e. with injury, death, expenses for recovery and impact on power generation process.

(e) Health risk assessment

- **Construction workers**

Construction workers health effects have 9 scores, which is at a moderate level and acceptable. However, health effect prevention and mitigation measures shall be established, or existing measures may be improved.

(7) Public health service system and the increase in migrant labours

(a) Health effect characteristics

The entry of migrant labours to undertake construction activities may have cause the epidemic of communicable diseases, namely diarrhea, sexually transmitted diseases, and other diseases, etc. Furthermore, migrant labours may cause social problems, such as narcotics, reduced safety, and conflicts with communities if they are not screened or well managed. Additionally, in case of on-the-job injuries or illness, migrant labours may be the cause of inadequacy in public health service system, since they will be sent to a local hospital or infirmary like local people.

Also, transportation of materials, equipment, machines and construction workers, an accident at work and an emergency case will lead to injuries and death. According to the interview of local public health personnel, 88.9% stated that medical personnel and medical devices, namely nurse, dental officer/dental nurse and public health officer/public health technician, etc. are insufficient. Inadequate medical devices included dental equipment, respirator and dressing set, etc. The existence of the project will increase the burden of local public health facilities. Nowadays, there is a shortage of medical personnel in Tambon Health Promotion Hospitals and government hospitals in the study area; the entry of migrant labours means the sharing of public health personnel and may induce diseases from other areas.

However, a suitable occupational health, safety and work environment plan and an evaluation and monitoring plan are established. An infirmary will be provided for construction workers for first aid to reduce the burden of the local public health service.

(b) Activities that may lead to health effects

Accidents from construction activities and the increase in 3,200 migrant labours during the construction period

(c) Vulnerable groups to health effects

Vulnerable groups to health effects include construction workers and people living in the areas nearby the construction site.

(d) Consideration of likelihood and severity of consequences

1. **Consideration of likelihood of health effects**

- **Construction workers**

During the construction phase, there will be about 3,200 migrant workers. It is likely that accidents and illness while working occur. As a result, the likelihood of health effects will be a moderate level (3 scores).

- **People living in the project vicinities**

During the construction phase, 3,200 construction workers will enter the project area, leading to diseases and accidents and increased users in local public health facilities despite the shortage of medical personnel and medical devices. In addition to this, the survey on opinion of local public health personnel reveals, the shortage of professional nurse, dental officer/ dental nurse and public health officer/public health technician, etc. Thus, the likelihood of impacts on the public health service system will be at a moderate level (3 scores).

Also, migrant labours may cause social and sanitation issues in communities. Contractors have to provide camps for construction workers in the project vicinities, it is likely to result in communicable diseases, narcotics, and crime. Furthermore, 88.9% of public health personnel stated that nowadays, the project area have social probems and crime, such as theft/plunder and quarrel and fight among teenagers in the entertainment venue.

Hence, the likelihood of people's health effects due to communicable diseases in the project area, narcotics and crime will be at a moderate level (3 scores) i.e. support from available statistics for likelihood forecast.

2. **Consideration of severity of consequences**

- **Construction workers**

In case contractors do not provide a proper sanitary system at their camps of construction workers and at the construction site, and the unavailability of infirmary, medical supplies, and an ambulance, there might be severe injuries. Therefore, severity of consequences will be at a moderate level (2 scores), i.e. with the increased morbidity rate, injury, death, expenses for recovery and impact on the operation during the construction phase.

- **People living in the project vicinities**

If a contractor does not pay attention to or does not consider the safety of construction workers, accidents at work or communicable diseases may occur. Construction workers may be sent to local hospitals which increases the burden of medical personnel. As a result, severity of consequences will be at a moderate level (2 scores), i.e. with the increased morbidity rate, injury, accumulated vulnerable groups, budgeting, strike, impact on power generation process and communities.

- **People living in the project vicinities**

As there will be about 3,200 construction workers during the construction phase, in case contractors do not screen migrant labours or migrant labours are not well managed, it may lead to an epidemic of diseases and impacts on the local public health service system and social problems like narcotics, crime and the safety in life and asset. Currently, gamble, narcotics, theft, plunder/robbery are problems in this area. Therefore, training on hygiene, disease and narcotic prevention will be provided for construction workers. Moreover, contractors shall adhere to the Labour Protect Action Act on a risk-based physical examination, prepare a list of construction workers, notify the number of construction workers, and congenital diseases to responsible public health facilities to mitigate and prevent these problems. Therefore, severity of consequences on people health effects will be at a moderate level (2 scores). That is, if construction workers snatch and run away, it may result in loss of assets of people.

(e) Health risk assessment

- **Construction workers**

Construction workers during the construction phase will have health risk at a moderate level (3 scores). Severity of consequences will be at a moderate level (2). As a result, health risk level of construction workers will be at a moderate level (6), which is acceptable; however, health effect prevention and mitigation measures shall be established, or existing measures may be improved.

- **People living in the project vicinities**

The local public health system will have more responsibilities. Migrant labours may cause the following problems: communicable diseases, narcotics and crime. The impact will be at a moderate level (3). Severity of consequences will be at a moderate level (2). Therefore, the risk of impact will be at a moderate level (6), which is acceptable; however, health effect prevention and mitigation measures shall be established, or existing measures may be improved.

(8) Mental health effects

- **Construction workers**

1. Mental health effect characteristics

Construction workers will be directly affected from work. Health and mental health effects include exposure to dust from land leveling, noise from machine operation, solid waste, construction waste, polluted water, accidents from transportation (materials and equipment and construction workers), occupational health, safety and the environment, the public health service system and the increase in migrant labours. These issues may be the causes of stress and anxiety while working.

2. Health risk assessment

Although construction workers are the most vulnerable group, comprehensive prevention and mitigation measures for all activities are established. Additionally, activities will be performed under the occupational health, safety and environmental management plan and according to legal requirements. Also, the staff have to wear a personal protective equipment (PPE) while working, as appropriate. Moreover, a personal protective equipment (PPE) is required to be checked regularly or in accordance with the safety procedure of the project. An infirmary and medical supplies as well as an ambulance will be provided for emergency cases according to the ministerial regulations of Ministry of Labour on welfare facilities at workplaces, B.E. 2548 (2005) at the construction site, etc.

The construction phase will take up about 51 months with 3,200 construction workers/day. As a result, the likelihood will be at a moderate level (3) and severity of consequences will be at a moderate level (2). Severity of accidents from transportation of construction materials and equipment and occupational health, safety and the environment will be at a high level (3) as theses may cause serious injuries or death. Hence, significance level of mental health effects and the livelihood of local people will be at a moderate Level (6-9), which is acceptable; however, health effect prevention and mitigation measures shall be established, or existing measures may be improved.

- **People living in the project vicinities**

1. Health effect characteristics

Transportation of tools, equipment, heavy machinery and construction workers will increase traffic on roads in the project area, cause delay in travel, increase road accidents and stress from travel and concerns for road accidents.

Additionally, the employment of migrant labours who have different livelihood from local people may cause conflicts. Dust, noise from construction material and equipment transportation, etc. contribute to stress and anxiety of people living in the project vicinities. Although psychiatric disorders (neurosis) are likely to increase in Rayong province, the data of outpatients in Rp. 504 show that they are not the main cause of illness in the study area.

2. Health risk assessment

Although psychiatric disorders (neurosis) are likely to increase in Rayong province with no prevention and mitigation measures for the effects on mental health and the livelihood of local people, the construction schedule will be publicized. This is to make communities confident that contractors are supervised to be in compliance with the measures included in the environmental impact assessment report which be attached to the contract. Therefore, it is expected that only the project area will be affected at a moderate level (3), severity of consequences will be at a moderate level (2). The impact on transportation will be at a low level (2) and severity of consequences will be at a high level (3). Hence, significance level of effects on mental health and the livelihood of local people will be at a moderate level (6), which are acceptable; however, health effect prevention and mitigation measures shall be established, or existing measures may be improved.

(2) Operation Phase

During the operation phase, the project operation may result in health threats to operators and people living within the sensitive receptors 5 km radius from the project boundary, such as changes in the air quality, noise, occupational health, safety and work environment, solid waste and hazardous waste. Health effect characteristics and risk assessment will be as follows:

(1) Air quality

(a) Health effect characteristics

During the operation phase, natural gas will be used as primary fuel and diesel oil will be used as reserve fuel. So, air pollution emission from the power plant may be harmful to health. These pollutants include nitrogen oxides (NO_X), sulphur dioxide (SO_2) and total suspended particulate (TSP), which affect human respiratory system. Inhalation of nitrogen oxides (NO_X) may irritate pulmonaryalveolus and tracheal collapse, especially, in the person who has asthma. Exposure to 210 $\mu g/m^3$ of sulphur dioxide (SO_2) will lead to the abnormal respiratory system and exposure to 290 $\mu g/m^3$ of sulphur dioxide (SO_2) will cause an arrhythmia, with short and shallow breathing, increased pulmonary resistance, reduced nasal mucus and nasopharynx size (Wongphan Limpasenee, 2000). Health effects depend on various factors, such as the duration of exposure, the health of affected person and the concentrations of pollutants. Details are shown in **Table 5.4.2-1** and **Table 5.4.2-2.**

AERMOD atmospheric dispersion modeling system is adopted to assess the impact on air quality in 6 cases (**Details are given in Chapter 5, Section Air Quality Assessment**), namely

Case 1: Impacts caused by Pluak Daeng Power Plant Project in the event of natural gas-fired operation at 100% load are assessed in conjunction with results of ambient air quality monitoring.

Case 2: Impacts caused by Pluak Daeng Power Plant Project in the event of natural gas-fired operation at minimum load are assessed in conjunction with results of ambient air quality monitoring.

Case 3: Impacts caused by Pluak Daeng Power Plant Project in the event of natural gas-fired operation at 100% load; plus the existing impacts caused by other industrial plants as specified in the environmental impact assessment report though there is not yet air pollutant emission within the radius of 15 kilometers from the project location; are assessed in conjunction with results of ambient air quality monitoring.

Case 4: Impacts caused by Pluak Daeng Power Plant Project in the event of diesel-fired operation at 100% load are assessed in conjunction with results of ambient air quality monitoring.

TABLE 5.4.2-1

IMPACTS OF FUEL COMBUSTION ON HUMAN HEALTH

Pollutants	Health Effects
Sulphur Dioxide (SO_2)	• Inhalation of the high amount of SO_2 (Gaseous SO_2) over a short period of time will cause breathing difficulty for a moment for those who have asthma or those working outdoors. Exposure to SO_2 or SO_2 particle will cause the respiratory system diseases and worsen heart disease. • Inhalation of SO_2 particles: SO_2 will have a chemical interaction with other substances in the air, causing fine solid particles of sulphate. Once inhaled, the fine solid particles of sulphate will accumulate in the lung, irritate the respiratory system, cause breathing difficulty, and respiratory system diseases and premature deaths. • Visibility impairment: In case of refraction of light or the light is absorbed by gas or SO_2 particles, it will impair visibility.
Total Suspended Particulate (TSP)	• Severe respiratory symptoms, i. e. respiratory irritation, cough or breathing difficulty • Impaired pulmonary function • More laboured breathing for those who have asthma • Chronic bronchitis • Arrhythmia • Heart disease, such as heart failure • Premature deaths for those who have heart disease or pneumonosis
Nitrogen oxides (NO_x)	• Nitric Oxide (NO) and nitrogen dioxide (NO_2) are compounds that are harmful to human. Inhalation of 140 $\mu g/m^3$ of nitrogen dioxide (NO_2) will cause slow dark adaptation (Wongphan Limpasenee, 2003). Those who have asthma will worsen from labored breathing in case of exposure to 190 $\mu g/m^3$ of this gas together with bronchioconstrictor. The abnormal respiratory system in human occurs if exposed to 1,300-3,800 $\mu g/m^3$ of this gas. The comparison of acute conditions between NO and NO_2 on pulmonary function shows that NO is apparently less harmful. • Nitrogen oxides cause smog because of the interaction between NO_x and volatile organic compound (VOC) while the light is the catalyst. Vulnerable groups include children, the senior people, those who have pneumonosis or bronchitis, such as asthma and those who work or exercise outdoors. Prolonged and regular exposure to nitrogen oxides will destroy lung tissue, impairing pulmonary function. In addition, ozone may be blown out far from an emission source affecting people or the environment in remote areas and agricultural products.

TABLE 5.4.2-1
IMPACTS OF FUEL COMBUSTION ON HUMAN HEALTH (CONT'D)

Pollutants	Health Effects
Nitrogen Oxides (NO_x) (cont'd)	• Weather changes: Nitrous Oxide (N_2O) which belongs to the family of nitrogen oxide, causes the greenhouse effect. Accumulation of this gas in the atmosphere makes global temperature higher which is a risk factor to human, causes the sea level rise and a considerable change in plants and animals. • The reaction of a toxic NO_x with other compounds, especially organic compound or ozone will form new toxic compounds. Some new toxic compounds are the cause of biological mutation. Examples of toxic compounds are nitrate radical, nitroarenes and nitrosamines.

Source: http://hpe4.anamai.moph.go.th/hia/air_pollutant.php, 2010

TABLE 5.4.2-2
EFFECTS OF NITROGEN DIOXIDE ON HUMAN

Concentrations		Duration of Exposure	Reasons	Bibliography
$\mu g/m^3$	ppm			
			Odour	
230	0.12	-	• 3 Out of 9 healthy males, smell the odour.	Henschier et al. (1960)
230	0.12	-	• Among 14 persons, most of them smell the odour immediately when the test starts.	Salamberidze (1967)
200	0.11	-	• 26 Out of 28 persons, smell the odour immediately when the test starts.	Feldman (1974)
			Effects on pulmonary function	
1,300-3,800	0.7-2.0	10 min	• Increase in respiratory system resistance when inhaling and exhaling	Suzuki & Ishikawa (1965)
190	0.1	1 hr/day	• Increase in respiratory system resistance and increase in restrictive impairment in 13 persons who have asthma among 20 persons	Orehek et al. (1976)
560,000-940,000	300-500	-	• Death due to pulmonary edema or loss of consciousness as a result of cerebral hypoxia	Grayson (1956)

TABLE 5.4.2-2

EFFECTS OF NITROGEN DIOXIDE ON HUMAN (CONT'D)

Concentrations		Duration of Exposure	Reasons	Bibliography
$\mu g/m^3$	ppm			
			Efects on community	
94	-	-	• Two groups of population living in the same region, different town, and different concentrations of nitrogen dioxide were compared. Results show that the concentration of 43 $\mu g/m^3$ nitrogen dioxide did not affect pulmonary function and did not increase the morbidity rate of respiratory system in non- smoking persons in urban population (Control Group)	Choen et al. (1972)
≥940	0.50	1 hr	• Housewives who cooked with a gas oven did not have an acute respiratory syndrome, compared with those who used an electric oven.	US.EPA (1976 b)

Source: Air pollution Control System Textbook, Department of Industrial Works, 2004

Case 5: Impacts caused by Pluak Daeng Power Plant Project in the event of diesel-fired operation at minimum load are assessed in conjunction with results of ambient air quality monitoring.

Case 6: Impacts caused by Pluak Daeng Power Plant Project in the event of diesel-fired operation at 100% load; plus the existing impacts caused by other industrial plants as specified in the environmental impact assessment report though there is not yet air pollutant emission within the radius of 15 kilometers from the project location; are assessed in conjunction with results of ambient air quality monitoring.

(b) Activity that leads to health effects

Stack emission

(c) Vulnerable groups to health effects

The project staff and people living in the project vicinities, especially vulnerable groups like children, the senior people and patients with chronic respiratory system

(d) Consideration of likelihood and severity of consequences

1. Consideration of likelihood

- **Project staff**

During the operation phase, the likelihood of project staff to be affected by air pollutants will be at a moderate level (3 scores) as they have to work in an operational area for a specific period of time and the operational area is the source of pollutants.

- **People living in the project vicinities**

Forecast results of air quality through AERMOD atmospheric dispersion modeling system show the maximum concentrations of nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and total suspended particulate (TSP) in case 3: Impacts caused by Pluak Daeng Power Plant Project in the event of natural gas-fired operation at 100% load; plus the existing impacts caused by other industrial plants as specified in the environmental impact assessment report though there is not yet air pollutant emission within the radius of 15 kilometers from the project location;are assessed in conjunction with results of ambient air quality monitoring in 31 sensitive receptors. It was found that the concentrations of such pollutants were lower than the standards. Combined with the current maximum measurement results, the concentrations of pollutants fall within the standards.

According to morbidity statistics of outpatients in Rp. 504 from Tambon Health Promoting Hospitals in the study area during 2011-2015, the majority of people in the study area suffered from respiratory system diseases, symptoms, signs and abnormalities due to clinical examination and laboratory test that cannot be classified, digestive disorders and oral diseases, respectively.

According to morbidity statistics of inpatients in Rp. 505 during 2011-2015, respiratory system diseases were not the main causes of the illness of people in the study area. Major diseases were endocrinopathy, malnutrition and metabolism, delivery, signs, symptoms and abnormalities due to clinical examination and laboratory test that cannot be classified and other intestinal infections **(Details are included in chapter 4 Section Collection of Public Health Baseline.).**

In addition, 66.7% of local public health personnel viewed that the existing environment affects illness, such as air quality, water quality and chemical substances, etc.

According to the information of existing environmental conditions of the study area, the project vicinities can still accommodate pollutants. However, as the project operation will be in the long-run, it is likely that air pollutants are accumulated. Therefore, the likelihood of people health effects will be at a moderate level (3 scores). That is, there are potential health effects which require strict control measures.

2. **Consideration of severity of consequences**
   - **Project staff**

The Continuous Emission Monitoring System (CEMs) will be installed at the stacks of the power plant to continuously monitor the air pollution emission rate. Monitoring results will be reported to Pluak Daeng Industrial Park. Also, the air pollution emission rate will be controlled for not exceeding the one mentioned in the EIA report. Therefore, severity of the project staff health effects will be at a moderate level (2 scores).

   - **People living in the project vicinities**

Forecast results of air quality through AERMOD atmospheric dispersion modeling system show the maximum concentrations of nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and total suspended particulate (TSP) in case 3: Impacts caused by Pluak Daeng Power Plant Project in the event of natural gas-fired operation at 100% load; plus the existing impacts caused by other industrial plants as specified in the environmental impact assessment report though there is not yet air pollutant emission within the radius of 15 kilometers from the project location;are assessed in conjunction with results of ambient air quality monitoring in 31 sensitive receptors. It was found that the concentrations of such pollutants were lower than the standards. Combined with the current maximum measurement results, the concentrations of pollutants fall within the standards. Maximum concentrations were found at Khao Song Phi Nong, Kao Jom Hae and tapioca orchard, about 12-18 km from the project area.

Hence, severity of consequences on people living in the project vicinities will be at a moderate level (2 scores). It is likely to affect people and increase illness because of air pollution.

(e) Health risk assessment

- **Project staff**

During the operation phase, the likelihood of the project staff exposure to air pollutants will be at a moderate level (3 scores), severity of consequences will be at a moderate level (2 scores) and significance level of impact will be at a moderate level (6 scores). The strict air quality impact prevention and mitigation measures shall be established.

- **People living in the project vicinities**

As pollutants released, i.e. particulate matter, nitrogen dioxide and sulphur dioxide meet the standards, severity of consequences will be at a moderate level (2 scores). According to morbidity statistics in Rp. 504, respiratory system diseases are the majority illness of people in the study area. Hence, the likelihood of people health effects will be at a moderate level (3 scores). Significance level of people health effects due to exposure to total suspended particulate will be at a moderate level (6 scores). Existing prevention and mitigation measures shall be checked for sufficiency and suitability.

(2) Noise

(a) Health effect characteristics

Exposure to noise levels that exceed 120 decibels (A) is likely to cause deafness and exposure to an average noise level of 90 decibels (A) or higher for more than 8 hours per day, or noise levels of 70 decibels (A) or higher all the time, is likely to cause hearing loss and deterioration in hearing. Prolonged exposure to noise may lead to mental health effects, namely stress, poor concentration, thought, and learning as well as decreased efficiency and effectiveness at work.

During the operation phase, tools, machines and equipment that generate 85 decibels (A) of noise level at maximum at the distance of 1 m from the noise source will be chosen for power generation. This is exceptional for a cooling tower where maximum noise level of water impact on the floor shall not exceed 91.0 decibels (A) at the distance of 1 m. The project staff are required to wear personal protective equipment, namely ear muff and earplugs all the time while working in a noisy area. Also, in the area where the noise level is 90 decibels (A), the work shall not exceed 8 hours. Furthermore, some machines will be placed in a closed building installed with a metal sheet of 0.64 mm thick (Steel 24 ga) or thicker, with the transmission loss (TL) of 18 decibels (A), or a material with the transmission loss (TL) of 18 decibels (A). Therefore, noise level from the machines, namely a gas turbine, steam turbine and generator will be reduced to 67 decibels (A). Regarding the sensitive receptors: communities in the west, the south and the north of the project, noise levels ranged from 39.5-41.1 decibels (A). Combined with maximum measurement results of 59.4-66.3 decibels (A), noise levels ranged from 59.5-66.3 decibels (A), 85.0%-94.7% of the standard value of Leq. 24 hr. Leq 1 hr from 06.00-22.00 hr and Leq. 5 min from 22.00-06.00 hr were used for noise forecast. Noise levels ranged from non-disturbance sound to 32.6 decibels (A). According to the forecast result, noise level exceeds the standards. Nontheless, a total noise level from project activities and the currently measured noise level is not different. As a result, noise levels from the project operation will not increase disturbance. **Details for appraisal for health effects are provided in Chapter 5 Section Noise**.

(b) Activities that lead to health effects

Noise from the machinery and electric generation equipment

(c) Vulnerable groups to health effects

The first vulnerable group is the project staff followed by people living within 5 km radius from the project boundary.

(d) Consideration of likelihood and severity of consequences

1. Consideration of likelihood

- **Project staff**

During the operation phase, the likelihood of the project staff health effects will be at a moderate level (3 scores) as these people will be exposed to noise all the time while working.

- **People living in the project vicinities**

During the operation phase, the likelihood of noise exposure of people living in the project vicinities will be at a moderate level (3 scores) as the impact may be in the long-run.

2. Consideration of severity of consequences

- **Project staff**

During the operation phase, the project staff are required to wear personal protective equipment (PPE), namely earplugs or earmuff throughout working hours and noise prevention and mitigation measures are established. Nonetheless, as the projects staff have to work for a continuous working time, severity of consequences will be at a moderate level (2 scores).

- **People living in the project vicinities**

Forecast results of noise in general reveal that in the 3 sensitive receptors, noise levels from power generation ranged from 39.5-41.1 decibels (A). Combined with the currently measured maximum noise levels ranging from 59.5-66.3 decibels (A), the noise level was not different from the currently measured one (59.4-66.3 decibels (A)). However, the noise level exceeded the standards (ranging from non-disturbance sound to 32.6 decibels (A)). However, taking into account a total noise level from project activities and the currently measured noise level is not different. As a result, noise levels from the project operation will not increase disturbance.

As a result, severity of consequences on people health effects will be at a moderate level (2 scores).

(e) Health risk assessment

- **Project staff**

During the operation phase, the likelihood of the project staff exposure to noise will be at a moderate level (3 scores), severity of consequences will be at a low level (2 scores) and significance level of impact will be at a moderate level (6 scores). The strict noise impact prevention and mitigation measures shall be established.

- **People living in the project vicinities**

During the operation phase, the likelihood of noise exposure of people living in the project vicinities will be at a moderate level (3 scores). Severity of consequences will be at a low level (2 scores). Significance level of impact will be at a moderate level (6 scores). The strict noise impact prevention and mitigation measures shall be established.

(3) Solid waste and hazardous waste

(a) Health effect characteristics

Waste during the operation phase is classified into 2 types: waste from power generation process and, i.e. scraps of material and container, air filter, used lubricant oil, resin, sludge and general waste generated from staff activities, i.e. sanitary waste.

Contamination to the environment may result in the breeding source of vectors, odour and conflicts with communities.

(b) Activities that may lead to health effects

Increased solid waste and waste from the project operation

(c) Vulnerable groups to health effects

Project staff and people living in the project vicinities

(d) Consideration of the likelihood and severity of consequences

1. Consideration of likelihood

- **Project staff**

The project staff and workers who collect general waste and waste are most likely to be affected eventhough waste are segregrated by type and suitably collected according to the Notification of Ministry of Industry on disposal of waste or unusable materials, B.E. 2548. Moreover, workers are required to wear personal protection equipment (PPE), such as rubber gloves, and protective clothing according to occupational health, safety and work environment. However, it is possible that the project staff are exposed to waste. Hence, the likelihood of cworkers and the project staff health effects will be at a moderate level (3 scores). The strict impact prevention and mitigation measures shall be established.

- **People living in the project vicinities**

The systematic solid waste and waste management measures are available. For example, solid waste from the office building will be collected for disposal by local agencies. Other waste such as lubricant oil, air filter and resin will be sent for disposal by the authorized agency.

As a result, the likelihood of people health effects will be at a moderate level (3 scores). Strict prevention and mitigation measures shall be established to mitigate exposure.

2. **Consideration of severity of consequences**

- **Project staff**

Severity of consequences on the project staff and operators will be at a moderate level (2 scores) because these people are likely to be directly exposed to waste, leading to injuries and the impact on power generation.

- **People living in the project vicinities**

The increase in solid waste and waste above may be harmful to health in case of direct exposure and accumulation in the body. However, suitable solid waste collection and disposal methods are provided by the project to prevent health effects on people living in the project vicinities.

As a result, severity of consequences on people will be at a moderate level (2 score).

(e) Health risk assessment

- **Project staff**

The likelihood of the project staff to be exposed to hazardous waste will be at a moderate level (3 scores). Exposure to hazardous waste will cause health effects. As a result, severity of consequences will be at a moderate level (2 scores). Significance level of health effects on the project staff wil be at a moderate level (6 scores). Prevention and mitigation measures shall be established. Alternatively, existing Prevention and mitigation measures shall be improved.

- **People living in the project vicinities**

The likelihood of exposure will be at a moderate level (3 scores). As exposure to hazardous waste can affect human health, severity of consequences will be at a moderate level (2 scores). Therefore, significance level of health effects will be at a moderate level (6 scores). Prevention and mitigation measures shall be established. Alternatively, existing ยrevention and mitigation measures shall be improved.

(4) Transportation

(a) Health effect characteristics

During the operation phase, transportation of chemical substances, oil and the project staff to the project location may affect transportation in the project area and the project vicinities, cause accidents, injuries or deaths.

Based on transportation impact assessment, the national highways which are the transportation route are in a good condition and do not affect traffic flow in the project vicinities.

(b) Activities that cause health effects

Transportation of chemical substances, oil and the project staff

(c) Vulnerable groups to health effects

Vulnerable groups to road traffic accidents during the operation phase include road users in the project vicinities and the project staff who commute from home to work in the project location.

(d) Consideration of the likelihood and severity of consequences

1. Consideration of likelihood

- **Project staff**

During the operation phase, the project staff and local people will commute on the same roads. However, as there will be only 60 projects staff, the likelihood of health effects will be at a low level (2 scores).

- **People living in the project vicinities**

According to the forecast of increased traffic during the operation phase in **Section 4.12: Transportation**, traffic conditions will not be different from the existing conditions. That is there will be a very good traffic flow on the National Highway No. 331, the National Highway No. 36, the Rural Road Ror Yor 2026 and the Rural Road Ror Yor 3013. These roads have sufficient carrying capacity for increased traffic. Although the project staff and local people use the same roads, the likelihood of people health effects will be at a low level (2 scores), i.e. low possibility with prevention and mitigation measures.

2. Consideration of severity of consequences

- **Project staff**

Severity of consequences on the project staff during the operation phase will be at a high level (3 scores) due to injuries, strike, impact on work and deaths.

- **People living in the project vicinities**

Since activities during the operation phase take a long time and accidents result in minor injuries, deformity or even deaths. Therefore, severity of consequences on people health effects will be at a high level (3 scores) due to injuries, impacts on communities or even deaths.

(e) Health risk assessment

- **Project staff**

Severity of consequences on the project staff health effects will be at a high level (3 scores) and the likelihood will be at a low level (2 scores). Therefore, significance level of impact will be at a moderate level (6 scores). Prevention and mitigation measures shall be established. Alternatively, existing measures shall be improved.

- **People living in the project vicinities**

Severity of consequences on health effects of road users who use the same roads of the project staff will be at a high level (3 scores) and the likelihood will be at a low level (2 scores). As a result, significance level of impact will be at a moderate level (6 scores) Prevention and mitigation measures shall be established. Alternatively, existing measures shall be improved.

(5) Socio-economics (employment and employment of local people)

The likelihood of employment will be at a moderate level (3). Qualified local people will have the priority for employment. This is to mitigate the impacts from migrant labours and increase benefits for communities, employment and job creation.

Local employment and job creation will lead to better quality of life, better healthcare and better option for health service. Therefore, benefits for communities will be at a moderate level (2). Significance level of impact on local employment will be at a moderate level (6), which are positive impacts.

(6) Occupational Health, Safety and work Environment

(a) Health effect characteristics

During the operation phase, an accident at work and on-the-job illness may occur, such as exposure to chemical substances, noise, heat, fire, boiler explosion, leaking oil tank, major hazard, etc. These may cause illness or deaths to operators or people living in the project vicinities. Because of the prolonged operation, if the work environment is unsuitable and if occupational health, safety and work environment regulations of the project is not adhered to, an accident at work and on-the-job illness may occur.

(b) Activities that may lead to health effects

During the operation phase, activities that may lead to health effects include

- Working with machinery
- Office work, such as paperwork, working with computer, brightly lit areas or dim ones, etc.
- Working with chemical substances

(c) Vulnerable group to health effects

The project staff are the vulnerable group to health effects.

(d) Consideration of the likelihood and severity of consequences

1. Consideration of likelihood

- **Project staff**

During the operation phase, accidents and illness may occur due to some activities, such as machine maintenance, working in noisy areas, dim areas or brightly lit ones, working in high heat areas, unsuitable ergonomics in the workplace, etc. These may be the cause of illness or even deaths.

Pluak Daeng Power Plant Project realizes occupational health, safety and work environment for maximum safety during working hours. The main goal of the project is zero accident. Hence, the likelihood of the project staff health effects will be at a low level (2 scores), i.e. low possibility with supporting data but prevention and mitigation measures are established by the project.

2. Consideration of severity of consequences

- **Project staff**

If an operator does not pay attention to or does not consider the safety while working, accidents at work may occur. The severity of accident may lead to injury or death. As a result, severity of consequences will be at a high level (3 scores), i.e. death and high cost for medical treatment.

(e) Health risk assessment

- **Project staff**

The risk level of the project staff health effects will be at a moderate level (6 scores). That is the prevention and mitigation measures shall be established. Alternatively, existing measures may be improved.

(7) Public health service and the increase in migrant labours

(a) Health effect characteristics and vulnerable groups

During the operation phase, the number of project staff working in the project area, accidents and illness because of the project activities, transportation of chemical substances, staff and accidents at work as well as unexpected accidents will increase the burden of local public health facilities and affect local people who have medical treatment at such local public health facilities.

However, a suitable occupation health, safety and work environment plan, the evaluation and monitoring plan of implementation are provided. An infirmary will be provided for treatment of minor illness so as to reduce the burden of local public health facilities. Pre-placement examination and general health check-up will be provided for health promotion and accurate diagnosis by physicians.

(b) Health risk assessment

- **Project Staff**

The likelihood of impacts on local public health facilities service because of illness or injuries will be at a moderate level (3). Because of these long-run impacts and the shortage of medical personnel and devices, severity of consequences will be at a moderate level (2). As a result, the health risk level will be at amoderate level (6), which is acceptable but needed to strictly adhere to prevention and mitigation measures.

- **People living in the project vicinities**

The likelihood of impacts on local public facilities service will be at a moderate level (3). The project staff will receive medical treatment at these local public facilities, causing delay for general people. Because of these long-run impacts and the shortage of medical personnel and devices, severity of consequences will be at a moderate level (2). As a result, the health risk level will be at a moderate level (6), which is acceptable but needed to strictly adhere to prevention and mitigation measures.

(8) Chemical substances

Since acidic and basic chemical substances and scale and corrosion inhibitor, in solid and liquid forms will be used in the project. The leakage or residue of the substances will have direct impacts on the project staff health effects. Therefore, appraisal of health effect or health risk because of chemical exposure was performed.

(a) Hazard identification

Preliminary assessment of health risk is based on data collection from MSDS of each type of chemical substances and the data of health effects from U.S. EPA (www.epa.gov/iris). Physical and chemical properties of each chemical substances (**Table 5.4.2-3**) and chemical exposure routes (**Table 5.4.2-4**) and health effects from chemical exposure are taken into account.

1. Sodium Chlorite ($NaClO_2$)

Skin exposure : Skin exposure will cause irritation and burning pain.

Inhalation : Inhalation of the vapor of this substance will lead to breathing difficulty, lung destruction, and irritation of respiratory system.

Eating or swollowing: Eating or swollowing of this substance will cause gastrotestinal tract irritation, stomachach, diarrhea, vomit, ecchymosis and anemia

Eye exposure : Eye exposure will bring about eye irritation or burning eyes, conjunctivitis and eye tissue.

TABLE 5.4.2-3

PHYSICAL AND CHEMICAL PROPERTIES OF CHEMICAL SUBSTANCES USED IN PLUAK DAENG POWER PLANT PROJECT

Name of Chemical Substances (Trade Name)	Chemical Formula	Boiling Point (°C)	Melting Point (°C)	Vapor Pressure (millimeter of mercury) at 20 °C	Specific Gravity (water = 1)	Molecular Weight (g/mole)	Autoignition Temperature (°C)	Flash Point (°C)	Solubility (gram/100 ml.)	Appearance Color and Odor
1. Sodium Chlorite 25%	$NaClO_2$	-	-	-	-	90.45	-	-	soluble	Solid, white
2. Hydrochloric Acid 35%	HCl	53	-74	-	1.1-1.19	-	-	-	soluble	Liquid, pale yellow, pungent
3. Ferric Chloride 40%	$FeCl_3$	-	304	<1	2.8	162.21	-	-	soluble	Liquid, brown, subtle smell
4. Polymer	-	-	-	-	-	-	-	-	soluble	Solid, white, pungent
5. Sodium Hydroxide 50%	NaOH	1390	318	<18	2.13	40	-	-	111 at 20 °C	Liquid, colorless, odorless
6. Sodium MetaBisulfite 1% ($Na_2S_2O_5$)*	-	-	300	-	1.48	-	-	-	soluble	Solid, white
7. RO Antiscalant (100%)	-	-	-	-	-	-	-	-	-	Solid, white
8. Sulfuric Acid 98%	H_2SO_4	100	10	1	1.84	98.08	-	-	soluble	Liquid, colorless, odorless
9. Citric Acid (15%)	$C_6H_8O_7$	-	155-157	-	-	-	-	-	-	Solid, colorless, odorless
10. Oxygen Scavenger (Elimin - OX)	-	-	-	-	1.02	-	-	-	soluble	Liquid, colorless, odorless
11. Aqueous Ammonia 25%	NH_3	-	-77	115	0.99	35.05	-	-	soluble	Liquid, colorless, pungent
12. Trisodium Phosphate	($Na_3PO_4.12H_2O$)	-	-	-	1.62	-	-	-	soluble	Solid, white / colorless, odorless
13. Scale and Corrosion Inhibitor	-	-	-5	-	1.14-1.30	-	-	-	soluble	Liquid, pale yellow/brown subtle smell

Remark: * $Na_2S_2O_5 + H_2O \longrightarrow NaHSO_3$

Sources: - Gulf PD Co., Ltd., 2016

- Center of Excellence on Hazardous Substance Management and Chulalongkorn University, 2016

TABLE 5.4.2-4

CHEMICAL EXPOSURE ROUTE BY TYPE AND CHEMICAL INTAKE

Name of Chemical Substances (Trade Name)	Chemical Intake			
	Skin Exposure	Inhalation	Eating or Swollowing	Eye Exposure
1. Sodium Chlorite 25%	✓	✓	✓	✓
2. Hydrochloric Acid 35%	✓	✓	✓	✓
3. Ferric Chloride 40%	✓	✓	✓	✓
4. Polymer	✓	✓	✓	✓
5. Sulfuric Acid 98%	✓	✓	✓	✓
6. Sodium Hydroxide 50%	✓	✓	✓	✓
7. Sodium Metabisulfite 1%	✓	✓	✓	✓
8. RO Antiscalant 100%	✓	✓	✓	✓
9. Citric Acid 15%	✓	✓	✓	✓
10.Oxygen Scavenger	✓	✓	✓	✓
11. Aqueous Ammonia 25%	✓	✓	✓	✓
12. Trisodium Phosphate	✓	✓	✓	✓
13. Scale and Corrosion Inhibitor	✓	✓	✓	✓

Sources: - Gulf PD Co., Ltd., 2016
- Center of Excellence on Hazardous Substance Management and Chulalongkorn University, 2016

2. Hydrochloric Acid (HCl)

Skin exposure : Skin exposure will cause irritation, rash and burning pain. Exposure to high concentration hydrochloric acid will result in blister.

Inhalation : Inhalation of the vapor of this substance will lead to cough, breathing difficulty, nasal inflammation, pharyngitis and upper respiratory tract problems. In the severe case, it will cause pulmonary edema, respiratory failure and death.

Eating or swollowing: Eating or swollowing of this substance will cause irritation, burned mouth, throat, oesophagus, gastrotestinal tract irritation, nausea, vomit, diarrhea and death.

Eye exposure : Eye exposure will bring about eye irritation or burning eyes, conjunctivitis and eye tissue.

Carcinogenicity : Prolonged exposure to the vapor of this substance will cause corrosion and corrosion activity. Those who have dermal disorders or eye diseases are susceptible to the vapor. This substance is not classified as carcinogen according to NTP but it is classified as carcinogen, Type 3 according to IARC

3. Ferric Chloride ($FeCl_3$)

Skin exposure : Skin exposure will cause irritation

Inhalation : In case of dissolved in water and inhaled in a large amount, it will cause the malfunctioning coronary system, hepatoxicity and nephrotoxicity

Eating or swollowing: In case of dissolved in water and swallowed, it will cause nausea and vomit.

Eye exposure : Eye exposure will bring about eye irritation.

4. Polymer

Skin exposure : Skin exposure will cause a minor skin irritation.

Inhalation : Inhalation of this substance will cause irritation to the respiratory system.

Eating or swallowing: It will be hazardous.

Eye exposure : Eye exposure will cause irritation and bloodshot eyes.

5. Sodium Hydroxide (NaOH)

Skin exposure : Skin exposure will cause irritation.

Inhalation : Inhalation of this substance will severely destroy mucosa and the upper respiratory system.

Eating or swallowing: It will be hazardous.

Eye exposure : Eye exposure will cause severe irritation (burn).

6. Sodium Metabisulfite ($Na_2S_2O_5$)

Skin exposure : Skin exposure will cause irritation.

Inhalation : Inhalation of this substance will bring about mucosa irritation, cough and breathing difficulty.

Eating or swallowing: Eating or swallowing will cause the irritation of oral mucosa, trachea, oesophagus and the digestive system.

Eye exposure : Eye exposure will cause eye irritation.

7. RO Antiscalant

Skin exposure : Skin exposure will cause irritation.

Inhalation : Inhalation of this substance will bring about irritation to the upper respiratory system.

Eating or swallowing: Eating or swallowing will be hazardous.

Eye exposure : Eye exposure will cause irritation.

8. Sulfuric Acid (H_2SO_4)

Skin exposure : The corrosion activity of this substance will cause burn and burning pain.

Inhalation : The corrosion activity of this substance will cause irritation to the respiratory system and the respiratory tract, pulmonary edema, sore throat, cough, breathing difficulty, and wheeze.

Eating or swallowing: Eating or swallowing this substance will cause nausea, vomit, etc.

Eye exposure : The corrosion activity of this substance will case bloodshort eyes, eye pain and blurred vision.

9. Citric Acid ($C_6H_8O_7$)

Skin exposure : Skin exposure will cause irritation.

Inhalation : Inhalation of this substance will bring about irritation to mucosa and the upper respiratory system.

Eating or swallowing: Eating or swallowing will be hazardous.

Eye exposure : Eye exposure will cause severe irritation

10. Oxygen Scavenger

Skin exposure : The severe corrosive substance can cause skin irritation.

Inhalation : Inhalation of this substance will cause rhinitis.

Eating or swallowing: Eating or swallowing will cause irritation to gastrointestinal tract.

Eye exposure : Eye exposure will cause eye irritation.

11. Aqueous Ammonia (NH_3)

Skin exposure : Skin exposure will cause irritation and burn.

Inhalation : Inhalation of this substance will irritation to the respiratory system, pulmonary edema and death.

Eating or swallowin: Eating or swollowing of this substance will cause irritation to oesophagus, stomach, peritonisis, nausea, vomit, diarrhea and unconciousness.

Eye exposure: Eye exposure will cause eye irritation and eye pain.

12. Trisodium Phosphate ($Na_3PO_4.12H_2O$)

Skin exposure : Skin exposure will cause burn.

Inhalation : Inhalation of this substance will bring about irritation to mucosa and the upper respiratory system.

Eating or swallowing: Eating or swallowing will be hazardous.

Eye exposure : Eye exposure will cause eye irritation.

13. Scale and Corrosion Inhibitor

Skin exposure : Skin exposure will cause minor irritation.

Inhalation : Inhalation of this substance will irritation to the respiratory system.

Eating or swallowing: Eating or swallowing will irritate the stomach.

Eye exposure : Eye exposure will cause eye irritation.

(b) Dose-response Assessment

When exposed in large amount doses, a chemical substance will be harmful or cause illness, indicating by dose-response relationship from the study in laboratory animals, which assess dose-response in human. A chemical substance is classified into 2 groups: noncarcinogenic substance and carcinogenic substance in human. Chemical substances used in the project are categorized as follows:

(b.1) Noncarcinogenic substance

1. **Sodium Chlorite ($NaClO_2$)**

- Acute Oral Toxicity (LD_{50}) with the concentration of 165 mg/kg in a guinea pig.
- Exposure of laboratory animal to Sodium Chlorite ($NaClO_2$): LD_{50} for Sodium Chlorite ($NaClO_2$) is 165 mg/kg, which makes 50% of guinea pig died.

2. **Hydrochloric Acid (HCl)**

- Acute Oral Toxicity (LD_{50}) with the concentration of 900 mg/kg in a rabbit
- Exposure of laboratory animal: LD_{50} for hydrochloric acid (HCI) is 900 mg/kg which makes 50% of rabbits died.

3. **Ferric Chloride ($FeCl_3$)**

- Oral Toxicity (LD_{50}) with the concentration of 450 mg/kg in a guinea pig
- Exposure of laboratory animal: LD_{50} for ferric chloride ($FeCl_3$) is 450 mg/kg which makes 50% of guinea pig died.

4. **Polymer**

- Acute Oral Toxicity (LD_{50}) with the concentration of 7,400 mg/kg in a guinea pig
- Exposure of laboratory animal: LD_{50} for polymer is 7,400 mg/kg which makes 50% of guinea pig died.

5. **Sodium Hydroxide (NaOH)**

6. **Based on MSDS**, direct exposure to sodium hydroxide (NaOH) in human will cause irritation but there is no data in laboratory animals and impacts on human.

7. **Sodium Metabisulfite ($Na_2S_2O_5$)**

- Acute Oral Toxicity (LD_{50}) with the concentration greater than 2,000 mg/kg in a guinea pig
- Exposure of laboratory animal: LD_{50} for sodium metabisulfite is greater than 2,000 mg/kg which makes 50% of guinea pig died.

8. **RO Antiscalant**

- Oral Toxicity (LD_{50}) with the concentration of 7,400 mg/kg in a guinea pig
- Exposure of laboratory animal: LD_{50} for RO Antiscalant is 7,400 mg/kg which makes 50% of guinea pig died.

9. Sulfuric Acid (H_2SO_4)

- Acute Oral Toxicity (LD_{50}) with the concentration of 2,140 mg/kg in a guinea pig
- Acute Toxicity of the Dust (LC_{50}) [1/] with the concentration of 510 mg/m^3 for 2 hours
- Exposure of laboratory animal: LD_{50} for sulfuric acid is 2,140 mg/kg which makes 50% of guinea pig died. Also, with the concentration of 510 mg/m^3 for 2 hours, 50% of guinea pig died.

10. Citric Acid ($C_6H_8O_7$)

- Acute Oral Toxicity (LD_{50}) with the concentration of 3,000 mg/kg in a guinea pig
- Exposure of laboratory animal: LD_{50} for citric acid, which is an acute toxicity is 3,000 mg/kg, makes 50% of guinea pig died.

11. Oxygen Scavenger

- Acute Oral Toxicity (LD_{50}) with the concentration of >5,000 mg/kg in a guinea pig
- Exposure of laboratory animal: LD_{50} for oxygen scavenger is 5,000 mg/kg makes 50% of guinea pig died.

12. Aqueous Ammonia (NH_3)

- Acute Oral Toxicity (LD_{50}) with the concentration of 350 mg/kg in a guinea pig
- Exposure of laboratory animal: LD_{50} for aqueous ammonia, which is an acute oral toxicity, is 350 mg/kg, makes 50% of guinea pig died.

13. Trisodium Phosphate ($Na_3PO_4.12H_2O$)

- Acute Oral Toxicity (LD_{50}) with the concentration of 7,400 mg/kg in a guinea pig
- Exposure of laboratory animal: LD_{50} for trisodium phosphate, which is an acute oral toxicity, is 7,400 mg/kg, makes 50% of guinea pig died.

14. Corrosion Inhibitor and Scale Inhibitor

Based on MSDS, this substance causes irritation to the body in case of direct exposure. However, the data is not available for a laboratory animal and human.

(b.2) Carcinogen

No carcinogen is found in accordance with the International Agency for Research on Cancer (IARC).

[1/] The concentration of a chemical substance in the air that is likely to make half (50%) of laboratory animals, that inhales it in a specific period of time, die.

(c) Health effect characteristics and vulnerable groups

Chemical exposure routes and types of chemical intake will be taken into account from chemical exposure of the staff, types of work, and maintenance of a chemical tramsmission pipeline in an emergency case, which needs to be relative to physical and chemical properties of each chemical substance. According to the review in Chapter 2, activities that cause chemical exposure include chemical transfer, use of chemical substance in the water treatment process, the wastewater treatment process, etc. The project staff or operators in nearby areas are likely to be exposed to a chemical substance through inhalation, skin, and eyes as well as accident from swallowing the chemical substance. Chemical exposure may cause irritation, or rash in the affected area. Moreover, swallowing or eating a chemical substance accidentally while working may cause a stomachache or vomit. However, occupational health, safety and the work environment measures are provided. For example, the staff are required to wear a personal protective equipment (PPE) suitable for each type of work, namely a dust mask or respirator mask, safety gloves, protective clothing, safety glasses, safety shoes, full face mask, eye shield, etc. Staff will be strictly supervised to use such equipment. Additionally, a washing area will be provided in a chemical storage area and the area where a chemical substance is used. Furthermore, MSDS and a kit for chemical leakage management, consisting of a chemical container, chemical absorbing material, etc. Also, a training on safety at work will be provided and awareness building will be made.

(d) Capability to accept risk

Base on occupational health, safety and the work environment measures, the likelihood of impact from exposure to a chemical substance will be at a moderate level (3). Severity of consequences will be at a high level (3) since a chemical intake can be through skin, inhalation, eating or swallowing and exposure to eyes which are hazardous. As a result, risk of chemical exposure will be at a moderate level (9) which is acceptable. However, health effect prevention and mitigation measures shall be established, or existing measures may be improved.

(9) Mental health

- **Staff**

(a) Health effect characteristics

The project operation may cause the project staff stress and anxiety as they work in the project area for a long time with heavy machinery operation, and air pollutant emissions. In addition, they are concerned about an unexpected event. Health effect matters that may lead to the mental health impact include an air quality (pollutant emissions), noisy machines, solid waste and hazardous waste, accidents from transportation, occupational health, safety and the environment, the public health service system and exposure to a chemical substance.

(b) Health impact assessment

Despite the unavailability of mental health impact prevention and mitigation measures, activities will be performed under the occupational health, safety and the environment plan and legal requirements. Furthermore, the staff are required to wear a personal protective equipment, as appropriate. Also, a personal protective equipment is required to be regularly checked or based on the project's safety procedure. A first aid unit and medical supplies as well as an ambulance shall be provided according to ministerial regulations on welfare facilities at workplaces, B.E. 2548 (2005) at the construction site, etc.

During the operation phase and throughout the project life, there will be about 60 staff. As a result, the likelihood of health effects will be at a moderate level (3). Severity of consequences will be at a moderate level (2). Severity of accidents due to material and equipment transportation, occupational health, safety and the environment and exposure to a chemical substance will be at a high level (3) since these may lead to severe injuries and deaths. As a result, significance level of mental health and the livelihood of project staff impacts will be at a moderate level (6-9), which is acceptable However, health effect prevention and mitigation measures shall be established, or existing measures may be improved.

- **People living in the project vicinities**

(a) Health effect characteristics and vulnerable group

Changes in the air quality may cause anxiety and stress. Also, people may be concerned about an unexpected event to the project, the increased traffic on roads in the project area which may cause delay in travel and the risk in road accident. Furthermore, cultural difference and difference in the way of life of the project staff and local people may cause problems. Mental health problems are potentially increased in the study area. Nontheless, the employment of local people will mitigate the conflicts. Qualified local people will be employed as the first priority so as to lessen the impacts from migrant labours and increase benefits for communities.

(b) Capability to accept risk

Despite the lack of prevention andmitigation for mental health and the livelihood of local people impacts, the people sector is enhanced to monitor the project operation, especially the power plant environmental management, to mitigate people's concerns and build the community confidence. As a result, this will be long run impacts. The likelihood of impacts will be at a moderate level (3). Severity of consequences will be at a moderate level (2). Therefore, significance level of the mental health and the livelihood of local people impacts will be at a moderate level (6).

Mitigation Measures

(1) Construction Period

Public Health

- First aid unit, basic medical supplies and an ambulance shall be provided in case of emergency according to the Ministerial Regulation of the Ministry of Labour concerning the Provision of Labour Welfare in Workplace, B.E.2548.
- Clean drinking water shall be provided for construction workers.
- Sanitary toilets shall be provided for construction workers: 1 5 persons/unit.
- Construction workers shall be trained on hygiene and disease prevention, supervised for their behaviors, annoyance and narcotics.
- Contractors shall be supervised to follow the labour law on conducting health check-up and health check-up according to risk-factor related work.
- The list of construction workers shall be created. The number of construction workers and the congenital disease of the construction workers shall be notified to the responsible public facilities before starting operations.
- Before the commencement of construction, construction workers, project staff, etc. should be trained on health issues and how to cope with severe accidents or emergencies.
- Environmental sanitation shall be provided at workers' camp and the construction site.
- Adequate public utilities and facilities shall be provided for a temporary workers' camp. Apart from this, the related standards or laws shall be followed, i.e. the Notification of Ministry of Public Health No. 7/2538 on the number of workers per space of workers' camp, etc.
- The accommodation of staff shall be provided according to the announcement of the Labour Welfare Committee on labour welfare measures for accommodation of workers for construction business.
- Security and safety shall be provided at the workers' camp.
- Construction workers' behavior shall be closely controlled to prevent nuisance and for the safety of nearby communities.
- Communicable disease surveillance shall be provided by local public health agencies and the project.
- Contractors shall be supervised to strictly adhere to terms and conditions, such as monitoring a worker's camp, narcotics sampling, segregrating solid waste at the workers' camp based on the monitoring method of sub-contractor's waste management.

- Contractors shall be supervised to coordinate with schools, especially a kindergarten to an elementary school, at least 6 months in advance in case construction workers want their children to attend schools in the project area.

Occupational Health, Safety and Environment

Measures on General Safety

- The agreement on occupational health and safety with the contractor shall be clearly identified
  - The project determined that the contractor and team perform operation within the power plant in the contract. It is mandatory that the contractor adheres to the occupational health, safety and working environment measures in terms of design, construction and operation so as to comply with the standards and regulations of occupational health and safety.
  - Knowledgeable personnel shall be assigned to be responsible for occupational health, safety and working environment.
  - The project and the main contractor shall appoint the safety, occupational health and working environment committee. The committee shall cover the supervisors from sub-contractors of the project. The Environmental health, and safety manager shall directly report to the project manager. A meeting shall be organized at least once a month for evaluation and suggestions.
  - First aid, basic medical supplies and an ambulance shall be provided in case of emergency according to Ministry of Labour regulation on Labour Welfare at workplace, B.E.2548.
  - Personal Protective Equipment shall be regulary checked according to the manual for project safety procedures.

Risks Mitigation Measures

- A steel structure shall be installed for the Heat Recovery Steam Generator. Also, a walkway and a ladder shall be provided for stability and safety.
- The insulation of the steam pipe system and hot water shall be installed for safety while operating.
- Equipment installation and construction shall be performed by the reliable and experienced contractor. A safety officer shall supervise the operations for compliance with safe work practices. The installation shall be checked and tested whether it meets the standard by an engineer.
- Before the commissioning is performed, the safety of the Heat Recovery Steam Generator shall be checked also, the operating conditions of a safety valve shall be tested and controlled by the authorized engineer for boiler testing according to the Engineering Act.

Fire control and fire fighting systems

- The main contractor shall prepare adequate fire fighting equipment for operators working in the dangerous area or works related to heat with the risk of fire. For example, while welding, the welders shall always have chemical fire extinguisher at the work station. As for welding on a high place, an insulation shall be paved under the area of welding to prevent splash from falling beneath which is unsafe for those working beneath.
- The main contractor shall prepare the cooperation plan with the local fire fighting agency for readiness in case of emergency.
- The entrance-exit of dangerous area due to the construction work and traffic shall be controlled by a supervisor or a safety officer.
- Working conditions and construction equipment shall be checked, especially in the area where danger or fire is likely to occur.
- Fire fighting equipment shall be always checked according to the manual for project safety procedures.

(2) Operation Period

Public Health

- First aid, basic medical supplies and an ambulance shall be provided in case of emergency according to Ministry of Labour regulation on Labour Welfare at Workplace, B.E.2548.
- Pre-placement examination and the annual health check-up shall be provided for staff at lease once a year.
- Health promotion activities shall be organized. Public relations campaign about environmental aspect and health issues for communities shall be done.
- Local public health facilities shall be supported in terms of health promotion, rehabilitation, disease prevention and healthcare for communities.
- Morbidity survey on people living within 5 km. radius of the project location shall be conducted.

Occupational Health, Safety and Environment

- The occupational health, safety and working environment committee shall be appointed to oversight operations. The occupational health, safety and working environment committee meeting shall be held at least once a month to evaluate, suggest solutions for problems, make improvements and promote occupational health, safety and working environment activities.
- Manual for project safety procedures shall be established for reference while working and providing training for the power plant staff. This manual is consistent with the details of machinery and equipment installed in the power plant. The manual also

complies with the Occupational Safety, Health and Environment Act. For example, the training course on safety at work will be provided for all new staff.

- Adequate personal protective equipment, which is suitable for working conditions shall be provided for all staff.
- First aid, basic medical supplies and an ambulance shall be provided in the power plant in case of emergency according to Ministry of Labour regulation on Labour Welfare at Workplace, B.E.2548.
- Types and number of safety equipment shall be identified. The equipment shall meet the standards. The equipment shall be checked regularly for readiness.
- Lighting systems: The Project shall provide a backup electrical system in case of emergency. Lighting systems shall be designed for safety purpose and adequate light while working.
- Pre-placement examination and the annual health check-up shall be provided for staff.
- A safety week activity shall be organized to urge and perform safety drills.
- A fire protection system and fire fighting system shall be provided by the power plant according to National Fire Protection Association (NFPA) and related requirements and standards.
- The fire fighting system shall be always checked according to the manual for project safety procedures.
- An emergency shall be established for operations in emergency cases. Emergencies can be divided into 2 levels (as illustrated in **Figure 9-3**).
  - <u>Emergency Level One</u>: It means the emergency that occurs in the power plant area. The emergency coordinator can control the situation. Damage can be limited by staff, workers and equipment available in the power plant until the situation returns to normal conditions.
  - <u>Emergency Level Two:</u> It means the emergency that occurs inside and outside the power plant. When the emergency coordinator evaluates that the emergency plan for the emergency level one is incapable, request for assistance shall be made in terms of manpower and equipment from Pluak Daeng Industrial Park to control the situation.
  - The annual emergency drill shall be performed for the power plant itself and together with Pluak Daeng Industrial Park. Moreover, training on emergency preparedness and response shall be provided for personnel at least once a year

Measures on transportation and unloading of Diesel

- Training on the practice according to the emergency plan

- Environmental Health & Safety (EH&S) Committee shall provide the staff the training on working regulations, work instructions and related documents. In case of changes in the details of working regulations / support documents in relation to emergency preparedness, and emergency prevention and suppression, EH&S Committee shall notify all staff.

• Oil leakage prevention

- The division/department that has to deal with oil shall follow the fuel oil unloading procedure.

- The operator who handle oil shall work carefully to prevent oil spill to the outside environment. The operator shall follow the fuel oil unloading procedure and MSDS.

• Preparation/ inspection of equipment in case of emergency: The following equipment shall be prepare for emergency.

- Personal protective equipment, such as rubber gloves, mask, air filter mask or other absorbing materials, as appropriate, such as sand, sawdust, cloth, or other materials having absorbing property or preventing oil diffusion. The operator who deals with oil shall operate carefully to prevent oilspill to the outside environment. The fuel oil unloading procedure and MSDS shall be follow.

- Suitable personal protective equipment, such as rubber gloves, mask, air filter mask or other absorbing materials

- The container of contaminated oil, drums, valves, and safety valves shall be checked on a monthly basis by the qualified person required by law

• The following materials shall be prepared all the time in response to emergency.

- In case of small oil leak

➢ The person who notice an abnormal situation shall solve the problem shortly.

➢ Scatter sand, sawdust, or other materials prepared by the division/department around the area of oil leak to limit the boundary of oilspill.

➢ Shortly notify the supervisor and the responsible staff to suppress the event.

➢ Use remnant of cloth or oil absorbing material to clean the area of oil leak.

➢ Compile all materials used for oil leak control and dump them into a hazardous waste container (according to solid waste management procedure).

➢ Clean the area of oil leak to prevent environmental impacts.

➢ The supervisor and the responsible person of the area where oil leaks organize the meeting to prevent the recurrence

- In case of large oil leakage
  - ➢ The person who notice an abnormal situation shall immediately notify the supervisor or the responsible person of the area and involved persons to fix the problem.
  - ➢ The area of large oil leak shall be enclosed to prevent diffusion to a broader area and to make it convenient for control.
  - ➢ The operator who controls oil leak shall be in the windward side to avoid air vapour. The operator shall wear safety equipment, such as a vapor prevention mask.
  - ➢ Oil leak suppression shall be in accordance with the oil leak prevention and response plan.

Safety measures for transport of chemicals

The operators of hazardous chemicals or objects shall adhere to the manual for project safety procedures for safe transport and the safety of communities, assets and the environment. Related laws and standards shall be followed. These include manual for transport of hazardous objects of Pollution Control Department, September 2011, manual for hazardous chemical management and handling in the place of business, July 2013 and the Notification of Department of Industrial Works on manual for storage of hazardous chemicals and objects, B.E.2550 and notification of Ministry of Industry on transport of hazardous objects under Department of Industrial Works, B.E.2558, such as

- Applying for transportation permit
- Affixing a label and tag on a chemical transport truck that meets the requirements of Department of Land Transport
- Separating and transporting chemicals in an appropriate and safe manner
- Preparing shipping paper
- Preparing Material Safety Data Sheet (MSDS) based on the properties of specific material both in Thai and English
- Providing personal protective equipment on a chemical transport truck
- Providing training on the hazard of transported chemicals and skills for safe driving while transporting chemicals for drivers. Also, drivers shall be trained on a preliminary solution in case of emergency

Safety measures for chemical storage

Regarding safety measures for chemical storage, Pluak Daeng Power Plant shall follow the Notification of Department of Industrial Works on manual for storage of hazardous chemicals and objects, B.E.2550 and manual for hazardous chemical management and handling, July 2013, such as

- Preparing Material Safety Data Sheet (MSDS) about the characteristics of hazardous objects both in Thai and English
- Categories of hazardous object: Category 1 (The criteria and established method shall be followed.), Category 2 (The competent authority shall be notified before

following the criteria and established method.) Category 3 (A license shall be obtained.) and Category 4 (Manufacturing, sale or possession shall be prohibited.)

- The storage place and storage method of hazardous chemicals shall be safe based on the nature or properties of hazardous chemicals.

Measures for safe use of chemical substances

With regards to measures for safe use of chemical substances, Pluak Daeng Power Plant Project shall adhere to OSHA standard and the ministerial regulations on the management, handling, and operation of safety, occupational health and working environment on hazardous chemicals, B.E.2556. Details of such measures are provided in manual for project safety procedures. Details consist of

- Preparing Material Safety Data Sheet (MSDS) about the characteristics of hazardous objects both in Thai and English. MSDS shall be available in working area
- Installing the prohibition sign, instruction sign or warning sign for working with hazardous chemicals in a public place
- Providing places and equipment for safety in working area for hazardous chemicals such as emergency eye wash, face and hand wash basin, and emergency showers
- Providing personal protective equipment for staff according to the hazards and severity of chemicals or the nature of work to prevent hazards that are likely to occur
- Establishing preventive measures for chemicals in the storage place of hazardous chemicals; establishing preliminary measures for remedy of hazards, such as an appropriate ventilation system; preventing the potential cause of fire; constructing a dike to prevent the leak of hazardous chemicals from the storage place and providing drains for spills for safe disposal. Drains for spills shall be separated from the drainage system
- Establishing preventive and control systems so that the atmospheric concentrations of hazardous chemicals in the workplace or the storage place shall not exceed the limits
- Measuring and analyzing the atmospheric concentrations of hazardous chemicals of the workplace and storage place
- Preparing fire fighting equipment and appropriate medical supplies for first aid
- Assigning the responsible person (chemist) for improvement of chemical safety plan
- The chemist and Environmental health and safety manager shall check and create a hazardous chemical checking plan for each working area. The hazardous chemical checking plan shall be reviewed and updated at least once a year
- Providing training for staff working with chemicals on how to use chemicals safely and guidelines for prevention and check of chemical leak

5.5 MAJOR HAZARD ASSESSMENT

5.5.1 Introducttion

The main fuel used in generating electricity in the project is natural gas and diesel is used as reserved fuel. Also, chemical substances are used in water quality enhancement. Accidental release of these fuels and chemical substances may incur environmental impacts due to their toxic, flammable or explosive properties. Apart from the properties and amount of the fuel or chemical substance accidentally released, the hazard level depends on the storage place and condition. Furthermore, in the event of the project's mechanical failure, there is likelihood of harm caused to property and life, which may occur not only in the project boundary but also the communities in the vicinity.

It is necessary that the project be planned, organized, managed, and executed in a systematic and exacting manner to minimize the likelihood of such hazards. Major hazard assessment is thus conducted to identify potential hazards and their severity levels. Measures developed for the project with a view to forestalling the potential hazards identified range from the designing to the operational management processes, including installing the safety equipment in compliance with international standards.

5.5.2 Methodology

Guidelines from relevant organizations such as the World Bank and the American Petroleum Institute (API) are used in the major hazard assessment. The process and approaches involved are as shown in **Figure 5.5.2-1**.

5.5.3 Risk and hazard assessment of natural gas (primary fuel) and diesel (reserve fuel) for power generation

5.5.3.1 Natural Gas (Main Fuel)

(1) Natural gas consumption rate

The project's electricity generation system is designed to consume natural gas as main fuel. The natural gas is to be supplied by PTT Plc. through the natural gas transmission pipeline connected to the project's metering and regulating station (MRS). At full load operation for maximum production capacity, the highest possible demand for natural gas is estimated to be around 150,380 million cubic feet per year.

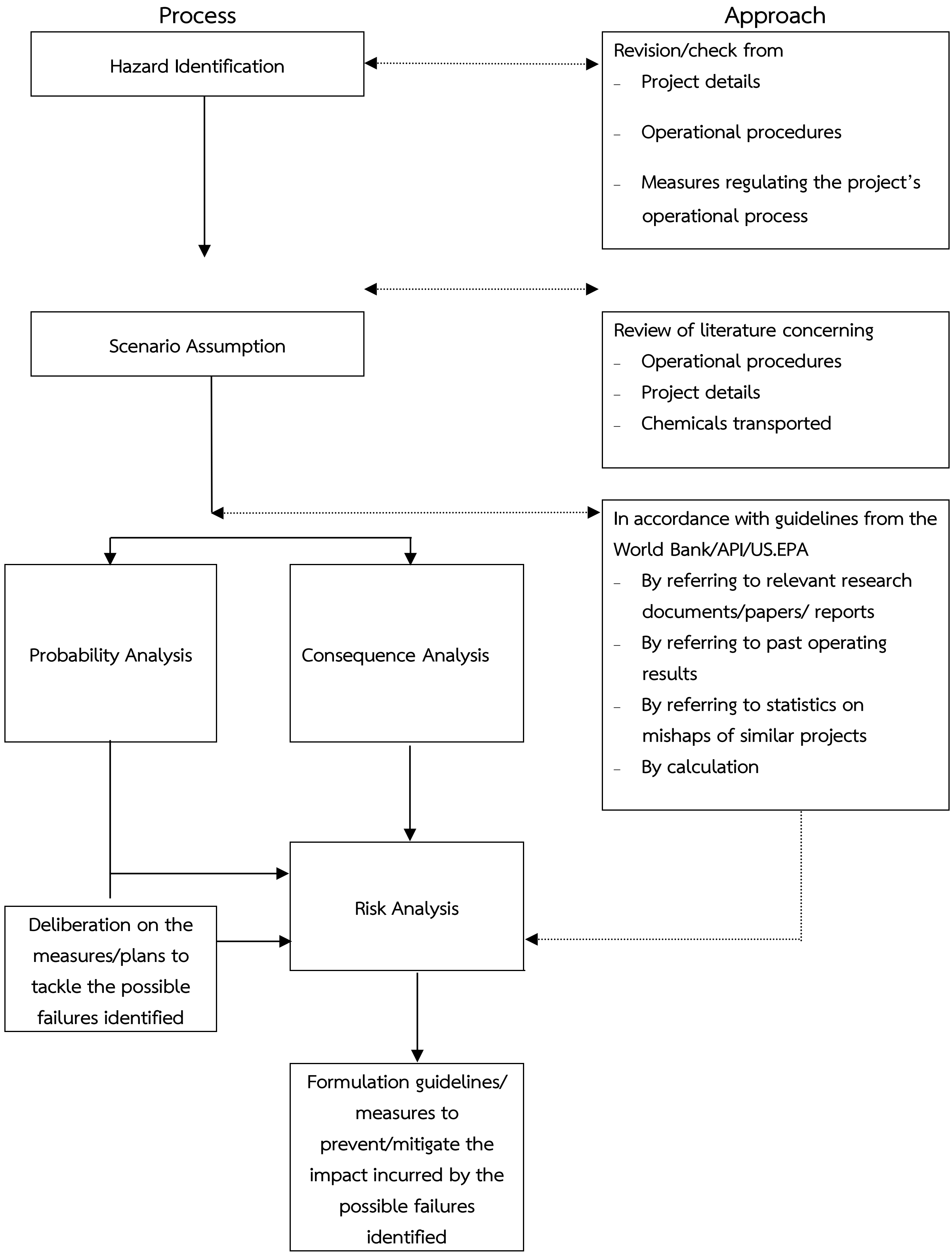


FIGURE 5.5.2-1 : DIAGRAM SHOWING THE SCOPE AND PROCESS OF MAJOR HAZARD ASSESSMENT

(2) Properties of natural gas

With reference to PTT Plc's Material Safety Data Sheet (MSDS), natural gas has low molecular weight and density and is lighter than air. The lower-upper flammable limit (LFL-UFL) is in the range of 5.0-15.0%. Details about natural gas properties are as summarized in **Table 5.5.3-1**. With respect to the chemical composition, natural gas consists mainly of methane (CH_4), which is in the range of 87.60-89.33 mole percent by volume, as shown in **Table 5.5.3-2**.

TABLE 5.5.3-1

GENERAL CHARACTERISTICS OF NATURAL GAS

Property	Value
molecular weight	depending on the composition
water solubility	3.5% (at 17°C)
vapour pressure	760 mmHg (at 161°C)
boiling point	-162 °C
flash point	-223°C
melting point	-183 °C
auto ignition temperature	537 °C
vapour density	0.555%
specific gravity at 15°C	0.53 - 0.80
flammable limits	
- lower flammable limit; LFL)	5.0%
- upper flammable limit; UFL)	15.0%

Source : http://www.pttplc.com/TH/MSDS-th/METHANE_Thai.htm, retrieved on 5th July 2015

TABLE 5.5.3-2
COMPONENTS OF THE NATURAL GAS USED IN PLUAK DAENG POWER PLANT PROJECT

Parameter	Composition Data (Mole percent)		
	Minimum*	Average*	Maximum*
carbon dioxide (CO_2)	4.41	1.43	0.00
nitrogen (N_2)	2.03	1.66	0.64
methane (C_1)	87.60	90.69	89.33
ethane (C_2)	3.92	4.91	8.53
propane (C_3)	1.36	0.88	1.00
isobutane (iC_4)	0.31	0.19	0.20
normal butane (nC_4)	0.25	0.16	0.20
isopentane (iC_5)	0.06	0.06	0.10
normal pentane (nC_5)	0.03	0.01	0.00
hexane (C_6)	0.01	0.00	0.00
heptane (C_7)	0.01	0.00	0.00
octane (C_8)	0.00	0.00	0.00
total	100.00	100.00	100.00
parameter	Qualitative Data		
HHV (Sat) Btu/scf	996	1024	1079
specific gravity (SG)	0.6477	0.6136	0.6153
Wobbe Index -WI WI = HHV (Dry) / SQRT (SG)	1,260	1,330	1,400

Remark : *Minimum, *average, and *maximum refer to the low Wobbe index, average Wobbe index and high Wobbe index respectively. A cubic meter of natural gas is estimated to contain the maximum amount of 50 μg of mercury and 50 ppm of H_2S.

Source : Gulf PD Co., Ltd. (2016)

5.5.3.2 Diesel (Reserved Fuel)

(1) Diesel consumption rate

At full load operation for maximum production capacity, the highest possible demand for diesel is estimated to be at the rate of about 8,631 m^3/day. However, diesel is to be used only in emergency cases, for example when there is problem in natural gas transportation or when there is an official order from the Electricity Generating Authority of Thailand to test the diesel-fired operation. If diesel-fired operation is estimated at 72 hours per year, the total annual diesel consumption will be 25,893 m^3.

(2) Properties of diesel

General details about the properties of diesel, which is used as the project’s reserved fuel, are shown in **Table 5.5.3-3**. The total amount of 26,000 m^3 of diesel is to be reserved in the project in two tanks of 14,300 m^3.

TABLE 5.5.3-3
GENERAL CHARACTERISTICS OF DIESEL USED AS THE PROJECT'S RESERVED FUEL NATURAL GAS

Parameter	Qualitative Data		Test Method
	Minimum	Maximum	
Specific gravity at 15.6°C	0.81	0.87	ASTM D 1298
Cetane index	50	-	ASTM D 613
Viscosity (cSt) at 40°C	1.8	4.1	ASTM D 445
Pour point (°C)	-	10	ASTM D 97
sulphur content (percent by weight)	-	0.005	ASTM D 2622
Copper strip corrosion	-	No.1	ASTM D 130
Oxidation stability (gram/cubic meter)	-	25	ASTM D 2274
Carbon residue (percent by weight)	-	0.30	ASTM D 4530
Water and sediment (percent by volume)	-	-	ASTM D 2709
Water (milligram/kilogram)		300	EN ISO 12937
Total contamination (milligram/kilogram)		24	EN 12662
Ash (percent by weight)	-	0.01	ASTM D 482
Flash point (°C)	52	-	ASTM D 93
Distillation temperature, 90% volume recovered (°C)	-	357	ASTM D 86
Polycyclic aromatic hydrocarbons (percent by weight)		11	ASTM D 2425
Dye concentration	-	4.0	ASTM D 1500
Lubricity to avoid excessive wear (micrometer)	-	460	CEC F-06-96

Source : Notification of the Department of Energy Business on characteristic and quality of diesel B.E. 2556 (2013), issued on 8th November 2013

5.5.3.3 Chemical Substances used in the Project

Most of the chemical substances used in the production process of Pluak Daeng Power Plant Project are for water quality enhancement by inhibiting scale and sludge formation in the pipeline. None of the chemical substances used are toxic substances or biocides, according to the Material Safety Data Sheet (MSDS) shown in **Appendix 3F**.

The details about the source, amount to be used, amount to be stored, and usage of each chemical substance are shown in **Table 5.5.3-4** and the data concerning the chemical substances used in the project with reference to applicable acts, which are retrieved from the Material Safety Data Sheet (MSDS) as shown in **Table 5.5.3-5.**

TABLE 5.5.3-4

TYPES AND AMOUNT OF CHEMICALS USED IN THE PROJECT

Chemical	Amount used[2/] (m^3/yr)	Material and size of storage container	Number of tanks	Use /conveyance in the project	Chemical storage place/ safeguard against leakage [1/]	Chemical supply source / chemical transportation
Raw water treatment system						
$NaClO_2$ 25%	20	Stored in a PE chemical storage tank, about 40 m^3	1	As precursor for the generation of chlorine dioxide for use as a water purifier / closed pipeline system	Raw water treatment building / with a concrete dike built around the tank	Domestically purveyed, delivered to the project in a chemical transport truck (liquid form)
HCl 35%	20	Stored in an FRP chemical storage tank, about 40 m^3	1	As precursor for the generation of chlorine dioxide for use as a water purifier / closed pipeline system	Raw water treatment building / with a concrete dike built around the tank	Domestically purveyed, delivered to the project in a chemical transport truck (liquid form)
Ferric chloride 40%	1,120	Stored in an FRP chemical storage tank, about 120 m^3	1	As flocculant in raw water treatment / closed pipeline system	Raw water treatment building / with a concrete dike built around the tank	Domestically purveyed, delivered to the project in a chemical transport truck (liquid form)
Polymer	40	Packaged in a bag, coming with an FRP chemical mixing tank, 16 m^3	1	As flocculant in raw water treatment / closed pipeline system	Raw water treatment building / with a concrete dike built around the tank	Domestically purveyed, delivered to the project in packaging bags for chemicals (25 kg)

TABLE 5.5.3-4

TYPES AND AMOUNT OF CHEMICALS USED IN THE PROJECT (CONT'D)

Chemical	Amount used[2/] (m^3/yr)	Material and size of storage container	Number of tanks	Use /conveyance in the project	Chemical storage place/ safeguard against leakage [1/]	Chemical supply source / chemical transportation
Sodium hydroxide ($NaOH$, 50%)	245	Stored in an FRP chemical storage tank, about 30 m^3	1	For pH adjustment in raw water treatment system, for mixed bed resin regeneration, and for pH adjustment in the neutralization pit in the mixed bed resin regeneration process / closed pipeline system	Raw water treatment building / with a concrete dike built around the tank	Domestically purveyed, delivered to the project in a chemical transport truck (liquid form)
Sodium bisulfite 1% ($Na_2S_2O_5 + H_2O \longrightarrow NaHSO_3$) (SMBS) (SBS)	15	Stored in a PE chemical storage tank, about 1 m^3	1	For protection of reverse osmosis membranes from free chlorine / closed pipeline system	Mixed bed resin regeneration building / with a concrete dike built around the tank	Domestically purveyed, delivered to the project in packaging bags for chemicals (25 kg)
For the mixed bed resin regeneration process, as well as for pH neutralization in wastewater treatment process						
RO antiscalant (100%)	5	Stored in a PE chemical storage tank, about 0.1 m^3	1	For preventing scaling on reverse osmosis membranes / closed pipeline system	Mixed bed resin regeneration building / with a concrete dike built around the tank	Domestically purveyed, delivered to the project in a chemical packaging barrel (25 liters)
Sulfuric acid (H_2SO_4, 98%)	10	stored in a carbon steel chemical storage tank, about 3 m^3	1	For mixed bed resin regeneration, and for pH adjustment in the neutralization pit in the mixed bed resin regeneration process / closed pipeline system	Mixed bed resin regeneration building / with a concrete dike built around the tank	Domestically purveyed, delivered to the project in a chemical transport truck (liquid form)

TABLE 5.5.3-4

TYPES AND AMOUNT OF CHEMICALS USED IN THE PROJECT (CONT'D)

Chemical	Amount used[2/] (m^3/yr)	Material and size of storage container	Number of tanks	Use /conveyance in the project	Chemical storage place/ safeguard against leakage [1/]	Chemical supply source / chemical transportation
Citric acid ($C_6H_8O_7$, 15%)	10	Stored in a PE chemical storage tank, about 2 m^3	1	For cleaning reverse osmosis membranes / closed pipeline system	Mixed bed resin regeneration building / with a concrete dike built around the tank	Domestically purveyed, delivered to the project in packaging bags for chemicals (25 kg)
Steam recycling system						
Oxygen scavenger (Elimin - OX) [3/]	15	Stored in a stainless chemical storage tank, 1,000 liters	4	for boiler water treatment / closed pipeline system	Chemical substance storage building / with a tray put under it	dDomestically purveyed, delivered to the project in a chemical packaging barrel (25 liters)
Aqueous ammonia (NH_3-25%)	45	Stored in a stainless chemical storage tank, 1,000 liters	4	for boiler water treatment / closed pipeline system	Chemical substance storage building / with a tray put under it	Domestically purveyed, delivered to the project in a chemical packaging barrel (25 liters)
Trisodium phosphate ($Na_3PO_4.12H_2O$)	30	Stored in a stainless chemical storage tank, 500 liters	4	for boiler water treatment / closed pipeline system	Chemical substance storage building / with a tray put under it	Domestically purveyed, delivered to the project in a chemical packaging barrel (25 kg.)
Liquid cooling system						
Scale and corrosion inhibitor [4/]	120	Stored in a PE tank, about 2 m^3	2	for preventing scaling in the liquid cooling system / closed pipeline system	Chemical substance storage building / with a concrete dike built around the tank	Domestically purveyed, delivered to the project in a chemical packaging barrel (1 m^3)

TABLE 5.5.3-4

TYPES AND AMOUNT OF CHEMICALS USED IN THE PROJECT (CONT'D)

Chemical	Amount used[2/] (m^3/yr)	Material and size of storage container	Number of tanks	Use /conveyance in the project	Chemical storage place/ safeguard against leakage [1/]	Chemical supply source / chemical transportation
$NaClO_2$ 25%	20	Stored in a PE chemical storage tank, about 40 m^3	2	As precursor for the generation of chlorine dioxide for use as a water purifier / closed pipeline system	Raw water treatment building / with a concrete dike built around the tank	Domestically purveyed, delivered to the project in a chemical transport truck (liquid form)
HCl 35%	20	Stored in a PE chemical storage tank, about 40 m^3	2	As precursor for the generation of chlorine dioxide for use as a water purifier / closed pipeline system	Raw water treatment building / with a concrete dike built around the tank	Domestically purveyed, delivered to the project in a chemical transport truck (liquid form)

Remarks :
1. Chemical substances used in the project are to be kept at the chemical substance storage building, where dikes are built to accommodate potential accidental release of chemical substances equal to the storage capacity of the largest storage tank . The manner of storage is to be in accordance with the Notification of the Department of Industrial Works on the Handbook of Chemical and Hazardous Material Storage B.E. 2550 (2007).
2. The chemical substance amounts to be used are subject to change depending on the quality of the raw water supply from Eastern Water Resources Development and Management Public Company Limited.
3. The oxygen scavenger used in the project is considered harmless or lowly hazardous (regardless of the amount taken) and is not classified as carcinogenic according to International Agency for research on Cancer (IARC)'s Agents Classified by IARC Monographs, Volumes 1-106.
4. The scale and corrosion inhibitor is a chemical compound consisting of polyphosphate, phosphates, zinc salt, organic polymer, and copper corrosion inhibitor. The chemical composition is subject to change depending on each manufacturer's commercial formula.

Source : Gulf PD Co., Ltd. (2016)

TABLE 5.5.3-5
COMPARATIVE DETAILS OF CHEMICAL SUBSTANCE USE BASED ON APPLICABLE ACTS AND THE MEDIAN LETHAL DOSE (LD_{50})

Name / general name of the chemical substance	Status	Hazardous Material Act 1992 (Type)	Lethal Weapon Control Act 1987	Labor Protection Act 1998	Median lethal dose (LD_{50})
Sodium chlorite 25%	liquid	-	-	-	acute oral toxicity (LD_{50}) = 165 mg/kg [rat]
HCl 35%	liquid	3	-	✓	acute oral toxicity (LD_{50}) = 900 mg/kg [rabbit]
Ferric chloride 40%	liquid	-	-	-	oral toxicity (LD_{50}) = 316 mg/kg [rat]
Polymer	solid	-	-	-	acute oral toxicity (LD_{50}) = 3,500 mg/kg [mouse]
Sulfuric acid	liquid	3	-	✓	oral toxicity (LD_{50}) = 2,140 mg/kg [rat]
Sodium metabisulfite	solid	-	-	-	acute oral toxicity (LD_{50}) = 1,131 mg/kg [rat]
RO antiscalant	liquid	no data	no data	no data	LD_{50} = 7,400 mg/kg [rat]
Oxygen scavenger	liquid	-	-	-	acute oral toxicity (LD_{50}) = 5 g/kg [rat]
Aqueous ammonia	liquid	-	-	-	oral toxicity (LD_{50}) = 350 mg/kg [rat]
Trisodium phosphate	solid	no data	no data	no data	-*
Scale and corrosion inhibitor (organic phosphate acid)	liquid	3	-	✓	-*
Sodium hydroxide	liquid	1	-	✓	-*
Citric acid	solid	no data	no data	no data	acute oral toxicity (LD_{50})=3,000mg/kg [rat]

Remark : -* Not identified as hazardous material according to Hazardous Material Act 1992, Lethal Weapon Control Act 1987, and Labor Protection Act 1998

Hazardous material Type 1 is the hazardous material of which the manufacturing, importation, exportation, or possession must be in compliance with applicable criteria and manners.

Hazardous material Type 2 is the hazardous material of which the manufacturing, importation, exportation, or possession must be notified to the relevant authorities and be in compliance with applicable criteria and manners.

Hazardous material Type 3 is the hazardous material of which the manufacturing, importation, exportation, or possession must be authorized.

Hazardous material Type 4 is the hazardous material of which the manufacturing, importation, exportation, or possession is prohibited

-* According to MSDS, no data on animal testing and effects on humans

5.5.3.4 Electrical Equipment and Machinery

All electric equipment and machinery are to be designed and tested in compliance with international product standards (as shown in **Table 5.5.3-6**) or those equivalent according to Thailand's applicable regulations. Four sets of combustion turbines (CT) are to be installed. The kinetic energy to drive the turbines which will in turn power the electricity generators is to be derived from the thermal energy produced by natural gas burning. The exhaust gas from the CTs is to be transmitted to the heat recovery steam generators (HRSG), which will use the thermal energy from the exhaust gas to produce the steam to be used in driving the turbines, which will in turn power the electricity generators (one set of HRSG per one set of CT).

TABLE 5.5.3-6

STANDARDS REFERRED TO IN THE DESIGN OF ELECTRIC EQUIPMENT AND MACHINERY

ANSI	American National Standard Institute
ASME	American Standard of Mechanical Engineers
AWS	American Welding Society
ISO	International Organization for Standardization
ASA	American Standard Association
IEC	International Electrochemical Commission
NEC	American National Electrical Code
API	American Petroleum Institute
IEEE	American Institute of Electric and Electronics Engineers
NFPA	American National fire Protection Association
JIS	Japanese Industrial Standards

Source : Gulf PD Co., Ltd. (2016)

5.5.4 Classification of Hazards

Major hazards are classified in accordance with the methods and techniques presented by the World Bank and the American Petroleum Institute in Techniques for Assessing Industrial Hazards, a Manual (1990), and Risk Base Inspection, Base Resources Document, API Publication 581 (2000). The consulting team take into consideration the likelihood of major hazards occurring with respect to both the fuels and chemical substances, as well as the equipment and machinery used in the project, the details of which are as follows:

5.5.4.1 Fuel/Chemical Substances

The main fuel used in generating electricity in the project is natural gas, while diesel is used as reserved fuel. For chemical substances, most of which are used in water quality enhancement, and the amount to be stored will be relatively small. The following factors are to be put into consideration in the hazard assessment.

(1) The location where there is probability that the natural gas/diesel may be accidentally released: for example the points of connection in various areas easily accessible to the personnel

(2) The nature of the accidental release: which is of two types – sudden release or gradual release

(3) The nature of the hazard occurring after the accidental release: whether it is flammable or nonflammable

(3.1) Ignition : which is of two types – immediate ignition or delayed ignition

(a) Fire: which in general can takes four different forms

Pool Fire: which occurs when there is a leak in the storage container or accidental release of a flammable material, resulting in its spreading over the area. The extent of the fire depends on the surface area of the fuel

Jet Fire: which occurs when a flammable agent is ignited after its release from a pressurized, punctured container or pipe. The intensity of the fire is determined by the release amount and the capacity of the source. The bigger the amount and the more pressurized the source is, the wider and longer the flames.

Fireballs and boiling liquid expanding vapor explosion (BLEVE): which is caused by the heat radiated from the fire burning in the vicinity of the vessel containing a flammable substance. If the temperature in the vessel rises and in turn causes the pressure inside to increase, it will tear apart. The flammable substance inside will diffuse into the atmosphere causing ignition in the form of big fireballs.

Flash Fire: which occurs when a chemical substance leaks and disperses into the air. The mixture of air and the dispersed flammable substance in the form of vapor cloud results in combustion, but not explosion.

Vapor cloud explosion (VCE): which occurs when a chemical substance leaks and disperses into the air. The mixture of air and the dispersed flammable substance in the form of vapor cloud results combustion and explosion.

(3.2) Case of accidental release without consequent ignition

Natural gas which is composed of many types of hydrocarbon compound such as methane, ethane, propane, butane, etc., among which methane generally constitutes the most. Other possible constituents include carbon dioxide and oxygen. As a rule, methane, the main constituent in natural gas, is considered non-toxic. Respiratory exposure to methane of high concentration may induce headache and eyesore, which can be healed when the victim gets fresh clean air. Nevertheless, methane is an asphyxiating substance, as it replaces and in turn reduces oxygen in the air.

Diesel respiratory exposure to the vapor of which can induce respiratory tract and lung being irritation, coughing, hyperventilation, chest burning pain, headache, nausea, fatigue, agitation, loss of control, depression and in the worst case coma. Prolonged exposure to diesel can induce cancer.

5.5.4.2 Electrical Equipment and Machinery

The main part of which involves the operation of the steam boiler. Possible mishaps in electricity generation include explosion of the steam boiler caused by continuous rise of the pressure inside, malfunction of the control or safety system and devices, for example.

5.5.5 Analysis of the Causes of the Mishaps

5.5.5.1 Accidental Release of Natural Gas

Three possible causes leading to accidental release in the natural gas transmission system include (1) decomposition of the pipeline (2) use of pipeline materials not to the standards set (3) third-person deed. In the construction phase of the project, in accordance with international standards, damage to the pipeline is to be prevented as follows. To protect against decomposition, the surface of the pipeline is to be coated. To enhance the strength, the pipeline is to be coated both inside and outside. In this way, probability of accidental release in natural gas transmission due to decomposition of the pipeline is very low.

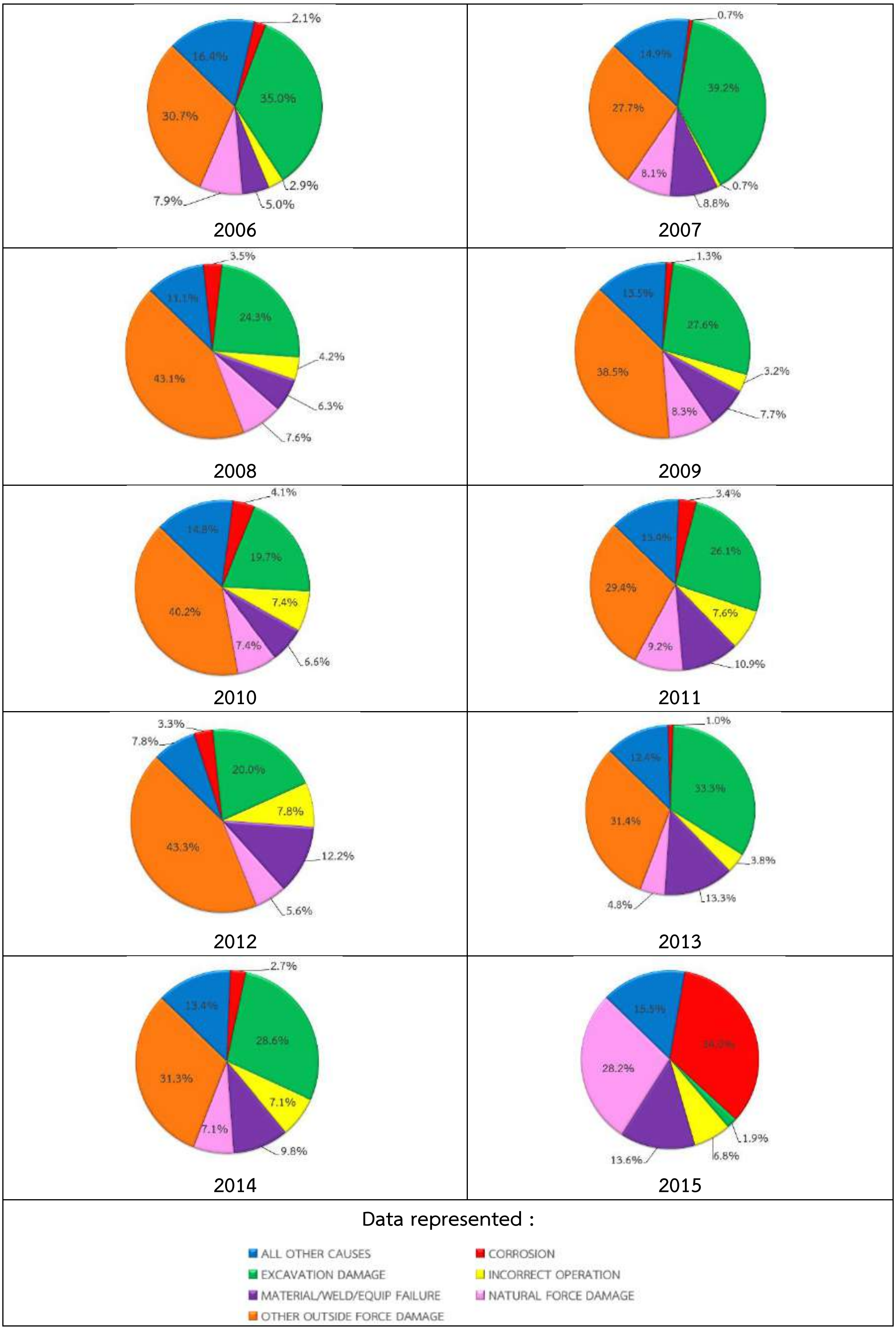
With reference to the 8th Report of the European Gas Pipeline Incident Data Group, December 2011, the statistics on mishaps in onshore natural gas transmission in European countries reveals the frequency of 3.51×10^{-4} cases/kilometer-year. According to the US Onshore Gas Transmission and Gathering System Operators, during 1996 to 2015 the total number of mishaps in land-based natural gas transmission in the US is 2,567, as shown in **Table 5.5.5-1**. For the causes of the mishaps in onshore natural gas transmission in the US during 2006 to 2014, most of which are external factors, the details are provided in **Figure5.5.5-1**.

TABLE 5.5.5-1

STATISTICS ON MISHAPS IN NATURAL GAS PIPELINE TRANSMISSION IN THE US DURING 1996 TO 2015

Year	Number of incidents (times)	Number of fatalities (persons)	Number of injuries (persons)	Damage values (dollars)
1996	110	47	109	$16,252,842
1997	102	9	67	$12,493,163
1998	137	18	64	$19,055,118
1999	118	16	80	$25,913,658
2000	154	22	59	$23,398,834
2001	124	5	46	$14,071,486
2002	102	10	44	$23,804,202
2003	141	11	58	$21,032,408
2004	172	18	41	$37,506,406
2005	168	15	38	$497,998,741
2006	140	18	30	$24,515,672
2007	148	9	32	$25,726,058
2008	144	6	49	$38,544,109
2009	156	9	49	$31,934,310
2010	122	11	44	$21,290,362
2011	119	13	53	$27,527,531
2012	90	9	46	$25,557,235
2013	105	8	36	$18,474,786
2014	112	18	94	$74,644,503
2015	103	5	35	$30,021,929
total	2,567	277	1,074	$1,009,763,353

Source : US DOT Pipeline and Hazardous Materials Safety Administration, (https://hip.phmsa.dot.gov/analyticsSOAP/saw.dll?Portalpages, retrieved on 12th July 2016)



Source : http://www.phmsa.dot.gov/, retrieved on 12th July 2016

FIGURE 5.5.5-1 : CHARTS SHOWING CAUSES OF MISHAPS IN NATURAL GAS PIPELINE TRANSMISSION IN THE US DURING 1996 TO 2015

Most of the natural gas transmission pipeline projects in Thailand are administered by PTT Plc. The statistics on mishaps in natural gas transmission pipeline in Thailand during 1981 to 2015 (35 years) reveals 21 incidents in total. Of this number, 12 were mishaps in PTT's own pipelines (as shown in **Table 5.5.5-2**), 8 of which were caused by a third-person deed, 3 of which occurred because of damaged equipment, and one of which is due to natural disaster. Eight incidents were started in the pipeline of PTT Natural Gas Distribution Co., Ltd., and one in the pipeline of Trans Thai – Malaysia (Thailand) Ltd., as shown in **Table 5.5.5-3** and **Table 5.5.5-4**.

With respect to probability of incident in natural gas transmission pipeline in Thailand under the administration of PTT Plc., as shown in **Table 5.5.5-2**, during 1981 to 2015 (35 years) the total number of incidents resulting in accidental release of natural gas from the pipeline is 12, seven of which were due to a release hole of ¼ inch, three of which were due to a release hole of one inch, and two of which were due to a release hole of four inches. There was no case of rupture category. Most of the incidents occurred with the 28-inch pipeline.

5.5.5.2 Accidental Release of Diesel

The statistics from the US Onshore Hazardous Liquid Systems reveals the total number of 6,227 incidents resulting from transportation of hazardous liquid during 1996 and 2015, as shown in **Table 5.5.5-5** and. The main causes of such incidents, occurring during 1st January 2006 to 31th December 2015, as shown in **Figure 5.5.5-2**, are decomposition of the pipeline and third-person deed.

According to the statistics on accidental release from the oil transmission pipeline in Thailand, about 429 kilometers long in total (the pipeline under the administration of Thai Petroleum Pipeline Co., Ltd. is about 360 kilometers long in total and that of Fuel Pipeline Transportation Co., Ltd. is about 69 kilometers long in total), during 1994 to 2015 (22 years), there was 1 incident due to a release hole of about 3-4 millimeters in diameter at the 11:00 position of the oil transmission pipeline under the administration of Thai Petroleum Pipeline Co., Ltd., which was caused by a 22 kV power transmission line being torn down, resulting in a short circuit to ground and the electric current subsequently flowing to the oil transmission pipeline (source – Changes in the Project Details in the Environmental Impact Assessment Report of the Oil Transmission Pipeline Project (Map Ta Phut - Si Racha), Thai Petroleum Pipeline Co., Ltd., May, 2015)

TABLE 5.5.5-2

STATISTICS ON MISHAPS IN PTT'S NATURAL GAS PIPELINE TRANSMISSION DURING 1981 TO DECEMBER 2015

	Year	Date	Incident	Corrective actions	Damage values	Improvement and change
1.	1982	-	Accidental release from a pipe of 28 inches in diameter located between BV#6 and 7 just before Bangpakong River Bridge (Bangpakong Power Plant - South Bangkok Power Plant pipeline system project), resulting in gas transmission being disrupted. A little leak through the seal of the fitting installed by the contractor's staff without approval (estimated size of the release hole is ¼ inch, for the statistical analysis of the incident data).	- Close the affected area - Plan for the repair procedure and suspension of gas transmission - Shut down the pipeline system - Cut the affected pipe to make the repair	Approximately three million baht	**Change** - Higher specification of steel (API 5L-X40, X60, X65) **Reason** - For enhanced steel strength - To enhance construction work efficiency
2.	1991	14th August	Accidental release from a pipe of 4 inches in diameter at the block valve station in front of SPG Company (Gas Pipeline Operation Center Region 1). A little leak through the gasket seal of the flange caused by soil subsidence (estimated size of the release hole is ¼ inch, for the statistical analysis of the incident data).	- Shut off the main supply valve - Plan for the repair procedure and suspension of gas transmission - Make the repair	-	**Change** - Higher specification of steel (API 5L-X40, X60, X65) **Reason** - For enhanced steel strength to enhance construction work efficiency

TABLE 5.5.5-2

STATISTICS ON MISHAPS IN PTT'S NATURAL GAS PIPELINE TRANSMISSION DURING 1981 TO DECEMBER 2015 (CONT'D)

	Year	Date	Incident	Corrective actions	Damage values	Improvement and change
3.	2534 (1991)	24th November	Accidental release from a pipe of 28 inches in diameter located between BV#8 and 9 (Bangpakong Power Plant - South Bangkok Power Plant pipeline system project), (Gas Pipeline Operation Center Region 1), incurred during the pre-boring process executed by the Department of Highways' contractor, resulting in a 4-inch release hole. Gas transmission was disrupted for 4 days (without approval from PTT).	– Announce an emergency plan – Suspend the gas transmission – Shut off the main supply valve – Cut the affected pipe to make the repair	suspension of gas transmission for 4 days, incurring the total loss of around ten million baht	**Change** – Having concrete slabs placed above the pipeline (in the areas at risk from third-person interference), only possible in the case of pipeline construction using open-cut method **Reason** – To reduce risk for damage caused by third-person interference – To enhance safety
4.	1998	19th February	A leak on a sealant injection fitting on an underground valve of the gas pipeline before entering Thana Inter Factory Station (Gas Pipeline Operation Center Region 1). A little leak on the 1/2-inch sealant injection fitting (estimated size of the release hole is ¼ inch, for the statistical analysis of the incident data).	– Plan for the suspension of gas transmission – Shut down the pipeline system from the gas separation plant to BV#2 – Close the affected area – Divert gas to flow through the parallel pipeline – Cut the affected pipe to make the repair	30,000 baht	**Change** – Additional measures in the maintenance plan **Reason** – Risk assessment with a view to enhancing the gas transmission pipeline system and emergency plan operation.
5.	1996	26th August	Accidental release from a pipe of 30 inches in diameter between BV#6 and Bangpakong Power Plant. A little leak through a weld failure caused by the construction work (estimated size of the	– Plan for the suspension of gas transmission – Switch the use of the gas transmission pipes in the affected area; the pipe of 24	four million baht	**Change** – Compliance with the latest edition of applicable standards in design and operation

TABLE 5.5.5-2

STATISTICS ON MISHAPS IN PTT'S NATURAL GAS PIPELINE TRANSMISSION DURING 1981 TO DECEMBER 2015 (CONT'D)

	Year	Date	Incident	Corrective actions	Damage values	Improvement and change
			release hole is ¼ inch, for the statistical analysis of the incident data).	inches in diameter is to be used instead - Cut the affected pipe to make the repair		**Reason** - Such standards are revised by panels of authorities on a regular basis to suit the present circumstances and avoid the recurrence of past mistakes
6.	1995	26th August	Accidental release from a pipe of 28 inches in diameter located before the gas separation plant (Rayong Gas Separation Plant - Bangpakong Power Plant ø 28-inch pipeline system project). A little leak from the pipe caused by a short circuit down from the Provincial Electricity Authority's high voltage pylon through its l ift truck to earth and the electric current subsequently flowing to the ground in the vicinity resulting in a pinhole puncture in the affected pipe (estimated size of the release hole is ¼ inch, for the statistical analysis of the incident data).	- Plan for the suspension of gas transmission - Shut down the pipeline system from the gas separation plant to BV#2 - Close the affected area - Divert gas to flow through the parallel pipeline - Cut the affected pipe to make the repair	Eight million baht	**Change** - Higher specification of steel (API 5L-X40, X60, X65) **Reason** - For enhanced steel strength - To enhance construction work efficiency
7.	1997	3rd October	An underground insulation joint leak from a pipe of 28 inches in diameter (Rayong Gas Separation Plant - Bangpakong Power Plant ø 28-inch parallel pipeline system project). A little leak from the pipe located about 8 meters away	- Announce an emergency plan - Plan for the shut-down - Close the affected area - Suspend the gas transmission		**Change** - Additional measures in the maintenance plan **Reason** - Risk assessment with a view to enhancing the gas transmission

TABLE 5.5.5-2

STATISTICS ON MISHAPS IN PTT'S NATURAL GAS PIPELINE TRANSMISSION DURING 1981 TO DECEMBER 2015 (CONT'D)

	Year	Date	Incident	Corrective actions	Damage values	Improvement and change
			outside the fence of BV#6 (estimated size of the release hole is ¼ inch, for the statistical analysis of the incident data).	- Change the installation of the insulation joint by installing it above ground instead of underground		pipeline system and emergency plan operation.
8.	1999	14th July	A sensing line leak from a ø ¾-inch release hole on the parallel pipeline between PV 141 and D-200 in Rayong Gas Separation Plant (Rayong Gas Separation Plant - Bangpakong Power Plant ø 28-inch parallel pipeline system project). A little leak through a weld failure (estimated size of the release hole is ¼ inch, for the statistical analysis of the incident data).	- Announce an emergency plan - Shut down the gas separation plant's system - Bypass the gas flow to enable the gas to enter the dew point control unit (DPCU) and then to the pipeline system as usual - Repair the affected spot	one million baht	
9.	2001	29th January	Accidental release from a pipeline of 8 inches in diameter in front of BV#2, which is connected to Laem Chabang Industrial Estate. A 4-inch release hole caused by a road grader during the road extension work executed by the Department of Highways' contractor.	- Announce an emergency plan - Close the affected area, bring the situation under control - Contact the clients so they can look for substitute energy - Shut off the main supply valve - Reduce the pressure r to zero	eight million baht	**Change** - Having concrete slabs placed above the pipeline (in the areas at risk from third-person interference), only possible in the case of pipeline construction using open-cut method **Reason** - To reduce risk for damage caused by third-person interference

TABLE 5.5.5-2

STATISTICS ON MISHAPS IN PTT'S NATURAL GAS PIPELINE TRANSMISSION DURING 1981 TO DECEMBER 2015 (CONT'D)

	Year	Date	Incident	Corrective actions	Damage values	Improvement and change
				- Contact the pipeline repair service company to cut the affected pipe to make the repair		
10.	2002	5th September	Accidental release from a pipe of 10 inches in diameter located on the main road of Thanyaburi District, Km 11, in Pathum Thani Province, occurring out of misunderstanding by the Department of Highways' contractor. A groove about 2 cm long cut with a handsaw onto the affected pipe, resulting in a 1-inch release hole.	- Announce an emergency plan - Bring the situation under control - Get the emergency contractor (TRC Plc.) to repair the affected pipe section - Reduce the pressure from BV#17 and make the repair using a repair sleeve or clamp	five million baht	**Change** - Having concrete slabs placed above the pipeline (in the areas at risk from third-person interference), only possible in the case of pipeline construction using open-cut method **Reason** - To reduce risk for damage caused by third-person interference and enhance safety
11.	2006	5th August	Accidental release from a pipe of 4 inches in diameter located on Suwannasorn Road, Km 97+159, in Saraburi Province, because of a mishap in the contractor's installation using the horizontal directional drilling (HDD) method of the pipeline of 12 inches in diameter in parallel with that of 4 inches in diameter, resulting in a release hole of about 1 inch and consequent gas leakage and ignition.	- Declare a state of emergency and close the area - Designate an emergency and situation control center - Isolate the affected pipe section and remove gas from the pipeline - Get the emergency contractor to repair the affected pipe section	6.1 million baht	**Change** - Publication of the handbook on standards of certain engineering construction works such as on the horizontal directional drilling (HDD) method whereby pressurized water is to be used to test the preexisting pipeline at every 0.5 meter and 0.5 - inch galvanized pipeline is to be

TABLE 5.5.5-2

STATISTICS ON MISHAPS IN PTT'S NATURAL GAS PIPELINE TRANSMISSION DURING 1981 TO DECEMBER 2015 (CONT'D)

	Year	Date	Incident	Corrective actions	Damage values	Improvement and change
				- Declare termination of the state of emergency - Produce the preliminary summary report analyzing the root cause of the incident - Contact the affected parties to offer compensation - Report on the investigation of the causes of the incident and guidelines in future preventive measures as well as follow up on impacts to the affected community and society		installed one meter below the preexisting pipeline **Reason** - To protect the preexisting pipeline - As a regulatory measure to ensure that efficient site supervisors and contractors are selected - To revise the emergency plan so that every activity is covered and the problem is promptly responded to
12	2008	21th November	A leak through a weld connecting a pipe of 24 inches to a pipe of 4 inches in diameter near Romklao5 Road. Backfilling conducted after the contractor finished welding the said pipes together accidentally causing a 1-inch crack on the weld.	- Declare a state of emergency and close the area - Designate an emergency and situation control center - Inform the clients and the affected parties - Isolate the affected pipe section and remove gas from the pipeline	not yet conclusive at the moment the information is retrieved	**Change** - Having all the necessary details clearly mentioned in the construction contract, for example when a ditch for a pipeline is backfilled, it must be backfilled in a manner that provides firm support under the pipe, and there are measures established to minimize impact damage to the pipeline

TABLE 5.5.5-2

STATISTICS ON MISHAPS IN PTT'S NATURAL GAS PIPELINE TRANSMISSION DURING 1981 TO DECEMBER 2015 (CONT'D)

	Year	Date	Incident	Corrective actions	Damage values	Improvement and change
				- Disseminate applicable information to the local people in the affected area - Repair the affected pipe section by the emergency contractor - Declare termination of the state of emergency - Produce the preliminary summary report analyzing the root cause of the incident - Contact the affected parties to offer compensation - Report on the investigation of the causes of the incident and guidelines in future preventive measures as well as follow up on impacts to the affected community and society		**Reason** - To protect the preexisting pipeline - As a regulatory measure to ensure that efficient site supervisors and contractors are selected - To keep the preexisting pipeline from moving resulting in a failure of a weld connecting two pipes - To produce the work instructions for important operation processes possibly incurring risks to the system such as backfilling and removal of sheet pipes - To make the operation staff aware of possible hazards and correct operational procedures with a view to minimizing incidents and mishaps

Remark: No death nor injury was reported in the 12 incidents.

Source: PTT Plc., 2016

TABLE 5.5.5-3

STATISTICS ON MISHAPS IN PTT NATURAL GAS DISTRIBUTION CO., LTD.'S NATURAL GAS PIPELINE TRANSMISSION DURING 1981 TO DECEMBER 2015

	Year	Date	Location	Cause	Failure	Pipe diameter (inch)	Gas pressure (bar(g))	Correction
1.	1992	2nd December	Bang Poo Industrial Estate Pattana 3	Third Party Wastewater	gas leakage	6	5	Cutting and replacing the affected pipe section
2.	2000	1st December	Bang Plee Industrial Estate Soi 5	Third Party Water	gas leakage/fire	6	5	Cutting and replacing the affected pipe section
3.	2003	5th April	Bang Poo Industrial Estate Soi 7	Third Party Water	gas leakage	4	5	Cutting and replacing the affected pipe section
4.	2004	23th September	Bang Poo Industrial Estate Pattana 3	Third Party Water	gas leakage	6	5	Cutting and replacing the affected pipe section
5.	2006	11th February	Bang Plee Industrial Estate Soi 6	Third Party Electrical	gas leakage	6	5	Cutting and replacing the affected pipe section
6.	2008	24th May	OTS, Ladkrabang	not mentioned	seal failure	not mentioned	Not mentioned	Shutting off the valve and replacing the affected pipe section
7.	2000	17th August	OTS, Navanakhon	not mentioned	seal failure	not mentioned	Not mentioned	Shutting off the valve and replacing the affected pipe section
8.	2012	28th August	Rojana Industrial Park	not mentioned	gas leakage	not mentioned	Not mentioned	Cutting and replacing the affected pipe section

Source: PTT Plc., 2016

TABLE 5.5.5-4

STATISTICS ON MISHAPS IN TRANS THAI – MALAYSIA (THAILAND) LTD.'S NATURAL GAS PIPELINE TRANSMISSION DURING 1981 TO DECEMBER 2015

	Year	Date	Incident	Corrective actions	Damage values	Improvement and change
1	2006	6th February	A short circuit fault of the Provincial Electricity Authority's 39 kV power transformer. The electric current travelling from the fuse box of the transformer through the body of a snake to the grounding system inflicting damage to the grounding system of the pressure indication controller of an LPG pipeline of 3/8 inch in diameter resulting in an accidental release of gas and ignition at BV# 1.	- The security staff of BV# 1 put off the fire using fire extinguishers. - The staff of Trans Thai – Malaysia (Thailand) Ltd. shut off the valve. - The pressure indication controller of the affected LPG pipeline was replaced.	- 50,000 baht	Change - upgrade of the grounding system and regular check-up to ensure its operational consistency

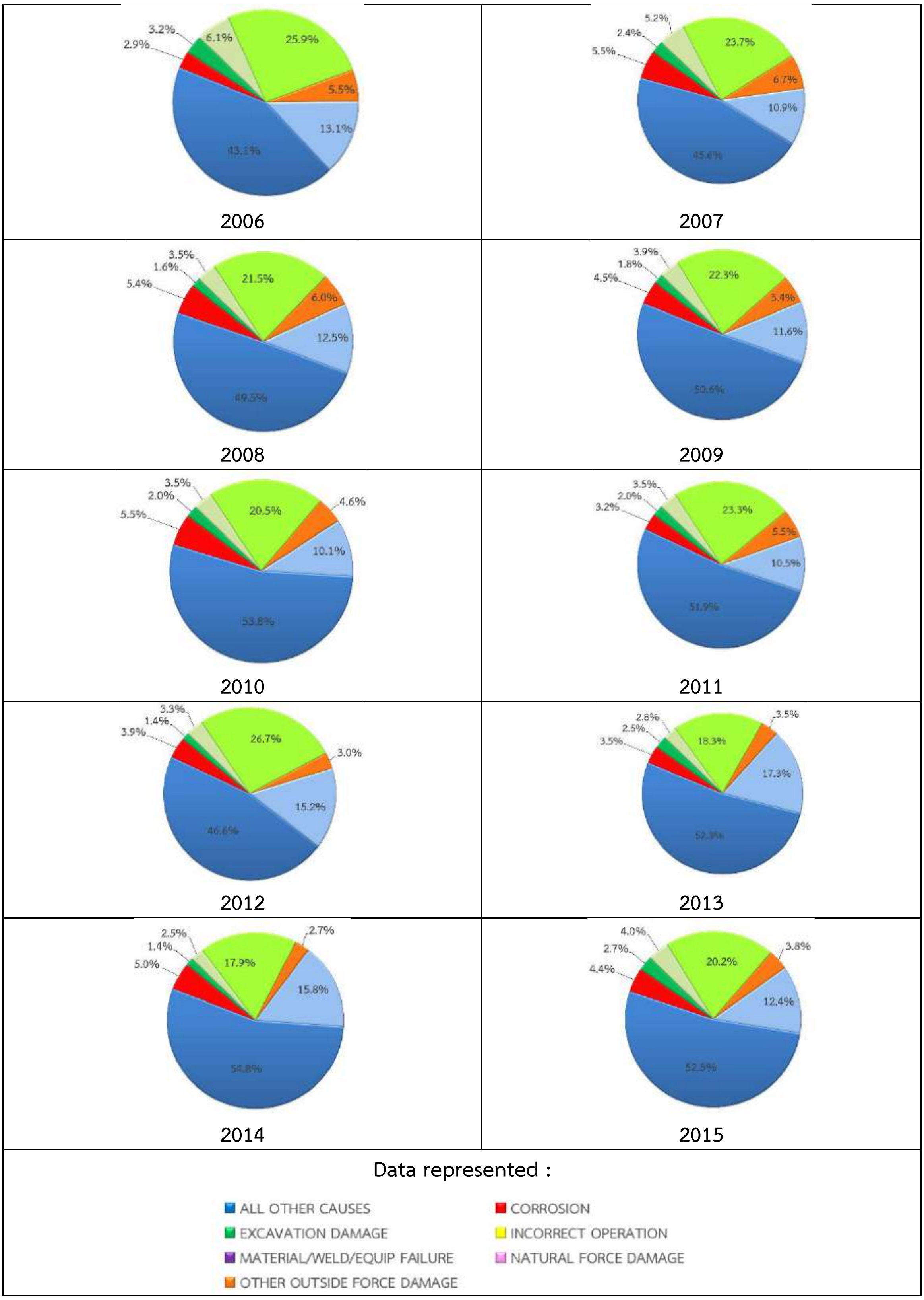
Source: PTT Plc., 2016

TABLE 5.5.5-5

STATISTICS ON MISHAPS IN ONSHORE HAZARDOUS LIQUID PIPELINE TRANSMISSION IN THE US DURING JANUARY 1st, 1996 TO DECEMBER 31th, 2015

Year	Number of incidents (times)	Number of fatalities (persons)	Number of injuries (persons)	Damage values (dollars)
1996	189	5	13	$84,331,311
1997	161	0	5	$42,382,642
1998	141	2	6	$52,564,979
1999	160	4	20	$84,352,560
2000	138	1	4	$131,924,797
2001	128	0	10	$24,929,751
2002	451	1	0	$49,667,697
2003	430	0	5	$67,377,845
2004	363	5	16	$86,508,894
2005	345	2	2	$276,878,210
2006	343	0	2	$59,584,322
2007	329	4	10	$59,666,188
2008	368	2	2	$136,875,358
2009	336	4	4	$63,215,857
2010	346	1	3	$1,071,955,017
2011	343	1	2	$268,225,237
2012	363	3	4	$144,044,956
2013	400	1	6	$278,350,540
2014	442	0	0	$129,169,137
2015	451	1	0	$246,208,657
total	**6,227**	**37**	**114**	**$3,358,213,955**

Source : US DOT Pipeline and Hazardous Materials Safety Administration, (https://hip.phmsa.dot.gov/analyticsSOAP/saw.dll?Portalpages, retrieved on 12th July 2016)



Source : http://www.phmsa.dot.gov/, retrieved on 12th July 2016

FIGURE 5.5.5-2 : CHARTS SHOWING CAUSES OF MISHAPS IN ONSHORE HAZARDOUS LIQUID PIPELINE TRANSMISSION IN THE U.S.A. DURING JANUARY 1st, 1996 TO DECEMBER 31th, 2015

5.5.6 Major Hazard Assessment in Different Scenarios

5.5.6.1 Major Hazard Assessment in Case of Accidental Release of Natural Gas/Diesel

Impacts from the accidental release and ignition to the surrounding area is investigated by the consultant. The damage incurred due to thermal radiation can be assessed from the amount of the thermal radiation received, which is measured in terms of the energy received per area unit all through the combustion period. For this, BREEZE HAZ mathematical model as developed by the US' Trinity Consultants Inc. is employed.

(1) Formulation of Hypotheses Regarding Accidental Release of Natural Gas/Diesel

With respect to the properties and chemical composition, natural gas consists mainly of methane, a hydrocarbon with low molecular weight and density that is lighter than air. If accidentally released, it quickly disperses and floats into the atmosphere. As for diesel, if accidentally released, the liquid remains largely on the ground surface and evaporates partially at the interface. The assessment of the likelihood of hazards is thus based on the natures of the accidental release and ignition of natural gas and diesel, as shown in **Figure 5.5.6-1** and **Figure 5.5.6-2**. The details are as follows:

- **Nature of the Accidental Release**

In assessing the likelihood of hazards, the nature of the potential accidental release is classified into two types, which are

- **Instantaneous release** is a release from a hole of medium or larger size and more than 10,000 pounds is released in three minutes; or a release caused by the pipe or tank being broken or seriously damaged; and there is likelihood of a fire happening instantaneously.
- **Continuous release** is a constant release over a longer period of time than an instantaneous release and is usually caused by a puncture of small size or less than 10,000 pounds being released in three minutes.

- **Release Hole Size**

The release hole sizes are classified in accordance with the American Petroleum Institute (API)'s guidelines into 4 categories – small, medium, large, and rupture, the details of which are as shown in **Table 5.5.6-1**.

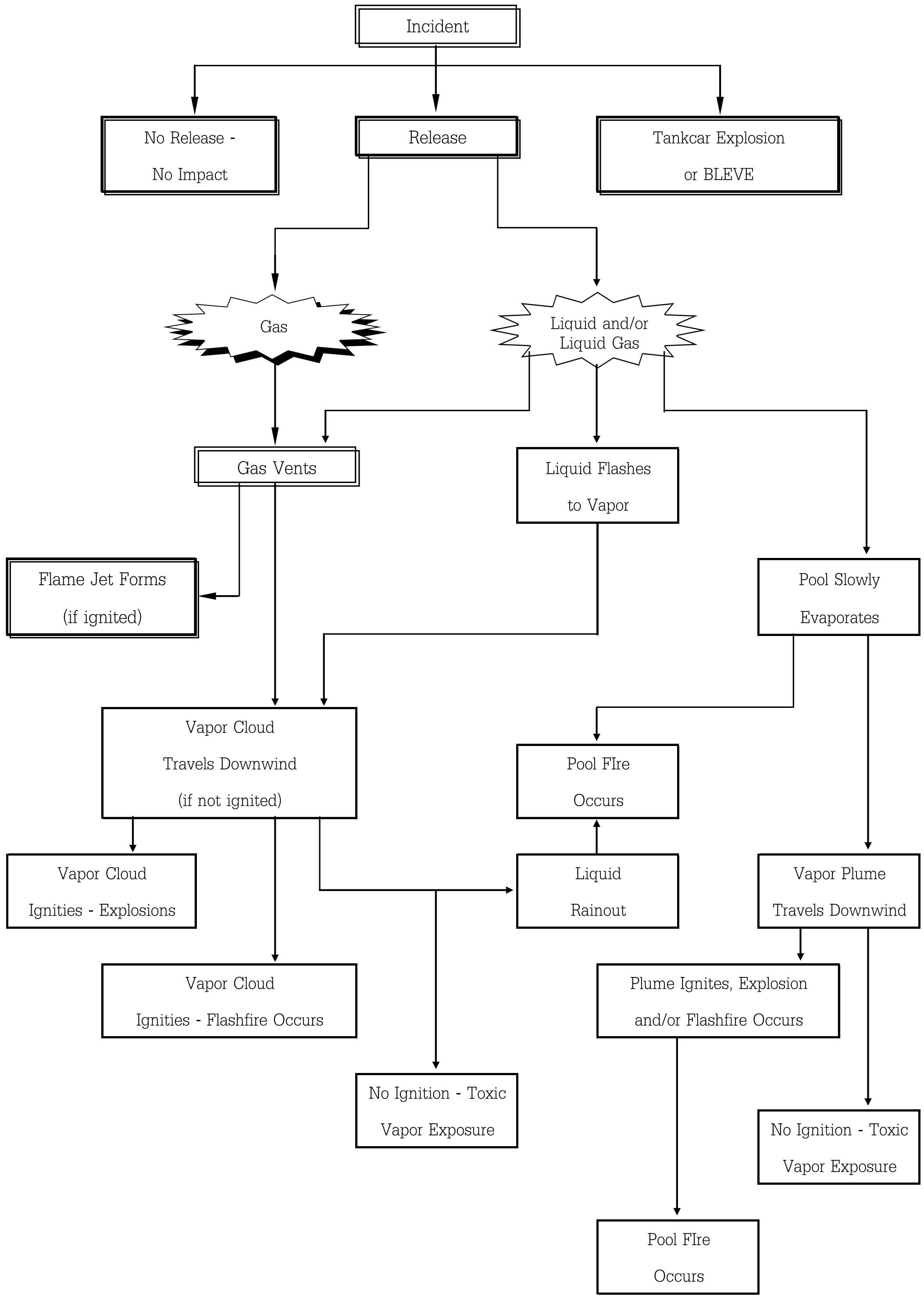


FIGURE 5.5.6-1 : NATURAL OF HAZARDOUS CHEMICAL ACCIDENTAL RELEASE

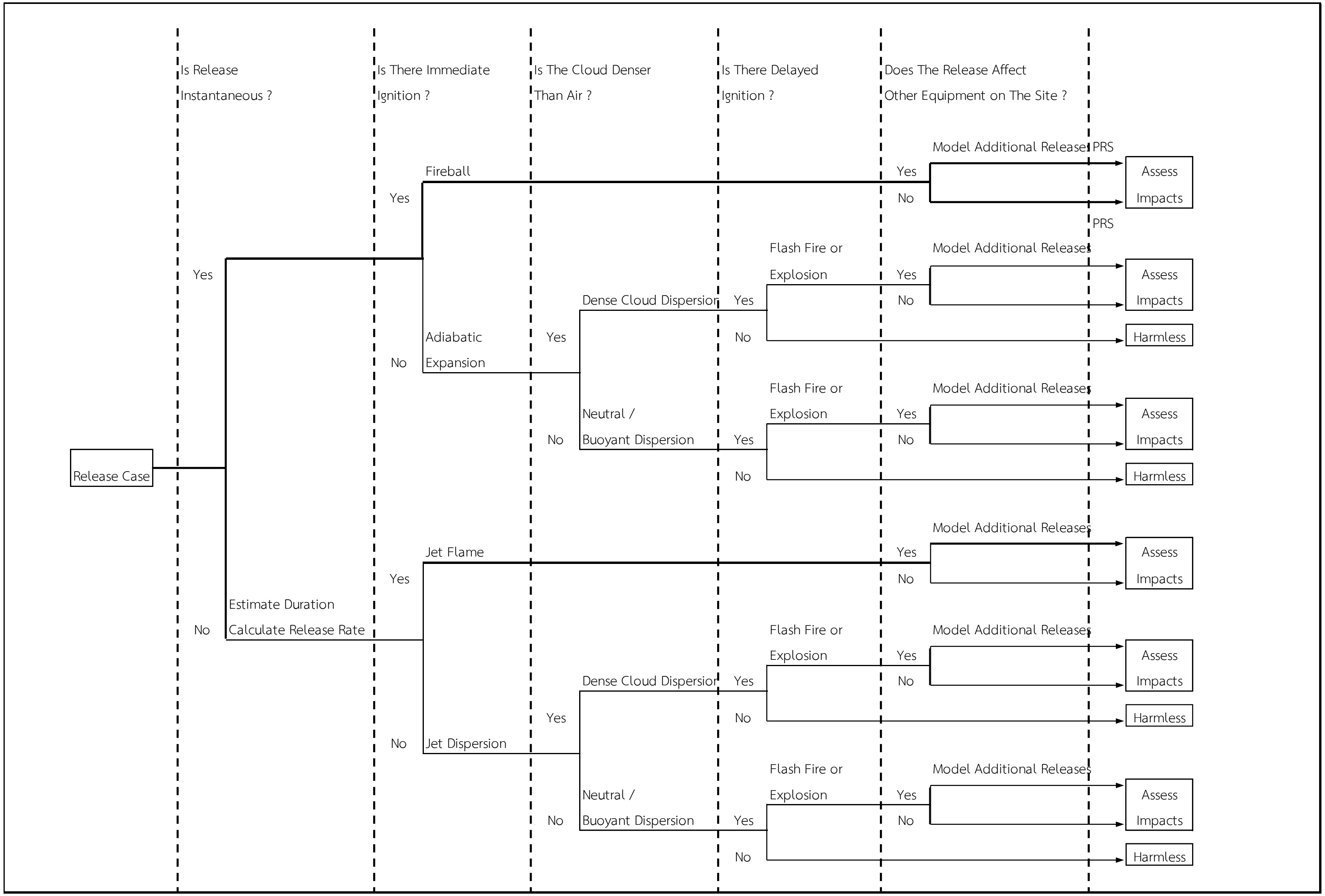


FIGURE 5.5.6-2 : FLAMMABLE GAS RELEASE CASES

TABLE 5.5.6-1

CLASSIFICATION OF RELEASE HOLE SIZES IN ACCORDANCE WITH THE AMERICAN PETROLEUM INSTITUTE (API)'S GUIDELINES

Release hole size	Diameter range	Value used in the assessment
Small	0 – ¼ inch	0.635 cm (1/4 inch)
Medium	¼ - 2 inch	2.54 cm (1 inch)
Large	2 – 6 inch	10.16 cm (4 inch)
Rupture	>16 inch	the diameter of the pipe is estimated to be 40.64 cm or less (16 inch)

Source : Risk Base Inspection, Base Resources Document; API Publication 581, 1st edition, May 2000

- **Duration of Release**

In the risk assessment of the natural gas/diesel transmission pipeline system, determination of the duration of release is based on the detection system and isolation system installed in the project's transmission pipeline system in accordance with the American Petroleum Institute (API)'s suggestion in Risk Base Inspection, Base Resources Document API Publication 581 (2000). In the event of accidental release of methane and oil vapour through welding around the connection points, once a leak is detected, the transmission pipeline system will be isolated automatically by the said systems; which are considered Class A according to the aforementioned document.

As suggested by the American Petroleum Institute (API), in the risk assessment of the transmission pipeline system with Class A detection system and isolation system in the case of a release hole of 4, 1, and 0.25 inch; the durations of release are estimated to be 5, 10, and 20 minutes respectively. For a rupture case, the duration of release is estimated to be 3 minutes. When assessing the probability of leakage from the release holes of different sizes, that from the release hole of 1 inch is found to be the highest. Therefore, in assessing the case likely to occur most and the worst case possible (rupture), the durations of release of natural gas/diesel from the pipeline are determined to be 10 and 3 minutes, respectively.

As for accidental release from the diesel storage tank, determination of the duration of release is based on the manned isolation system, which is considered Class B. In the case of a release hole of 4, 1, and 0.25 inch, the durations of release are estimated to be 10, 20, and 30 minutes, respectively. For a rupture case, the duration of release is estimated to be the same as that of a release hole of 4 inches, which is 30 minutes. When assessing the probability of leakage from the release holes of different sizes, that from the release hole of 1 inch is found to be the highest. Therefore, in assessing the case likely to occur most and the worst case possible (rupture), the durations of release of natural diesel from the storage tank are determined to be 20 and 10 minutes, respectively.

- **Release Rate**
  - **Natural Gas Transmission Pipeline**

The main natural gas transmission pipeline in the project area starts at the gas metering station and ends at the gas compressors, from which the natural gas will be transmitted to the electricity generating units through the pipelines of 12 and 18 inches in diameter. The natural gas transmission pipeline in Pluak Daeng Power Plant Project is of iron and of two different diameters.

- Two natural gas transmission pipelines of 18 inches in diameter, connected from the gas metering station to the gas compressors, 125 meters in length each. The pipelines are designed to be able to withstand the minimum pressure of 50 barg at the temperature of 50 degree Celsius.
- Two natural gas transmission pipelines of 18 inches in diameter, connected from the gas compressors to the relay point from which gas is further relayed through the pipelines of 12 inches in diameter to each individual gas turbine. One pipeline is 147 meters long (relaying gas to gas turbine number 1 and 2). Another pipeline is 359 meters long (relaying gas to gas turbine number 3 and 4). The pipelines are designed to be able to withstand the minimum pressure of 60 barg at the temperature of 150 degree Celsius.
- Natural gas transmission pipelines of 12 inches in diameter connected from the relay point where the aforementioned pipeline of 18 inches in diameter are connected, to the flow meter, then to each individual gas turbine : four pipelines in total, 165, 253, 163, and 428 meters long, respectively. The pipelines are designed to be able to withstand the minimum pressure of 60 barg at the temperature of 150 degree Celsius.
- Natural gas transmission pipelines of 12 inches in diameter connected from the flow meter through the fuel gas heater to each individual gas turbine, four pipelines in total, 40 meters long each. The pipelines are designed to be able to withstand the minimum pressure of 60 barg at the temperature of 360 degree Celsius.

Given the above conditions, the rates of release from the natural gas transmission pipeline in the case of a hole of 1 inch and a rupture can be calculated as shown in **Table 5.5.6-2**. When assessing hazards from natural gas release and its consequent ignition at the connection points, only the case where the release rate is higher than those shown is to be taken into consideration.

TABLE 5.5.6-2

RELEASE RATES AND QUANTITIES IN CASE OF A RELEASE HOLE OF 1 INCH AND A RUPTURE ON THE NATURAL GAS TRANSMISSION PIPELINE

Release hole size	Release rate (kilogram/second)				Release quantity (kilogram)			
	P 50 barg T 50 °C1/	P 60 barg T 150 °C2/	P 60 barg T 150 °C3/	P 60 barg T 360 °C4/	P 50 barg T 50 °C1/	P 60 barg T 150 °C2/	P 60 barg T 150 °C3/	P 60 barg T 360 °C4/
1 inch	2.99	3.12	3.12	2.55	1793.30	1874.43	1,874.43	1,532.37
rupture	765.14	799.76	449.86	367.77	137,725.78	143,956.01	80,975.25	66,198.20

Remarks : 1/ The pipelines connected from the gas metering station to the gas compressor are 18 inches in diameter, inside of which the pressure is 50 barg and the temperature is 50 degree Celsius.

2/ The pipelines connected from the gas compressors to the relay point, from which gas is further relayed through the pipelines of 12 inches in diameter, are 18 inches in diameter, inside of which the pressure is 60 barg and the temperature is 150 degree Celsius.

3/ The pipelines connected from the relay point, where the aforementioned pipelines of 18 inches in diameter are connected to the flow meters, is 12 inches in diameter, inside of which the pressure is 60 barg and the temperature is 150 degree Celsius.

4/ The pipelines connected from the flow meters to the gas turbines are 12 inches in diameter, inside of which the pressure is 60 barg and the temperature is 150 degree Celsius.

- **Diesel Transportation Pipeline**

The diesel transmission pipeline of the project starts at the storage tank, from which diesel is conveyed to the electricity generation unit. The pipeline directly connected to the storage tank is 12 inches in diameter. The diameter of the pipeline is decreased to 10, 8, 6, and 5 inches along the way to the electricity generation unit (**Table 5.5.6-3**). The details are as follows:

- Diesel transmission pipeline of 12 inches in diameter connected from the storage tank to the fuel oil transfer pump. The pipeline is 104 meters long and is designed to be able to withstand the minimum pressure of 4 barg at the temperature of 50 degree Celsius.
- Diesel transmission pipeline of 12 inches in diameter connected from the fuel oil transfer pump to each individual gas turbine. The pipeline is approxiamately 78 meters long and is designed to be able to withstand the minimum pressure of 16 barg at the temperature of 50 degree Celsius.
- Diesel transmission pipeline of 10 inches in diameter and 128 inches in length, connected from the aforementioned transmission pipeline of 12 inches in diameter, which is further connected to the transmission pipelines of 8 inches and that of 6 inches (129, 175, 169, and 257 meters in length, respectively), and finally to the main fuel oil pump in each individual electricity generation unit. The pipelines are designed to be able to withstand the minimum pressure of 16 barg at the temperature of 50 degree Celsius.

TABLE 5.5.6-3

RELEASE RATES AND QUANTITIES IN CASE OF A RELEASE HOLE OF 1 INCH AND A RUPTURE ON THE DIESEL TRANSMISSION PIPELINE

Release hole size	Release rate (kilogram/second)						Release quantity (kilogram)					
	P 4 barg T 50 °C[1/]	P 16 barg T 50 °C[2/]	P 16 barg T 50 °C[3/]	P 16 barg T 50 °C[4/]	P 16 barg T 50 °C[5/]	P 120 barg T 50 °C[6/]	P 4 barg T 50 °C[1/]	P 16 barg T 50 °C[2/]	P 16 barg T 50 °C[3/]	P 16 barg T 50 °C[4/]	P 16 barg T 50 °C[5/]	P 120 barg T 50 °C[6/]
1 inch	3.77	6.81	6.81	6.81	6.81	18.81	2,241.78	4,083.73	4,083.73	4,083.73	4,083.73	11,287.4
Rupture	538.03	980.09	680.62	435.60	245.02	470.31	96,845.05	176,416.96	122,511.79	78,407.55	44,104.24	84,655.50

Remarks:
1/ The pipeline connected from the diesel storage tank to the electricity generation unit is 12 inches in diameter, inside of which the pressure is 4 barg and the temperature is 50 °C
2/ The pipeline connected from the fuel oil transfer pump through the relay point to each gas turbine is 12 inches in diameter, inside of which the pressure is 16 barg and the temperature is 50 °C
3/ For the diesel transmission pipeline of 10 inches in diameter, the pressure inside is 16 barg and the temperature is 50 °C
4/ For the diesel transmission pipeline of 8 inches in diameter, the pressure inside is 16 barg and the temperature is 50 °C
5/ For the diesel transmission pipeline of 6 inches in diameter, the pressure inside is 16 barg and the temperature is 50 °C
6/ For the diesel transmission pipeline of 5 inches in diameter, the pressure inside is 120 barg and the temperature is 50 °C

- Diesel transmission pipeline of 5 inches in diameter, connected from the main fuel oil pump to the gas turbine in each individual electricity generation unit, four pipelines in total, 45 meters long each. The pipelines are designed to be able to withstand the minimum pressure of 120 barg at the temperature of 50 degree Celsius.

Given the above conditions, the rates of release from the diesel transmission pipeline in the case of a hole of 1 inch and a rupture can be calculated as shown in **Table 5.5.6-3**. When assessing hazards from diesel release and its consequent ignition at the connection points, only the case where the release rate is higher than those shown is to be taken into consideration.

- **Diesel Storage Tank**

Diesel is to be reserved in the project to the amount of 26,000 m^3 in two tanks of 14,300 m^3, 37 meters in diameter and 14 meters high. The maximum storage amount is 90% of the tank volume, which is not more than 13,000 m^3 per tank. The rates of release from the atmospheric storage tank in the case of a hole of 1 inch and a rupture can be calculated as shown in **Table 5.5.6-4.**

- **meteorological factors**

Meteorological condition is a factor influencing the nature of toxic substance dispersion from its origin to the receptor. How severe the incident is depends on meteorological factors. According to the Guidance on the Application of Refined Dispersion Models for Hazardous/Toxic Air Releases US.EPA (1993), the meteorological factors affecting and involving dispersion of toxic substance include the wind speed, atmospheric stability, temperature, relative humidity, and air pressure. In the risk analysis of major hazards caused by accidental release and consequent ignition in the project’s natural gas/diesel transmission pipeline, meteorological data covering 10 years from 2006 to 2015 were collected (Meteorological Department, 2016) from Huay Pong Air quality monitoring Station, as this is the station nearest to the project location. The details of input data used in the mathematical model are as follows:

- Wind speed – 1.0 knot
- Atmospheric stability - F
- Temperature – 28.0 degree Celsius
- Relative humidity – 77.0%
- Air pressure - 1009.4 Hecto Pascal

TABLE 5.5.6-4
RELEASE RATES FROM THE DIESEL STORAGE TANK IN CASE OF A RELEASE HOLE OF 1 INCH AND A RUPTURE

Release hole size	Release rate (kilogram/second)	Release quantity (kilogram)
1 inch	4.58	5,497.67
rupture	659.72	395,831.55

- **Analysis of Areas at Risk**
  - **Natural Gas Transmission Pipeline System**

Risk of severe hazard happening in the natural gas transmission pipeline system can be assessed with reference to the statistics on natural gas transmission pipeline incident, both inside and outside the country, for example those in the USA by referring to the data from the American Petroleum Institute(API). The findings reveal very low chance of accidental natural gas release hazard. Nevertheless, in this study the areas where accidental release of natural gas is possible are assessed. These mainly involve the connection points and areas where third persons can easily access to perform activities such as around the metering and regulating station (MRS), gas compressors, and gas turbines.

  - **Oil Transportation Pipeline System**

Risk of severe hazard happening in the oil transportation pipeline system can be assessed with reference to the statistics on oil transportation pipeline incident, both inside and outside the country, for example those in the USA by referring to the data from the American Petroleum Institute(API). The findings reveal very low chance of oil accidental release hazard. Nevertheless, in this study the areas where oil accidental release is possible are assessed. These mainly involve the connection points such as the points where the oil tanks and oil pumps are connected, the relay points where oil is relayed to each individual gas turbine, and the points where pipelines of different diameter sizes are connected.

  - **Diesel Storage Tanks**

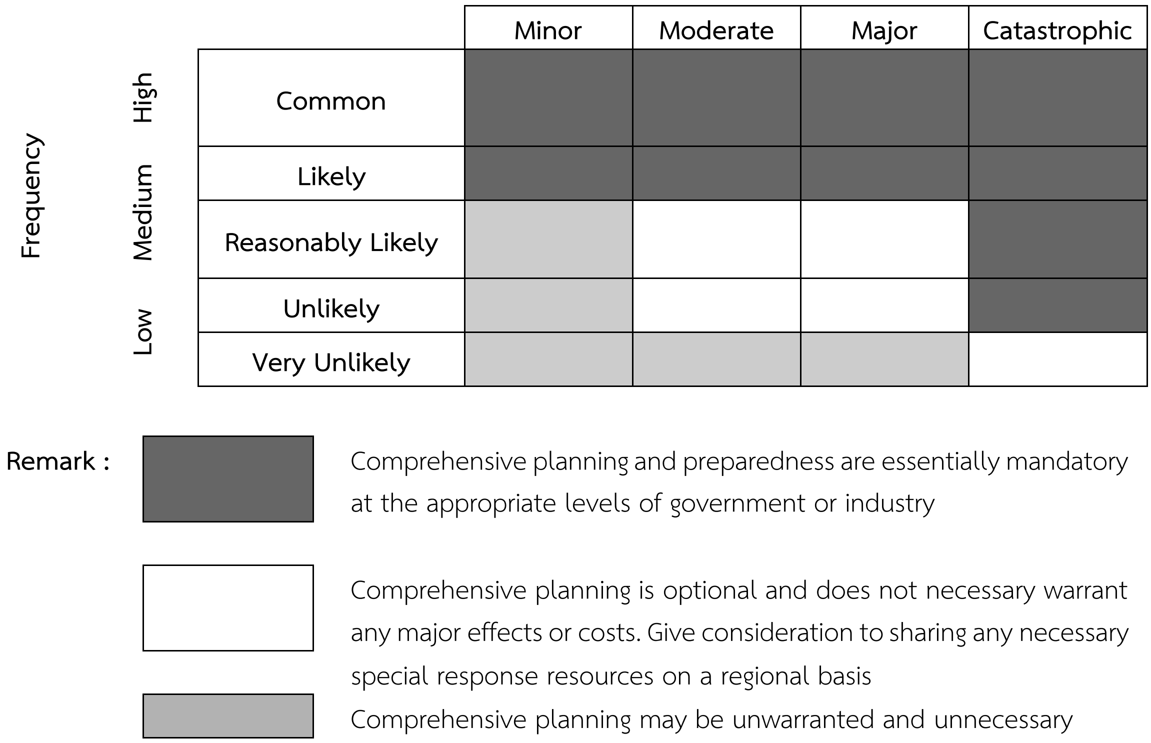
The areas where diesel accidental release is possible are mainly the points where the storage tanks are connected.

(2) Risk Assessment

According to API's assessment of risk to major hazards, two factors are put into consideration – probability or frequency of the incident and level of severity of the incident with respect to the impact incurred. The metrix table is used in the risk assessment with the Y axis representing the frequency of the incident and the X axis representing the level of severity incurred, as shown in **Figure 5.5.6-3**. The details are as follows:

- Probability or frequency of the incident : the assessment is based on the criteria in the Handbook of Chemical Hazard Analysis Procedures (1990) developed by the Federal Emergency Management Agency, U.S. Department of Transportation, U.S.EPA. The details are shown in **Table 5.5.6-5**.
- Severity level of the incident : the assessment is based on the criteria in the Handbook of Chemical Hazard Analysis Procedures (1990) developed by the Federal Emergency Management Agency, U.S. Department of Transportation, U.S.EPA. The details are shown in **Table 5.5.6-6**.

The impacts from the accidental release and combustion resulting from the thermal energy incurred, which are measured in terms of the amount of energy incurred per area unit, as shown in **Table 5.5.6-7**. For the impacts from the explosion at different pressure levels, the details are shown in **Table 5.5.6-8**.



Source: Handbook of Chemical Hazard Analysis Procedures, Federal Emergency Management Agency, U.S. Department of Transportation, 1990.

FIGURE 5.5.6-3 : ACCIDENT FREQUENCY/SEVERITY SCREENING MATRIX

TABLE 5.5.6-5
DEFINITION OF PROBABILITY OR FREQUENCY OF THE INCIDENT CATEGORIES

Level of probability	Definition
Common	expected to occur one or more times each year on average (>1 time/year)
Likely	expected to occur at least once every 10 years on average (>0.1 time/year)
Reasonably likely	predicted to occur between once every 10 years and once every 100 years on average (0.1 - 1×10^{-2} time/year)
Unlikely	predicted to occur between once every 100 years and once every 1,000 years on average (1×10^{-2} - 1×10^{-3} time/year)
Very Unlikely	predicted to occur less than once in 1,000 years (<1×10^{-3} time/year)

Source : Handbook of Chemical Hazard Analysis Procedures, Federal Emergency Management Agency, U.S. Department of Transportation, U.S.EPA, 1990.

TABLE 5. 5.6-6
DEFINITION OF SEVERITY OF THE INCIDENT CATEGORIES

Level of severity	Definition
Minor	- Few human injuries - No need for evacuation - Minimal contamination of the environment, no need for cleanup effort
Moderate	- Not more than 10 human fatalities, and not more than 100 human injuries - Evacuation of up to 2,000 people - Contamination of the environment requiring a cleanup effort
Major	- Up to 100 human fatalities, and up to several hundred human injuries - Evacuation of up to 20,000 people - Contamination of the environment requiring a formal cleanup effort
Catastrophic	- More than 100 human fatalities, and more than 300 human injuries - Evacuation of more than 20,000 people - Contamination of the environment requiring a formal and prolonged cleanup effort

Source : Handbook of Chemical Hazard Analysis Procedures, Federal Emergency Management Agency, U.S. Department of Transportation, 1990.

TABLE 5.5.6-7

IMPACTS FROM THE ACCIDENTAL RELEASE AND COMBUSTION RESULTING FROM THE THERMAL ENERGY INCURRED

Incident flux (kW/m^2)	Type and scope of the impact incurred	
	Damage to equipment	Damage to people
37.5	Damage to process equipment	– 100% lethality if exposed for 1 minute, 1% lethality if exposed for 10 seconds
25.0	Minimum energy to ignite wood without a flame	– 100% lethality if exposed for 1 minute, severe injury if exposed for 10 seconds
12.5	Minimum energy to ignite wood with a flame and melt plastic	– 1% lethality if exposed for 1 minute, first degree burns if exposed for 10 seconds
4.0	-	– Skin burning pain if exposed for longer than 20 seconds, but no blistering
1.6	-	– No discomfort caused for long exposure

Source : World Bank Technical Paper No.35, 1988

TABLE 5.5.6-8

IMPACTS FROM THE EXPLOSION AT DIFFERENT PRESSURE LEVELS

Pressure level (psig)	Scope of the impact
0.345	1-99% fatalities among exposed victims
0.138	Complete destruction of structures and process equipment in the vicinity
0.069	Severe damage to structures and process equipment in the vicinity
0.039	Glass windows shaking and partially damaged (but reparable)

Source : Lees, Frank P., Loss Prevention in the Process Industries, Vol. 1. London and Boston, 1980

(2.1) Probability of Risk

(a) Probability of Pipeline/Tank Leakage

Probability of risk of leakage in the natural gas/diesel pipelines and diesel storage tanks is assessed with reference to the statistics on the frequency of the incidents as collected by API and published in the Risk Based Inspection, Base Resource Documents; API Publication 581 (2000). The details are shown in **Table 5.5.6-9**.

TABLE 5.5.6-9

FREQUENCY OF ACCIDENTAL RELEASE FROM EQUIPMENT AND PIPING OF DIFFERENT SIZES AS COLLECTED BY THE AMERICAN PETROLEUM INSTITUTE (API)

Type of equipment	Frequency of accidental release in a year (time/year/foot)			
	release hole of 0.25 inch	release hole of 1 inch	release hole of 4 inch	rupture
Piping, 1.905 cm (0.75 inch) diameter, per ft	1×10^{-5}	-	-	3×10^{-7}
Piping, 2.54 cm (1 inch) diameter, per ft	5×10^{-6}	-	-	5×10^{-7}
Piping, 5.08 cm (2 inch) diameter, per ft	3×10^{-6}	-	-	6×10^{-7}
Piping, 10.16 cm (4 inch) diameter, per ft	9×10^{-7}	6×10^{-7}	-	7×10^{-8}
Piping, 15.24 cm (6 inch) diameter, per ft	4×10^{-7}	**4×10^{-7}**	-	**8×10^{-8}**
Piping, 20.32 cm (8 inch) diameter, per ft	3×10^{-7}	**3×10^{-7}**	8×10^{-8}	**2×10^{-8}**
Piping, 25.40 cm (10 inch) diameter, per ft	2×10^{-7}	**3×10^{-7}**	8×10^{-8}	**2×10^{-8}**
Piping, 30.48 cm (12 inch) diameter, per ft	1×10^{-7}	**3×10^{-7}**	3×10^{-8}	**2×10^{-8}**
Piping, 40.64 cm (16 inch) diameter, per ft	1×10^{-7}	3×10^{-7}	2×10^{-8}	2×10^{-8}
Piping, >40.64 cm (16 inch) diameter, per ft	6×10^{-8}	**2×10^{-7}**	2×10^{-8}	**1×10^{-8}**
Atmospheric Storage Tank	4×10^{-5}	**1×10^{-4}**	1×10^{-5}	**2×10^{-5}**

Source : Risk Based Inspection, Base Resource Documents; API Publication 581, 2000

Having investigated the probability of risk of leakage in the natural gas/diesel pipelines and diesel storage tanks with reference to the American Petroleum Institute's data as shown in **Table 5.5.6-9**, the consultant find that probability of incident involving the one-inch release hole is the highest and thus choose to assess probability of incident in the case of one-inch release hole and that in the case of rupture, which is the worst case possible. For the project's pipeline of 5 inches in diameter, the data on frequency of the incidents caused by accidental release from the pipeline of 6 inches in diameter are chosen to represent the case, as the frequency is higher than that from the pipeline of 4 inches in diameter. For the project's pipeline of 18 inches in diameter the data on frequency of the incidents caused by accidental release from the pipeline of 16 inches in diameter are chosen.

The details of the assessment of probability of incident caused by release holes of varying sizes are as follows:

(a.1) Natural Gas Transmission Pipeline

- **The pipelines of 18 inches in diameter, 125 meters in length, connected from the area of the MRS to that of the gas compressors**

In the case of release hole of 1 inch

$$\text{Probability of incident} = 2\times10^{-7}\ \text{time/year/foot}\times\frac{3{,}280.84\ \text{foot}}{1\ \text{kilometer}}\times 0.125\ \text{kilometer}$$

$$= 8.20\text{x}10^{-5}\ \text{time/year}$$

In the case of rupture

$$\text{Probability of incident} = 1\times10^{-8}\ \text{time/year/foot}\times\frac{3{,}280.84\ \text{foot}}{1\ \text{kilometer}}\times 0.125\ \text{kilometer}$$

$$= 4.10\text{x}10^{-6}\ \text{time/year}$$

- **The pipelines of 18 inches in diameter, connected from the gas compressor to the relay point from which gas is further relayed through the pipelines of 12 inches in diameter, 147 and 359 meters in length**

In the case of release hole of 1 inch (147-meter-long pipeline)

$$\text{Probability of incident} = 2\times10^{-7}\ \text{time/year/foot}\times\frac{3{,}280.84\ \text{foot}}{1\ \text{kilometer}}\times 0.147\ \text{kilometer}$$

$$= 9.65\text{x}10^{-5}\ \text{time/year}$$

In the case of release hole of 1 inch (359-meter-long pipeline)

$$\text{Probability of incident} = 2\times10^{-7}\ \text{time/year/foot}\times\frac{3{,}280.84\ \text{foot}}{1\ \text{kilometer}}\times 0.359\ \text{kilometer}$$

$$= 2.36\times10^{-4}\ \text{time/year}$$

In the case of rupture (147-meter-long pipeline)

$$\text{Probability of incident} = 1\times10^{-8}\ \text{time/year/foot}\times\frac{3{,}280.84\ \text{foot}}{1\ \text{kilometer}}\times 0.147\ \text{kilometer}$$

$$= 4.82\times10^{-6}\ \text{time/year}$$

In the case of rupture (359-meter-long pipeline)

$$\text{Probability of incident} = 1\times10^{-8}\ \text{time/year/foot}\times\frac{3{,}280.84\ \text{foot}}{1\ \text{kilometer}}\times 0.359\ \text{kilometer}$$

$$= 1.18\times10^{-5}\ \text{time/year}$$

- **The pipelines of 12 inches in diameter, connected from the relay point, where gas is previously relayed through the pipelines of 18 inches in diameter, to the flow meters, 165, 253, 163, and 428 meters long**

In the case of release hole of 1 inch (165-meter-long pipeline)

Probability of incident $= 3\times10^{-7}$ time/year/foot$\times \frac{3{,}280.84 \text{ foot}}{1 \text{ kilometer}} \times$ 0.165 kilometer

$= 1.62\times10^{-4}$ time/year

In the case of release hole of 1 inch (253-meter-long pipeline)

Probability of incident $= 3\times10^{-7}$ time/year/foot$\times \frac{3{,}280.84 \text{ foot}}{1 \text{ kilometer}} \times$ 0.253 kilometer

$= 2.49\times10^{-4}$ time/year

In the case of release hole of 1 inch (163-meter-long pipeline)

Probability of incident $= 3\times10^{-7}$ time/year/foot$\times \frac{3{,}280.84 \text{ foot}}{1 \text{ kilometer}} \times$ 0.163 kilometer

$= 1.60\times10^{-4}$ time/year

In the case of release hole of 1 inch (428-meter-long pipeline)

Probability of incident $= 3\times10^{-7}$ time/year/foot$\times \frac{3{,}280.84 \text{ foot}}{1 \text{ kilometer}} \times$ 0.428 kilometer

$= \mathbf{4.21\times10^{-4}}$ time/year

In the case of rupture (165-meter-long pipeline)

Probability of incident $= 2\times10^{-8}$ time/year/foot$\times \frac{3{,}280.84 \text{ foot}}{1 \text{ kilometer}} \times$ 0.165 kilometer

$= 1.08\times10^{-5}$ time/year

In the case of rupture (253-meter-long pipeline)

Probability of incident $= 2\times10^{-8}$ time/year/foot $\times \frac{3{,}280.84 \text{ foot}}{1 \text{ kilometer}} \times$ 0.253 kilometer

$= 3.43\times10^{-5}$ time/year

In the case of rupture (163-meter-long pipeline)

Probability of incident $= 2\times10^{-8}$ time/year/foot$\times \frac{3{,}280.84 \text{ foot}}{1 \text{ kilometer}} \times$ 0.163 kilometer

$= 1.07\times10^{-5}$ time/year

In the case of rupture (428-meter-long pipeline)

Probability of incident = 2×10^{-8} time/year/foot $\times \frac{3,280.84 \text{ foot}}{1 \text{ kilometer}} \times$ 0.428 kilometer

= 2.81×10^{-5} time/year

- **the pipelines of 12 inches in diameter, 40 meters in length, connected from the flow meter to the gas turbine**

In the case of release hole of 1 inch

Probability of incident = 3×10^{-7} time/year/foot $\times \frac{3,280.84 \text{ foot}}{1 \text{ kilometer}} \times$ 0.040 kilometer

= 3.94×10^{-5} time/year

In the case of rupture (428-meter-long pipeline)

Probability of incident = 2×10^{-8} time/year/foot $\times \frac{3,280.84 \text{ foot}}{1 \text{ kilometer}} \times$ 0.040 kilometer

= 2.62×10^{-6} time/year

In addition, with reference to the record of leakage of natural gas transmission pipeline system in Thailand, 1,940 kilometers long in total for land-based pipeline, in 35 years (PTT Plc., 2016), the frequency of incidents incurred is 12 times / (35 years x 1,940 kilometers), which equals 1.77×10^{-4} time/year/kilometer (or equivalent to 5.39×10^{-8} time/year/foot). When this is used in assessing the probability of incident which can occur to the natural gas transmission pipeline in the project, the results are as shown in **Table 5.5.6-10**. When the PTT's record of leakage of natural gas transmission pipeline of every size in 35 years is put in comparison with the statistics on probability of incident as collected by API, the probability is lower. As API is an organization internationally recognized for its reliable sources of data on petroleum transportation, its data on accidental release probability are referred to for the worst case possible in the project's risk assessment.

(a.2) Diesel transmission pipeline

- **The pipeline connected from the area of the diesel storage tank to the electricity generation units - 12 inches in diameter, 104 meters in length**

In the case of release hole of 1 inch

Probability of incident = 3×10^{-7} time/year/foot $\times \frac{3,280.84 \text{ foot}}{1 \text{ kilometer}} \times$ 0.104 kilometer

= 1.02×10^{-4} time/year

TABLE 5.5.6-10
COMPARISON BETWEEN PTT PLC.'S RECORD OF LEAKAGE OF NATURAL GAS TRANSMISSION PIPELINE IN 35 YEARS AND THE ASSESSED PROBABILITY OF ACCIDENTAL RELEASE FROM THE NATURAL GAS TRANSMISSION PIPELINE WITH REFERENCE TO API'S DATA

Release hole size	Frequency of accidental release from natural gas transmission pipeline (time/year/kilometer)		Assessed probability of accidental release from the project's natural gas transmission pipeline (time/year); based on the length of the project's piping of varying sizes	
	API[1/]	PTT[2/]	API	PTT
pipeline of 18 inches in diameter, 125 meters in length				
1 inch	9.84×10^{-4}	$1.77X10^{-4}$	8.20×10^{-5}	$2.21X10^{-5}$
rupture	6.56×10^{-5}	-	4.10×10^{-6}	-
pipeline of 18 inches in diameter, 147 meters in length				
1 inch	9.84×10^{-4}	$1.77X10^{-4}$	9.65×10^{-5}	$2.60\ X10^{-5}$
Rupture	6.56×10^{-5}	-	4.82×10^{-6}	-
pipeline of 18 inches in diameter, 359 meters in length				
1 inch	9.84×10^{-4}	$1.77X10^{-4}$	2.36×10^{-4}	$6.35\ X10^{-5}$
Rupture	6.56×10^{-5}	-	1.18×10^{-5}	-
pipeline of 12 inches in diameter, 165 meters in length				
1 inch	9.84×10^{-4}	$1.77X10^{-4}$	1.62×10^{-4}	$2.92\ X10^{-5}$
rupture	6.56×10^{-5}	-	1.08×10^{-5}	-
pipeline of 12 inches in diameter, 253 meters in length				
1 inch	9.84×10^{-4}	$1.77X10^{-4}$	2.49×10^{-4}	$4.48\ X10^{-5}$
rupture	6.56×10^{-5}	-	3.43×10^{-5}	-
pipeline of 12 inches in diameter, 163 meters in length				
1 inch	9.84×10^{-4}	$1.77X10^{-4}$	1.60×10^{-4}	$2.89\ X10^{-5}$
ท่อแตก	6.56×10^{-5}	-	1.07×10^{-5}	-
pipeline of 12 inches in diameter, 428 meters in length				
1 inch	9.84×10^{-4}	$1.77X10^{-4}$	4.21×10^{-4}	$7.58\ X10^{-5}$
rupture	6.56×10^{-5}	-	2.81×10^{-5}	-
pipeline of 12 inches in diameter, 40 meters in length				
1 inch	9.84×10^{-4}	$1.77X10^{-4}$	3.94×10^{-5}	$7.08\ X10^{-5}$
rupture	6.56×10^{-5}	-	2.62×10^{-6}	-

Remark : [1/] probability of accidental release from natural gas transmission pipeline of different sizes according to API's data (as shown in **Table 5.21.20**)

[2/] probability of accidental release from natural gas transmission pipeline of different sizes under PTT Plc.'s operation (according to PTT's data, there has been no accidental release from a rupture)

In the case of rupture

Probability of incident = 2×10^{-8} time/year/foot $\times \frac{3,280.84 \text{ foot}}{1 \text{ kilometer}} \times 0.104$ kilometer

= 6.82×10^{-6} time/year

- **The pipeline connected from the fuel oil transfer pump to the relay point and then to each individual gas turbine, 12 inches in diameter, 78 meters in length**

In the case of release hole of 1 inch

Probability of incident = 3×10^{-7} time/year/foot $\times \frac{3,280.84 \text{ foot}}{1 \text{ kilometer}} \times 0.078$ kilometer

= 7.68×10^{-5} time/year

In the case of rupture

Probability of incident = 2×10^{-8} time/year/foot $\times \frac{3,280.84 \text{ foot}}{1 \text{ kilometer}} \times 0.078$ kilometer

= 5.12×10^{-6} time/year

- **The diesel transmission pipeline of 10 inches in diameter and 128 inches in length**

In the case of release hole of 1 inch

Probability of incident = 3×10^{-7} time/year/foot $\times \frac{3,280.84 \text{ foot}}{1 \text{ kilometer}} \times 0.128$ kilometer

= 1.26×10^{-4} time/year

In the case of rupture

Probability of incident = 2×10^{-8} time/year/foot $\times \frac{3,280.84 \text{ foot}}{1 \text{ kilometer}} \times 0.128$ kilometer

= 8.40×10^{-6} time/year

- **The diesel transmission pipeline of 8 inches in diameter and 114 inches in length**

In the case of release hole of 1 inch

Probability of incident = 3×10^{-7} time/year/foot $\times \frac{3,280.84 \text{ foot}}{1 \text{ kilometer}} \times 0.114$ kilometer

= 1.12×10^{-4} time/year

In the case of rupture

Probability of incident = 2×10^{-8} time/year/foot $\times \dfrac{3{,}280.84 \text{ foot}}{1 \text{ kilometer}} \times$ 0.114 kilometer

= 7.48×10^{-6} time/year

- **The diesel transmission pipeline of 6 inches in diameter and 129, 175, 169, and 257 inches in length**

In the case of release hole of 1 inch (129-meter-long pipeline)

Probability of incident = 4×10^{-7} time/year/foot $\times \dfrac{3{,}280.84 \text{ foot}}{1 \text{ kilometer}} \times$ 0.129 kilometer

= 1.69×10^{-4} time/year

In the case of release hole of 1 inch (175-meter-long pipeline)

Probability of incident = 4×10^{-7} time/year/foot $\times \dfrac{3{,}280.84 \text{ foot}}{1 \text{ kilometer}} \times$ 0.175 kilometer

= 2.30×10^{-4} time/year

In the case of release hole of 1 inch (169-meter-long pipeline)

Probability of incident = 4×10^{-7} time/year/foot $\times \dfrac{3{,}280.84 \text{ foot}}{1 \text{ kilometer}} \times$ 0.169 kilometer

= 2.22×10^{-4} time/year

In the case of release hole of 1 inch (257-meter-long pipeline)

Probability of incident = 4×10^{-7} time/year/foot $\times \dfrac{3{,}280.84 \text{ foot}}{1 \text{ kilometer}} \times$ 0.257 kilometer

= 3.37×10^{-4} time/year

In the case of rupture (129-meter-long pipeline)

Probability of incident = 8×10^{-8} time/year/foot $\times \dfrac{3{,}280.84 \text{ foot}}{1 \text{ kilometer}} \times$ 0.129 kilometer

= 3.39×10^{-5} time/year

In the case of rupture (175-meter-long pipeline)

Probability of incident = 8×10^{-8} time/year/foot $\times \dfrac{3{,}280.84 \text{ foot}}{1 \text{ kilometer}} \times$ 0.175 kilometer

= 4.59×10^{-5} time/year

In the case of rupture (169-meter-long pipeline)

Probability of incident $= 8\times10^{-8}$ time/year/foot$\times \dfrac{3{,}280.84 \text{ foot}}{1 \text{ kilometer}} \times 0.169$ kilometer

$= 4.44\times10^{-5}$ time/year

In the case of rupture (257-meter-long pipeline)

Probability of incident $= 8\times10^{-8}$ time/year/foot$\times \dfrac{3{,}280.84 \text{ foot}}{1 \text{ kilometer}} \times 0.257$ kilometer

$= 6.75\times10^{-5}$ time/year

- **The diesel transmission pipeline of 5 inches in diameter and 45 inches in length**

In the case of release hole of 1 inch

Probability of incident $= 4\times10^{-7}$ time/year/foot $\times \dfrac{3{,}280.84 \text{ foot}}{1 \text{ kilometer}} \times 0.045$ kilometer

$= 5.91\times10^{-5}$ time/year

In the case of rupture

Probability of incident $= 8\times10^{-8}$ time/year/foot$\times \dfrac{3{,}280.84 \text{ foot}}{1 \text{ kilometer}} \times 0.045$ kilometer

$= 1.18\times10^{-5}$ time/year

In addition, with reference to the record of accidental release of oil transportation pipeline system in Thailand from 1994 to December 2015 (22 years), approximately 429 kilometers long in total (the pipeline under the administration of Thai Petroleum Pipeline Co., Ltd. is about 360 kilometers long in total and that of Fuel Pipeline Transportation Co., Ltd. is about 69 kilometers long in total), one incident occurred under the administration of Thai Petroleum Pipeline Co., Ltd. involving a release hole of approximately 3-4 millimeters in diameter. The probability of incident is thus equal to $1.06X10^{-4}$ time/year/kilometer. Moreover, in assessing the robability of incident which can occur to the oil transportation pipeline in the project, the statistics on probability of incident as posited by API, an organization internationally recognized for its reliable sources of data on petroleum transportation, is put into comparison; revealing that Thai Petroleum Pipeline Co., Ltd.'s probability of incident during the period of 22 years is lower (as shown in **Table 5.5.6-11**). Therefore, API's data on accidental release probability are referred to for the worst case possible in the project's risk assessment.

TABLE 5.5.6-11

COMPARISON BETWEEN THAI PETROLEUM PIPELINE CO., LTD.'S RECORD OF LEAKAGE OF OIL TRANSMISSION PIPELINE IN 22 YEARS AND THE ASSESSED PROBABILITY OF ACCIDENTAL RELEASE FROM THE OIL TRANSMISSION PIPELINE WITH REFERENCE TO API'S DATA

Release hole size	Frequency of accidental release from oil transmission pipeline (time/year/kilometer)		Assessed probability of accidental release from the project's oil transmission pipeline (time/year); based on the length of the project's piping of varying sizes	
	API[1/]	Thai Petroleum Pipeline Co., Ltd.[2/]	API	Thai Petroleum Pipeline Co., Ltd.
Pipeline of 12 inches in diameter, 104 meters in length				
1 inch	9.84×10^{-4}	-	1.02×10^{-4}	-
rupture	6.56×10^{-5}	-	6.82×10^{-6}	-
Pipeline of 12 inches in diameter, 78 meters in length				
1 inch	9.84×10^{-4}	-	7.68×10^{-5}	-
rupture	6.56×10^{-5}	-	5.12×10^{-6}	-
Pipeline of 10 inches in diameter, 128 meters in length				
1 inch	9.84×10^{-4}	-	1.26×10^{-4}	-
Rupture	6.56×10^{-5}	-	8.40×10^{-6}	-
Pipeline of 8 inches in diameter, 114 meters in length				
1 inch	9.84×10^{-4}	-	1.12×10^{-4}	-
Rupture	6.56×10^{-5}	-	7.48×10^{-6}	-
Pipeline of 6 inches in diameter, 129 meters in length				
1 inch	9.84×10^{-4}	-	1.69×10^{-4}	-
rupture	6.56×10^{-5}	-	3.39×10^{-5}	-
Pipeline of 6 inches in diameter, 175 meters in length				
1 inch	9.84×10^{-4}	-	2.30×10^{-4}	-
rupture	6.56×10^{-5}	-	4.59×10^{-5}	-
Pipeline of 6 inches in diameter, 169 meters in length				
1 inch	9.84×10^{-4}	-	2.22×10^{-4}	-
rupture	6.56×10^{-5}	-	4.44×10^{-5}	-
Pipeline of 6 inches in diameter, 257 meters in length				
1 inch	9.84×10^{-4}	-	3.37×10^{-4}	-
rupture	6.56×10^{-5}	-	6.75×10^{-5}	-
Pipeline of 5 inches in diameter, 45 meters in length				
1 inch	9.84×10^{-4}	-	5.91×10^{-5}	-
rupture	6.56×10^{-5}	-	1.18×10^{-5}	-

Remark : [1/] probability of accidental release from oil transmission pipeline of different sizes according to API's data

[2/] probability of accidental release from oil transmission pipeline of different sizes under Thai Petroleum Pipeline Co., Ltd.'s operation (According to Thai Petroleum Pipeline Co., Ltd.'s data, there has been no accidental release from a release hole of 1 inch nor a rupture. However, there was an accidental release from a release hole of about 3-4 millimeters and the probability of accidental release is 1.06×10^{-4} time/year/kilometer)

(a.3) Diesel storage tank

In the case of release hole of 1 inch

Assessment in the case there is a release hole of 1 inch at the atmospheric storage tank, the probability of incident = 1×10^{-4} time/year

In the case of rupture

Assessment in the case there is rupture in the area of the flange or pipe fitting, with the size of the puncture assessed in regard to the size of the largest pipe fitting, i.e. 12 inches, probability of incident = 2×10^{-5} time/year

Concerning accidental release probability of the storage tank with reference to API's data, as shown in **Table 5.5.6-10**, in the case of the release hole of 1 inch, the probability of incident is $1X10^{-4}$ time/year. In the case of rupture, the probability of incident is $7X10^{-8}$ time/year. As there are no statistical data on accidental release from the storage tank in Thailand available, the accidental release probability of the storage tank is assessed with reference to API's data thereon.

(b) Probability of natural gas/diesel ignition

According to Risk Based Inspection, Base Resource Documents; API Publication 581 (2000), the probability of incident caused by either instantaneous or continuous accidental release of substances in the form of gas (natural gas) and liquid (diesel), and probability of different incidents incurred in the condition below the auto-ignition temperature are as shown in **Table 5.5.6-12** and **Table 5.5.6-13**.

TABLE 5.5.6-12

PROBABILITY OF INCIDENT CAUSED BY ACCIDENTAL RELEASE OF SUBSTANCES IN THE FORM OF GAS (C1-C2) IN DIFFERENT CASES

Manner of release	Probability of incident		Probability of accidental release and ignition				
	No Ignition	Ignition	Vapor Cloud Explosion (VCE)	Fireball	Flash Fire	Jet Fire	Pool Fire
instantaneous release	0.8	0.2	0.04	0.01	0.15	-	-
continuous release	0.8	0.2	0.04	-	0.06	0.1	-

Source : Risk Based Inspection, Base Resource Documents; API Publication 581, 2000

TABLE 5.5.6-13

PROBABILITY OF INCIDENT CAUSED BY ACCIDENTAL RELEASE OF SUBSTANCES IN THE FORM OF LIQUID (C9-C16) IN DIFFERENT CASES

Manner of release	Probability of incident		Probability of accidental release and ignition				
	No Ignition	Ignition	Vapor Cloud Explosion (VCE)	Fireball	Flash Fire	Jet Fire	Pool Fire
instantaneous release	0.95	0.05	-	-	-	-	0.05
continuous release	0.95	0.05	-	-	-	0.01	0.04

Source : API, API Publication 581, first edition, May 2000.

In the case of accidental release of natural gas, instantaneous or continuous, the probability that the gas can combust is 0.2 or 20%. In other words, if accidental release of natural gas occurs 100 times, the probability that the gas can combust is 20 times. The natures of combustion probability can be categorized as follows:

- Probability of ignition in the form of fireballs: can occur in the case of instantaneous release of natural gas in large quantity, which leads to combustion and starts fire in the form of fireballs. The probability is 0.01 or 1% of the total incidents of accidental release.
- Probability of ignition in the form of flash fire: can occur in the case of both instantaneous and continuous accidental release. The probability is 0.15 and 0.06 respectively or 15% and 6%, respectively of the total incidents of accidental release.
- Probability of ignition in the form of jet fire: can occur only in the case that there are instantaneous release of natural gas and consequent combustion. The pressure from the gas inside the pipeline causes flame to spurt from the release hole. The probability is 0.1 or 10% of the total incidents of accidental release.
- Probability of ignition in the form of vapor cloud explosion: can occur in the case of both instantaneous and continuous accidental release. The probability is 0.04 or 4% of the total incidents of accidental release.

In the case of accidental release of diesel, instantaneous or continuous, the probability that the diesel can combust is 0.05 or 5%. In other words, if accidental release of diesel occurs 100 times, the probability that the diesel can combust is 5 times. The natures of fire probability can be categorized as follows:

- Probability of ignition in the form of jet fire : can occur only in the case that there are instantaneous release of diesel and consequent combustion. The pressure from the vapor inside the pipeline causes flame to spurt from the release hole. The probability is 0.01 or 1% of the total incidents of accidental release.

- Probability of ignition in the form of pool fire: can occur in the case of both instantaneous and continuous accidental release. The probability is 0.05 and 0.04, respectively or 5% and 4% respectively of the total incidents of accidental release.

(c) Probability of accidental release and ignition of natural gas/diesel

(c.1) Natural gas transmission pipeline

For the nature of accidental release from gas transmission pipeline system, with reference to **Table 5.5.6-12**, the probability of harm caused to property and life resulting from consequent natural gas combustion is of three different ignition forms – jet fire, fireballs, and VCE. There is probability of accidental release and all aforementioned forms of ignition occurring to the project's natural gas transmission pipeline, both that of 12 inches and 18 inches in diameter. This mostly involves release holes of small size (1 inch), and continuous mode of accidental release. The ignition likely to occur most is in the form of jet fire. The probability is 0.10 or 10% of the total incidents of accidental release. With reference to the levels of likelihood of major hazards set in line with U.S.EPA's guidelines (1990), the details of which are shown in **Table 5.5.6-15**; the project's likelihood of major hazards is at the level of 'Very Unlikely', as shown in **Table 5.5.6-14**.

However, natural gas, which is lighter than air, can disperse relatively well when compared to other types of gas if accidentally released. Moreover, the probability of natural gas accumulation to the flammable limits and explosion limits are very low. In comparison, LPG, for example, is less safe, because it is heavier than air and its dispersion is thus dense and low above the surface, as shown in **Figure 5.5.6-4**. In this way, probability of accidental release and ignition in the forms of fireballs, and VCE is highly unlikely.

TABLE 5.5.6-14
LEVELS OF LIKELIHOOD OF MAJOR HAZARDS ASSOCIATED WITH THE PROJECT'S NATURAL GAS TRANSMISSION PIPELINE FAILURES

Release hole size	Probability of accidental release (time/year)	Probability of ignition (time/year)	Levels of likelihood of major hazards
		Jet Fire	Jet Fire
1. The pipeline connected from the gas metering station to the gas compressor : 18 inches in diameter, 125 meters in length			
– release hole size of 1 inch	8.20×10^{-5}	8.20×10^{-6}	Very Unlikely
– release hole size of 18 inches (rupture)	4.10×10^{-6}	4.10×10^{-7}	Very Unlikely
2. The pipeline connected from the gas compressors to the branch point, from which gas is further relayed through the pipeline of 12 inches in diameter : 18 inches in diameter, 147 meters in length			
– release hole size of 1 inch	9.65×10^{-5}	9.65×10^{-6}	Very Unlikely
– release hole size of 18 inches (rupture)	4.82×10^{-6}	4.82×10^{-7}	Very Unlikely
3. The pipeline connected from the gas compressors to the branch point, from which gas is further relayed through the pipeline of 12 inches in diameter : 18 inches in diameter, 359 meters in length			
– release hole size of 1 inch	2.36×10^{-4}	2.36×10^{-5}	Very Unlikely
– release hole size of 18 inches (rupture)	1.18×10^{-5}	1.18×10^{-6}	Very Unlikely
4. The pipeline connected from the branch point, where the pipeline of 18 inches in diameter is connected to the flow meter : 12 inches in diameter, 165 meters in length			
– release hole size of 1 inch	1.62×10^{-4}	1.62×10^{-5}	Very Unlikely
– release hole size of 12 inches (rupture)	1.08×10^{-5}	1.08×10^{-6}	Very Unlikely
5. The pipeline connected from the branch point, where the pipeline of 18 inches in diameter are connected to the flow meter : 12 inches in diameter, 253 meters in length			
– release hole size of 1 inch	2.49×10^{-4}	2.49×10^{-5}	Very Unlikely
– release hole size of 12 inches (rupture)	3.43×10^{-5}	3.43×10^{-6}	Very Unlikely
6. The pipeline connected from the branch point, where the pipeline of 18 inches in diameter is connected to the flow meter : 12 inches in diameter, 163 meters in length			
– release hole size of 1 inch	1.60×10^{-4}	1.60×10^{-5}	Very Unlikely
– release hole size of 12 inches (rupture)	1.07×10^{-5}	1.07×10^{-6}	Very Unlikely
7. The pipeline connected from the branch point, where the pipeline of 18 inches in diameter is connected to the flow meter : 12 inches in diameter, 428 meters in length			
– release hole size of 1 inch	4.21×10^{-4}	4.21×10^{-5}	Very Unlikely
– release hole size of 12 inches (rupture)	2.81×10^{-5}	2.81×10^{-6}	Very Unlikely
8. The pipeline connected from the flow meter to the gas turbine : 12 inches in diameter, 40 meters in length			
– release hole size of 1 inch	3.94×10^{-5}	3.94×10^{-6}	Very Unlikely
– release hole size of 12 inches (rupture)	2.62×10^{-6}	2.62×10^{-7}	Very Unlikely

Source : Risk Based Inspection, Base Resource Documents; API Publication 581, 2000

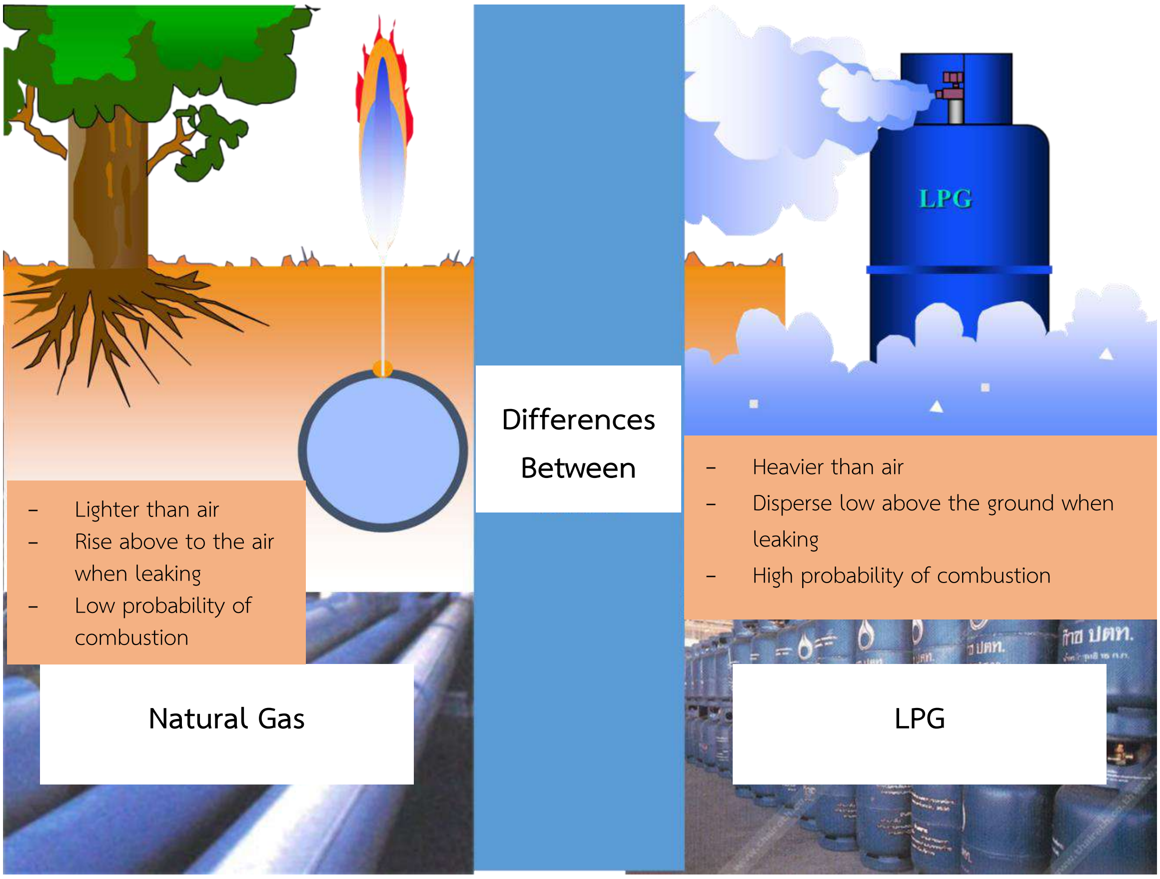


FIGURE 5.5.6-4 : EXAMPLE OF DIFFERENCES BETWEEN LEAKING NATURAL GAS AND LEAKING LIQUEFIED PETROLEUM GAS

In this study; therefore, only impacts resulting from natural gas accidental release and ignition, which can inflict harm to property and lives, in the form of jet fire, the probability of which is the highest; are investigated.

(c.2) Diesel transportation pipeline and diesel storage tank

- Diesel transportation pipeline

For the nature of accidental release from the diesel transportation pipeline, with reference to **Table 5.5.6-14**, the probability of harm caused to property and life resulting from consequent combustion is of two different ignition forms – jet fire, and pool fire. For the boiling temperature of diesel is between 180-340 degree Celsius; as a result, there is no probability of ignition in the form of jet fire. As the accidental release of diesel is of continuous nature, there is probability of ignition in the form of pool fire, which is equal to 0.04 or 4%. Moreover, sustained accidental release from the diesel transportation pipeline can cause ignition in the form of fireball and VCE. In this study; therefore, impacts resulting from diesel accidental release and subsequent combustion, which can inflict harm to property and life; in the form of pool fire, fireballs, and VCE are investigated. With reference to the levels of likelihood of major hazards set in line with U.S.EPA's guidelines (1990), the details of which are shown in **Table 5.5.6-16**; the project's likelihood of severe hazards is at the level of 'Very Unlikely', as shown in **Table 5.5.6-16**.

TABLE 5.5.6-16

LEVELS OF LIKELIHOOD OF MAJOR HAZARDS ASSOCIATED WITH THE PROJECT'S DIESEL TRANSMISSION PIPELINE FAILURES

Release hole size	Probability of accidental release (time/year)	Probability of ignition (time/year)			Levels of likelihood of major hazards		
		Pool Fire	Fireball	VCE	Pool Fire	Fireball	VCE
1. The pipeline connected from the diesel storage tank to the electricity generation unit : 12 inches in diameter, 104 meters in length							
– Release hole size of 1 inch	1.02×10^{-4}	4.08×10^{-6}	1.02×10^{-4}	1.02×10^{-4}	Very Unlikely	Very Unlikely	Very Unlikely
– Release hole size of 12 inches (rupture)	6.82×10^{-6}	2.73×10^{-7}	6.82×10^{-6}	6.82×10^{-6}	Very Unlikely	Very Unlikely	Very Unlikely
2. The pipeline connected from the fuel oil transfer pump through the branch point to each gas turbine : 12 inches in diameter, 78 meters in length							
– Release hole size of 1 inch	7.68×10^{-5}	3.07×10^{-6}	7.68×10^{-5}	7.68×10^{-5}	Very Unlikely	Very Unlikely	Very Unlikely
– Release hole size of 12 inches (rupture)	5.12×10^{-6}	2.05×10^{-7}	5.12×10^{-6}	5.12×10^{-6}	Very Unlikely	Very Unlikely	Very Unlikely
3. The diesel transmission pipeline of 10 inches in diameter, 128 meters in length							
– Release hole size of 1 inch	1.26×10^{-4}	5.04×10^{-6}	1.26×10^{-4}	1.26×10^{-4}	Very Unlikely	Very Unlikely	Very Unlikely
– Release hole size of 10 inches (rupture)	8.40×10^{-6}	3.36×10^{-7}	8.40×10^{-6}	8.40×10^{-6}	Very Unlikely	Very Unlikely	Very Unlikely
4. ธhe diesel transmission pipeline of 8 inches in diameter , 114 meters in length							
– Release hole size of 1 inch	1.12×10^{-4}	4.48×10^{-6}	1.12×10^{-4}	1.12×10^{-4}	Very Unlikely	Very Unlikely	Very Unlikely
– Release hole size of 8 inches (rupture)	7.48×10^{-6}	2.99×10^{-7}	7.48×10^{-6}	7.48×10^{-6}	Very Unlikely	Very Unlikely	Very Unlikely
5. The diesel transmission pipeline of 6 inches in diameter, 129 meters in length							
– Release hole size of 1 inch	1.69×10^{-4}	6.76×10^{-6}	1.69×10^{-4}	1.69×10^{-4}	Very Unlikely	Very Unlikely	Very Unlikely
– Release hole size of 6 inches (rupture)	3.39×10^{-5}	1.36×10^{-7}	3.39×10^{-5}	3.39×10^{-5}	Very Unlikely	Very Unlikely	Very Unlikely
6. The diesel transmission pipeline of 6 inches in diameter, 175 meters in length							
– Release hole size of 1 inch	2.30×10^{-4}	9.20×10^{-6}	2.30×10^{-4}	2.30×10^{-4}	Very Unlikely	Very Unlikely	Very Unlikely
– Release hole size of 6 inches (rupture)	4.59×10^{-5}	1.84×10^{-7}	4.59×10^{-5}	4.59×10^{-5}	Very Unlikely	Very Unlikely	Very Unlikely
7. The diesel transmission pipeline of 6 inches in diameter , 169 meters in length							
– Release hole size of 1 inch	2.22×10^{-4}	8.88×10^{-6}	2.22×10^{-4}	2.22×10^{-4}	Very Unlikely	Very Unlikely	Very Unlikely
– Release hole size of 6 inches (rupture)	4.44×10^{-5}	1.76×10^{-7}	4.44×10^{-5}	4.44×10^{-5}	Very Unlikely	Very Unlikely	Very Unlikely

TABLE 5.5.6-16

LEVELS OF LIKELIHOOD OF MAJOR HAZARDS ASSOCIATED WITH THE PROJECT’S DIESEL TRANSMISSION PIPELINE FAILURES (CONT’D)

Release hole size	Probability of accidental release (time/year)	Probability of ignition (time/year)			Levels of likelihood of major hazards		
		Pool Fire	Fireball	VCE	Pool Fire	Fireball	VCE
8. The diesel transmission pipeline of 6 inches in diameter, 257 meters in length							
– Release hole size of 1 inch	3.37×10^{-4}	1.35×10^{-5}	3.37×10^{-4}	3.37×10^{-4}	Very Unlikely	Very Unlikely	Very Unlikely
– Release hole size of 6 inches (rupture)	6.75×10^{-5}	2.70×10^{-6}	6.75×10^{-5}	6.75×10^{-5}	Very Unlikely	Very Unlikely	Very Unlikely
9. The diesel transmission pipeline of 5 inches in diameter, 45 meters in length							
– Release hole size of 1 inch	5.91×10^{-5}	2.36×10^{-6}	5.91×10^{-5}	5.91×10^{-5}	Very Unlikely	Very Unlikely	Very Unlikely
– release hole size of 5 inches (rupture)	1.18×10^{-5}	4.72×10^{-6}	1.18×10^{-5}	1.18×10^{-5}	Very Unlikely	Very Unlikely	Very Unlikely

Source : Risk Based Inspection, Base Resource Documents; API Publication 581, 2000

- **Diesel storage tank**

For the nature of accidental release from the diesel storage tank, with reference to **Table 5.5.6-14**, the probability of harm caused to property and life resulting from consequent diesel combustion is of two different ignition forms – jet fire, and pool fire. As the way diesel is stored in the project, pressurization and evaporation in the storage tank are unlikely. As the boiling temperature of diesel is between 180-340 degree Celsius, there is no probability of ignition in the form of jet fire. Also, diesel evaporates slowly and the pressure level in the oil transmission pipeline is not very high. For a jet fire to occur, the fuel must be kept at a high pressure. As the accidental release of diesel at the point connected to the storage tank is of continuous nature, there is probability of ignition in the form of pool fire, which is equal to 0.04 or 4%. In addition, sustained release of diesel at the storage tank can cause ignition in the form of fireball and VCE. In this study; therefore, impacts resulting from diesel accidental release and consequent combustion, which can inflict harm to property and life, in the form of pool fire, fireballs and VCE are investigated. With reference to the levels of likelihood of major hazards set in line with U.S.EPA's guidelines (1990), the details of which are shown in **Table 5.5.6-6**; the project's likelihood of severe hazards is at the level of 'Very Unlikely', as shown in **Table 5.5.6-17**.

TABLE 5.5.6-17

LEVELS OF LIKELIHOOD OF MAJOR HAZARDS ASSOCIATED WITH THE PROJECT'S DIESEL STORAGE TANK FAILURES

Release hole size	Probability of accidental release (time/year)	Probability of ignition (time/year)			Levels of likelihood of major hazards		
		Pool Fire	Fire ball	VCE	Pool Fire	Fire ball	VCE
Diesel storage tank							
- Release hole size of 1 inch	1×10^{-4}	4.0×10^{-6}	1×10^{-4}	1×10^{-4}	Very Unlikely	Very Unlikely	Very Unlikely
- Release hole size of 12 inches (rupture)	7×10^{-8}	2.8×10^{-9}	7×10^{-8}	7×10^{-8}	Very Unlikely	Very Unlikely	Very Unlikely

Source : Risk Based Inspection, Base Resource Documents; API Publication 581, 2000

(2.2) Results of incident severity analysis

In analyzing the level of severity and modeling the accidental release and combustion of natural gas, BREEZE HAZ mathematical model is employed. Consideration is based on the nature of the accidental release (sudden or gradual) and nature of the combustion (sudden or delayed). The findings from the case study are as follows:

(a) Natural gas transmission pipeline system / diesel transportation pipeline system

- In the case that the control system is immediately activated after the accidental release
- In the case that the control system is not immediately activated after the incident resulting in the release of the natural gas for 10 minutes. (The duration of 10 minutes is used here because the probability that a release hole of 1 inch can occur is the highest and the duration of the accidental release through the release hole of this size as postulated by API is 10 minutes.)

(b) Diesel storage tank

- In the case that the control system is immediately activated after the accidental release
- In the case that the control system is not immediately activated after the incident resulting in the release for 20 minutes. (The duration of 20 minutes is used here because the probability that a release hole of 1 inch can occur is the highest and the duration of the accidental release through the release hole of this size as postulated by API is 20 minutes.)

Based on the general condition of the accidental release as well as the probability of the consequent combustion, probability of ignition in the form of jet fire is the highest for natural gas accidental release. For diesel accidental release, probabilities of combustion in the form of pool fire and VCE are the highest. To assess the severity of the incident, the results of the calculation of the distance of thermal radiation and the pressure impact are compared with the criteria set to determine the impacts to equipment and personnel as caused by different degrees of thermal energy as well as impact from the pressure, with reference to the World Bank's guidelines stated in World Bank Technical Paper No.55 (1989) as shown in **Table 5.5.6-7**.

For the results of the assessment of different cases of hazard in the project with respect to the areas with probability of accidental release, the case study of which is as follows:

- **Natural gas transmission pipeline**

  - The radius of thermal radiation at different energy levels from the area of the pipeline connecting the MRS to the area of the gas compressor, 18 inches in diameter and 125 meters in length, in the cases of combustion in the form of jet fire through a release hole of 1 inch and a rupture. The details are shown in **Figure 5.5.6-5**.
  - The radius of thermal radiation at different energy levels from the area of the pipeline connecting the gas compressor to the area where the gas is further relayed to the 12-inch in diameter pipeline, 18 inches in diameter and 147 meters and 350 meters in length, in the cases of ignition in the form of jet fire through a release hole of 1 inch and a rupture. The details are shown in **Figure 5.5.6-6**.
  - The radius of thermal radiation at different energy levels from the area where the gas is relayed from the 18-inch in diameter pipeline to the flow meter, 12 inches in diameter and 165, 253, 163, and 428 meters in length, in the cases of ignition in the form of jet fire through a release hole of 1 inch and a rupture. The details are shown in **Figure 5.5.6-7**. (The picture exhibits the case of 428-meter-long pipeline, which is considered the worst case scenario.)
  - The radius of thermal radiation at different energy levels from the area of the pipeline connecting the flow meter to the gas turbine, 12 inches in diameter and 40 meters in length, in the cases of ignition in the form of jet fire through a release hole of 1 inch and a rupture. The details are shown in **Figure 5.5.6-8**.

- **Diesel transportation pipeline**

  - The radius of thermal radiation at different energy levels from the area of the diesel transportation pipeline of 12 inches in diameter, which is the main pipeline connected from the storage tank to the fuel oil transfer pump, 104 meters in length, in the cases of ignition in the form of fireball and VCE through a release hole of 1 inch and a rupture. The details are shown from **Figure 5.5.6-9 to Figure 5.5.6-11**.
  - The radius of thermal radiation at different energy levels from the diesel transportation pipeline of 12 inches in diameter, which is the main pipeline connected from the fuel oil transfer pump to each individual gas turbine, 78 meters in length, in the cases of combustion in the form of fireball and VCE through a release hole of 1 inch and a rupture. The details are shown from **Figure 5.5.6-12 to Figure 5.5.6-14**.
  - The radius of thermal radiation at different energy levels from the diesel transportation pipeline of 10 inches in diameter, 128 meters in length, which is connected from the aforementioned pipeline of 12 inches in diameter, then to the pipeline of 8 inches in diameter (114 meters in length), then to the pipeline of 6 inches in diameter (129, 175, 169, and 257 meters in length), and finally to the main fuel oil pump in each individual electricity generation unit; in the cases of ignition in the form of fireball and VCE through a release hole of 1 inch and a rupture. The details are shown from **Figure 5.5.6-15 to Figure 5.5.6-23.**

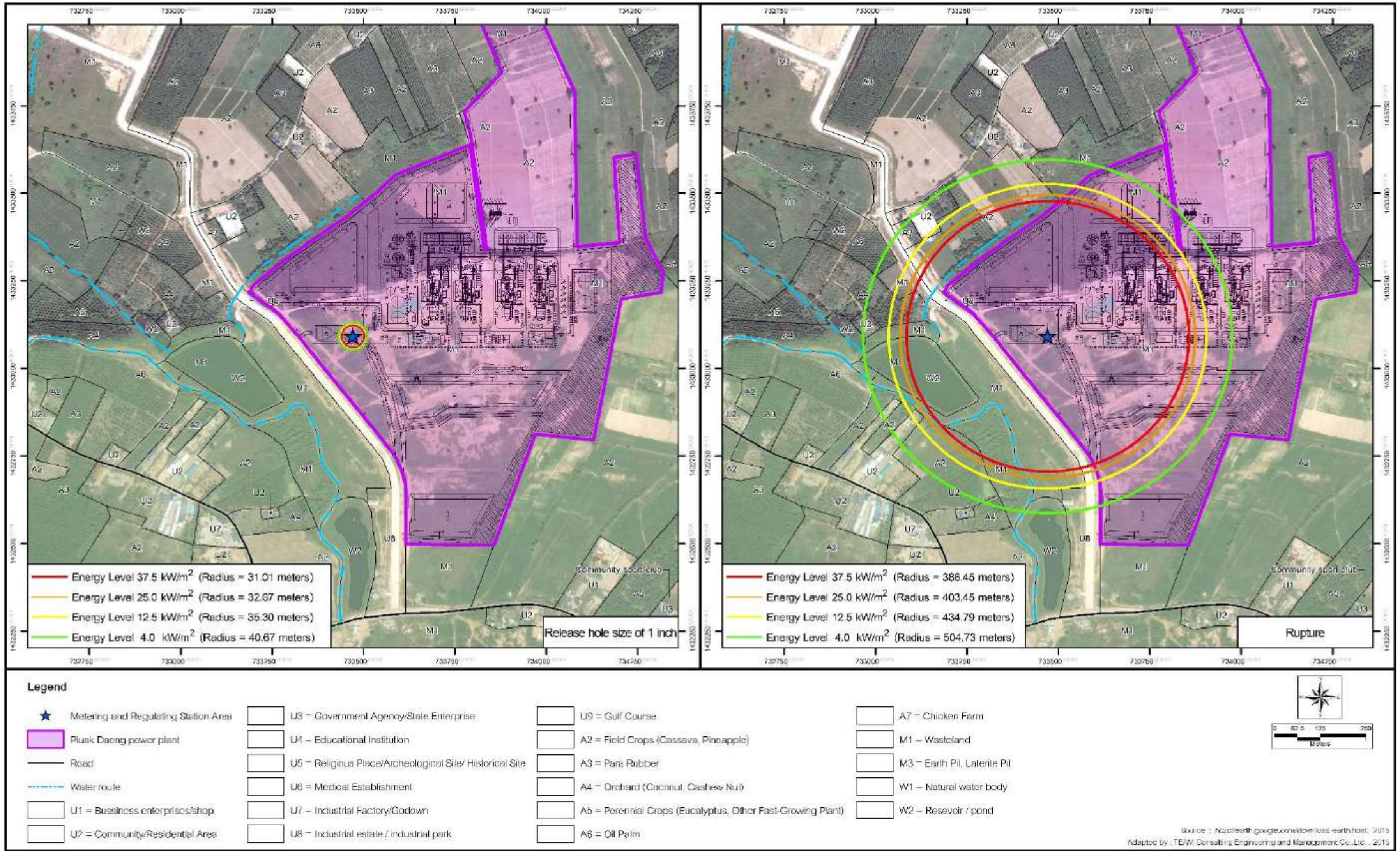


FIGURE 5.5.6-5 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN JET FIRE AROUND MRS AREA TO THE GAS COMPRESSOR

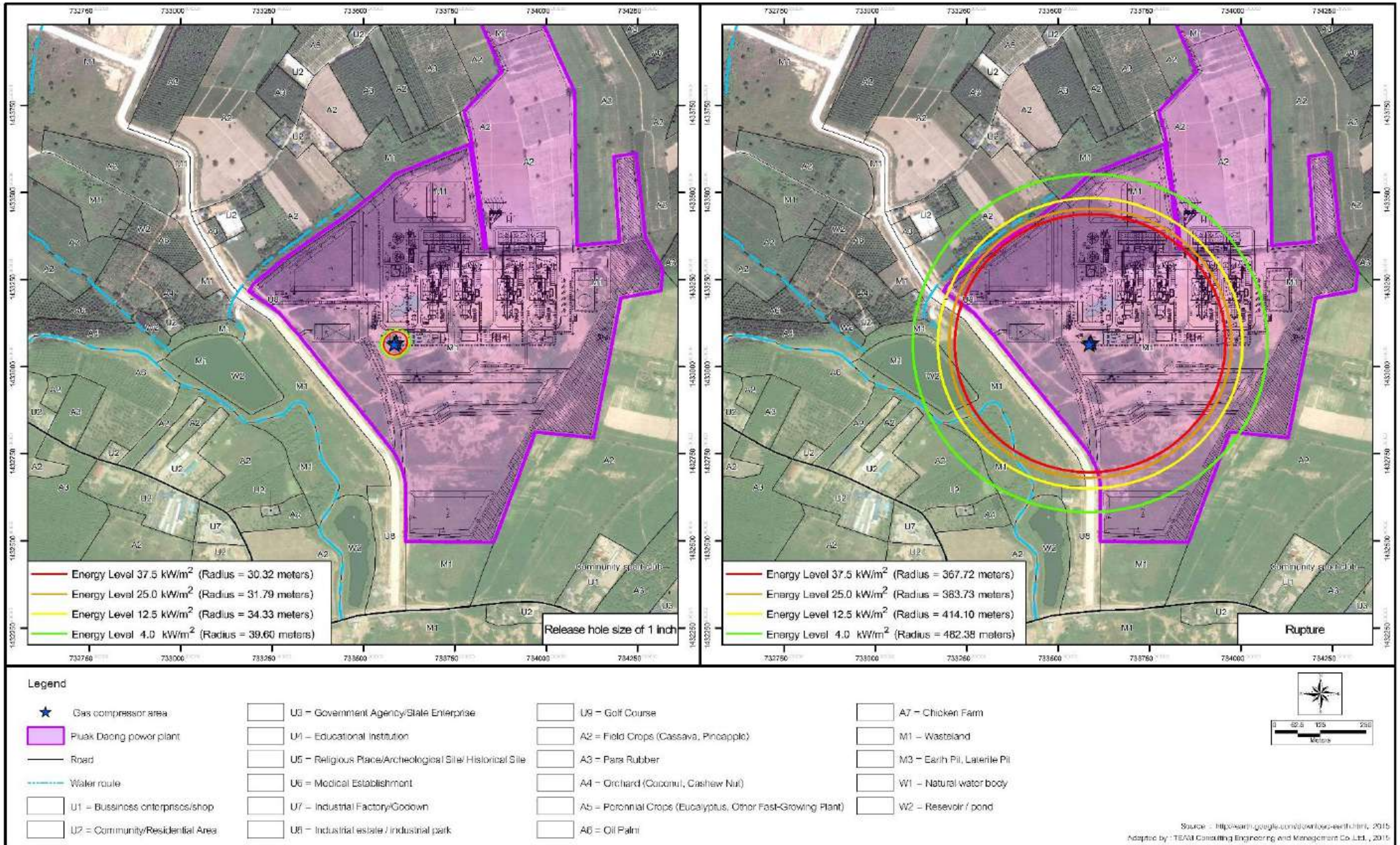


FIGURE 5.5.6-6 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN JET FIRE AROUND PIPELINE CONNECTED FROM THE GAS COMPRESSOR TO THE BRANCH POINT RELAYED THROUGH THE PIPELINE OF 12 INCHES IN DIAMETER

TEAM

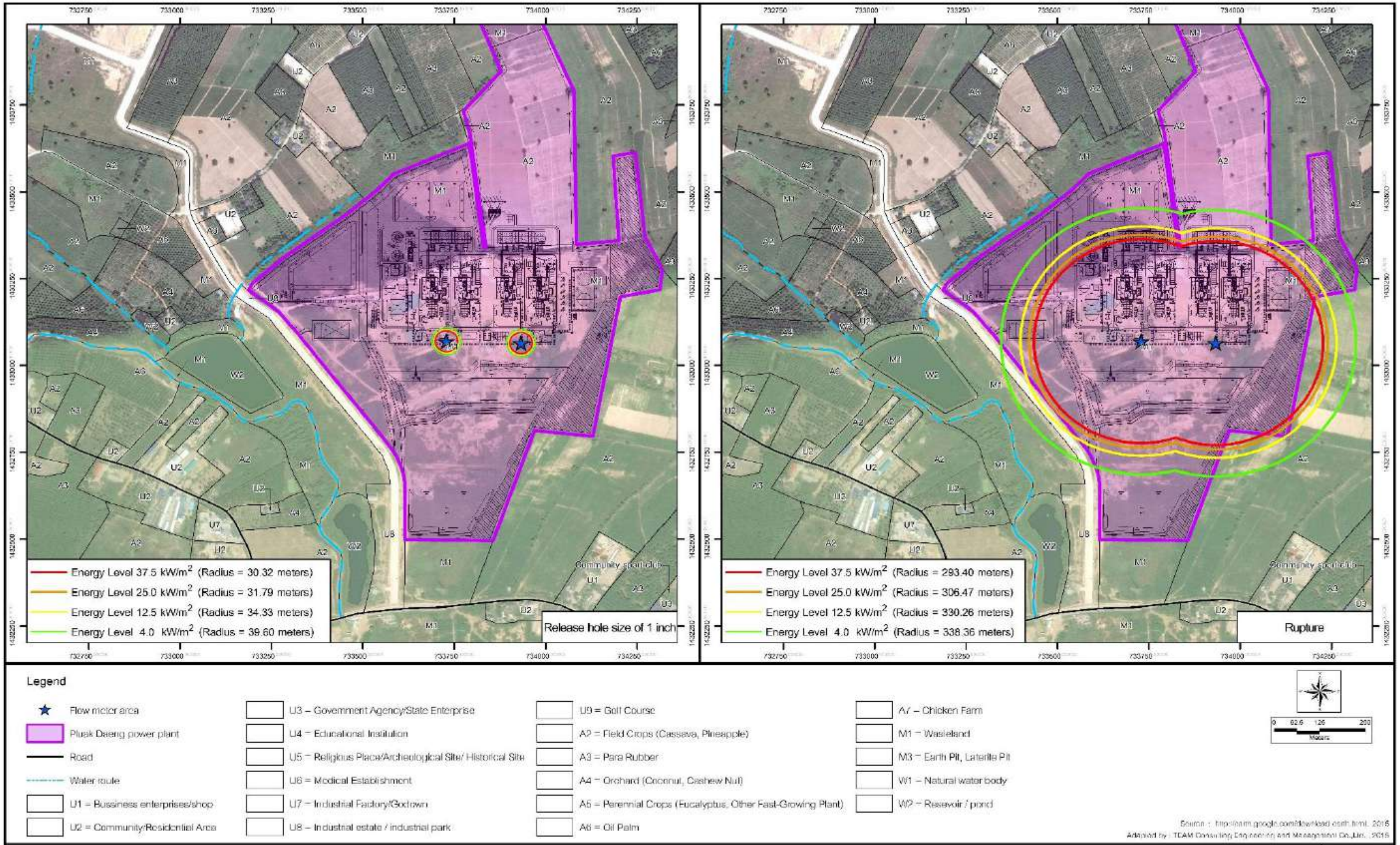


FIGURE 5.5.6-7 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN JET FIRE AROUND BRANCH POINT OF PIPELINE OF 18 INCHES IN DIAMETER TO FLOW METER OF 12 INCHES IN DIAMETER

TEAM

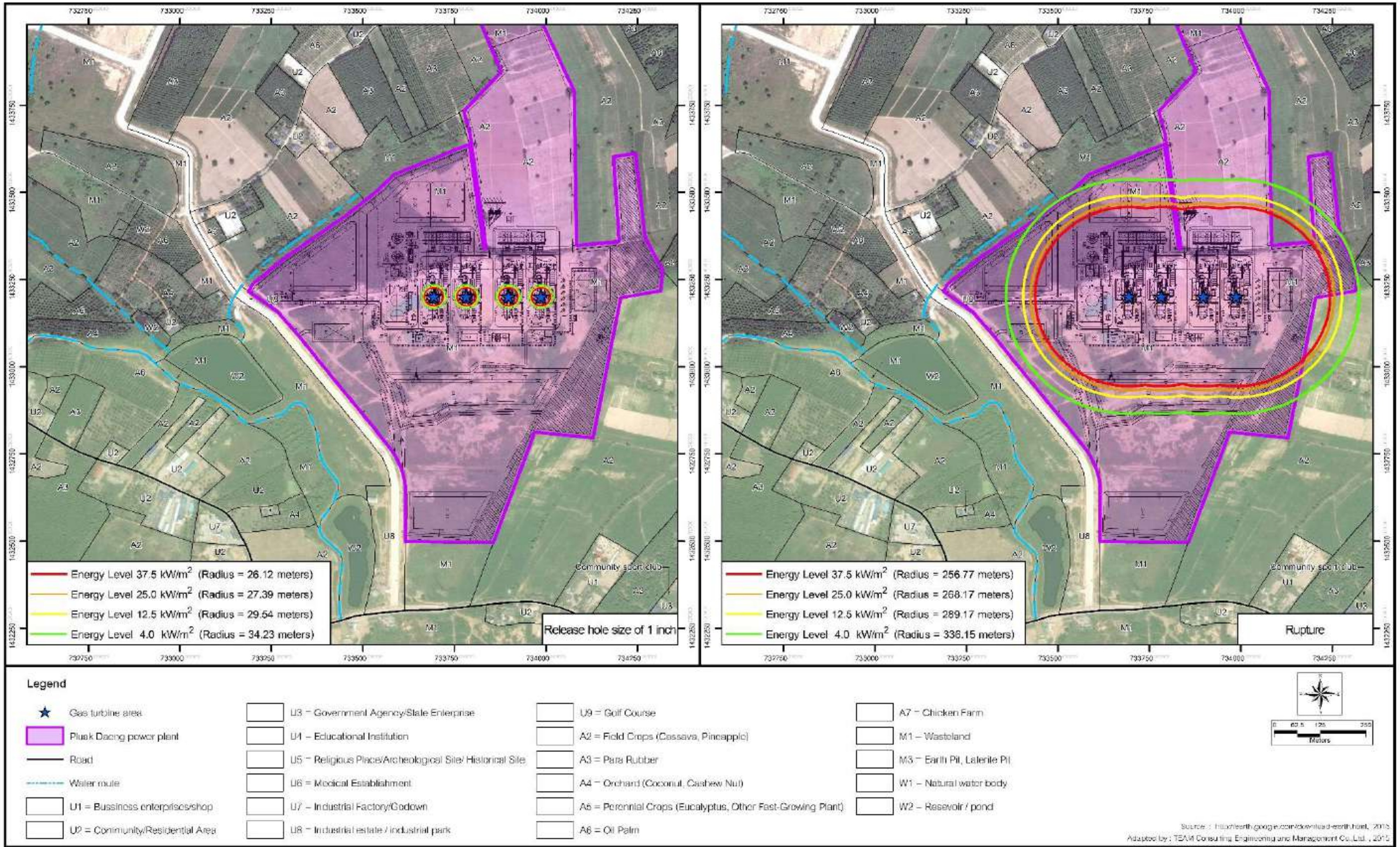


FIGURE 5.5.6-8 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN JET FIRE AROUND BRANCH POINT OF PIPELINE FROM FLOW METER TO GAS TURBINE OF 12 INCHES IN DIAMETER

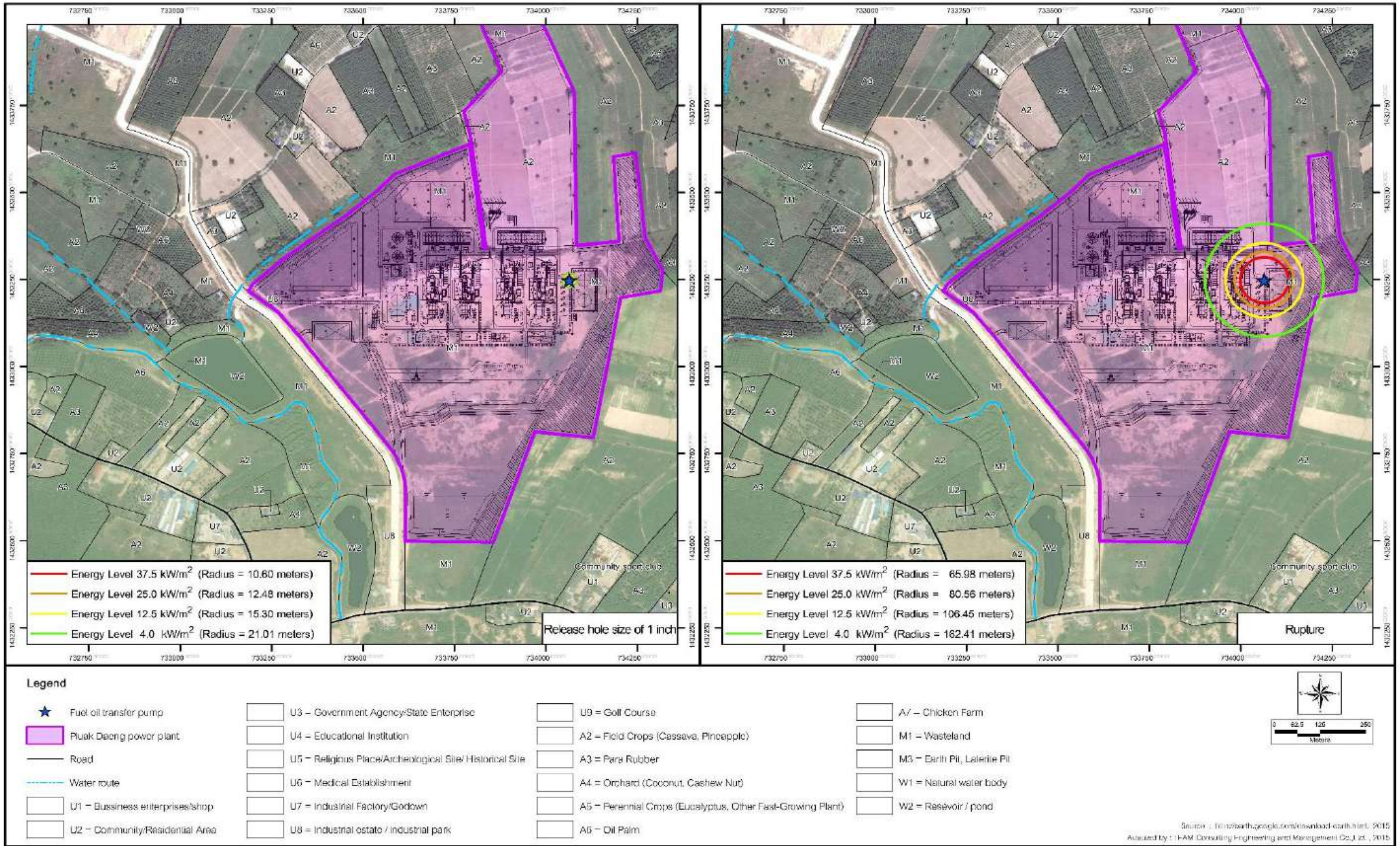


FIGURE 5.5.6-9 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN POOL FIRE AROUND DIESEL TRANSMISSION PIPELINE OF 12 INCHES IN DIAMETER FROM DIESEL STORAGE TANK

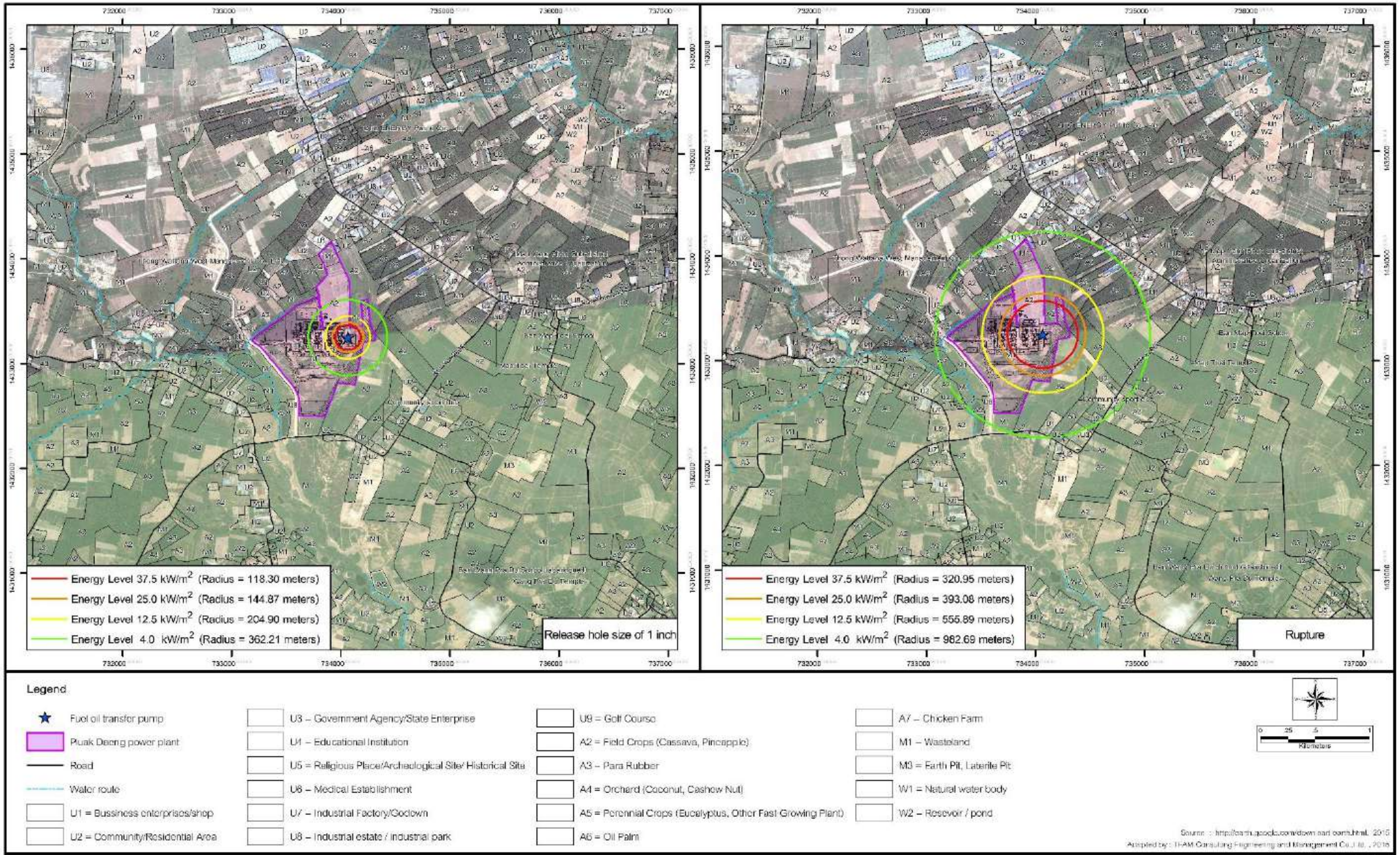


FIGURE 5.5.6-10 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN FIREBALL AROUND DIESEL TRANSMISSION PIPELINE OF 12 INCHES IN DIAMETER FROM DIESEL STORAGE TANK

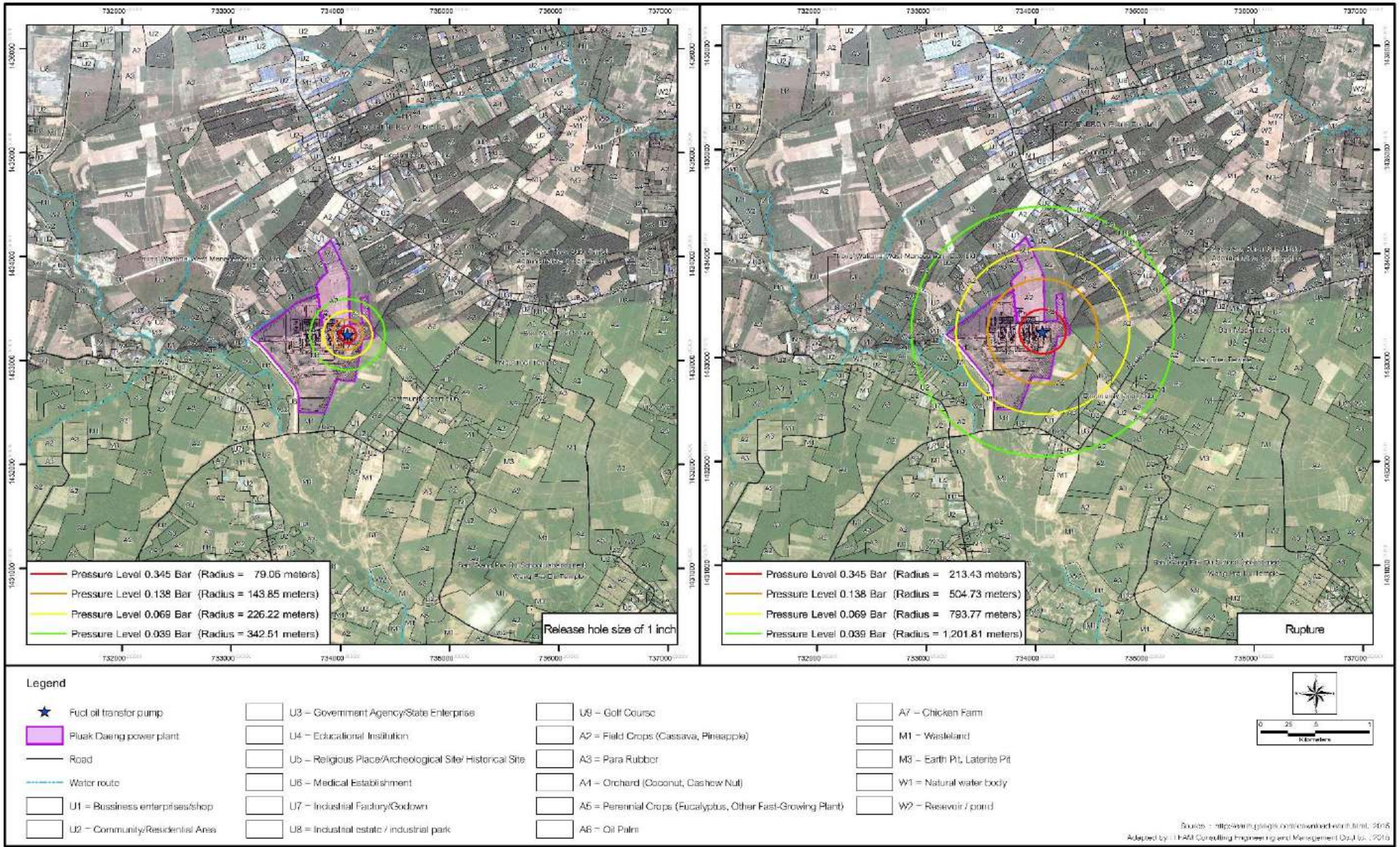


FIGURE 5.5.6-11 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN VCE AROUND DIESEL TRANSMISSION PIPELINE OF 12 INCHES IN DIAMETER FROM DIESEL STORAGE TANK

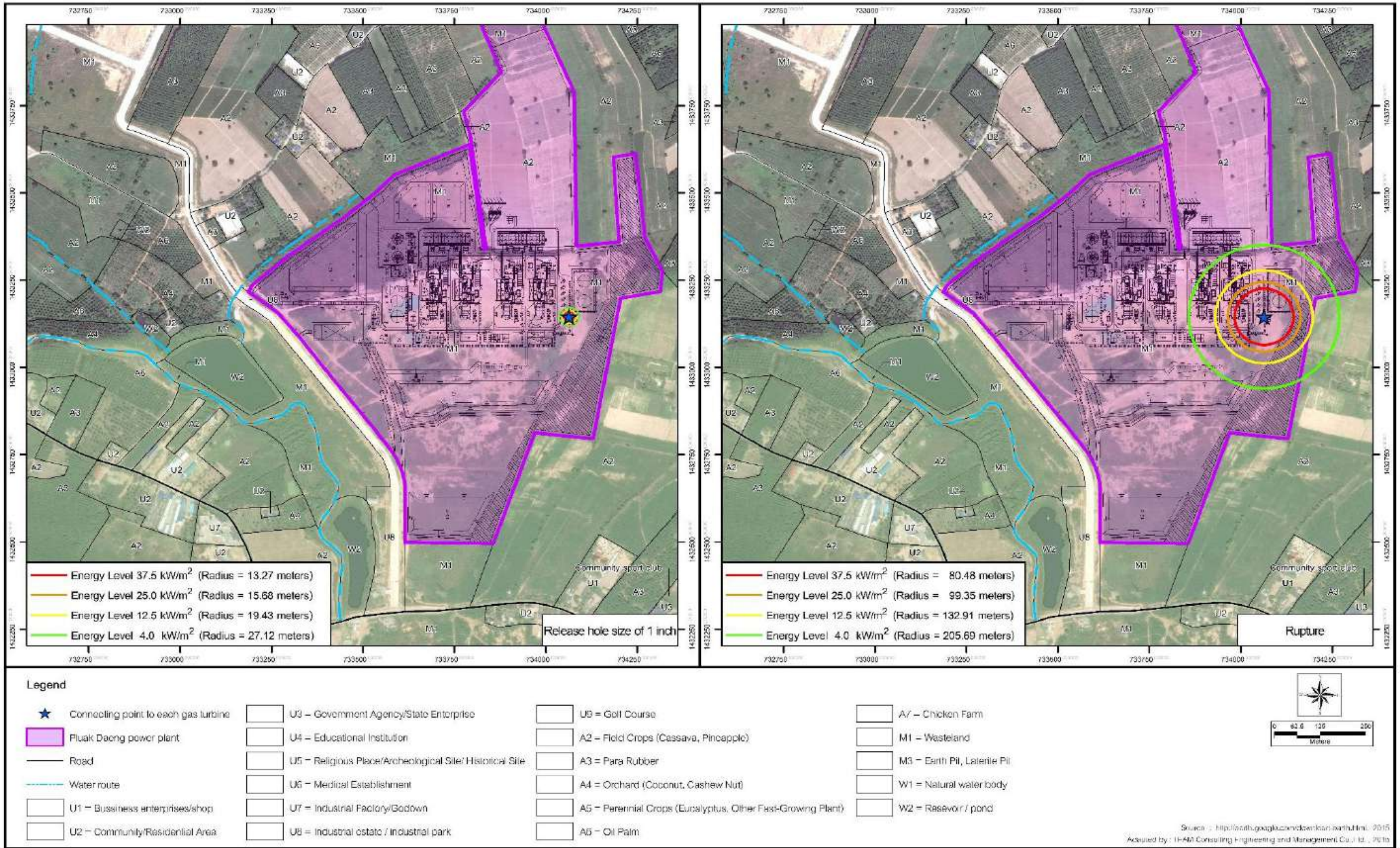


FIGURE 5.5.6-12 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN POOL FIRE AROUND MAIN PIPELINE FROM FUEL OIL TRANSFER PUMP TO EACH INDIVIDUAL GAS TURBINE

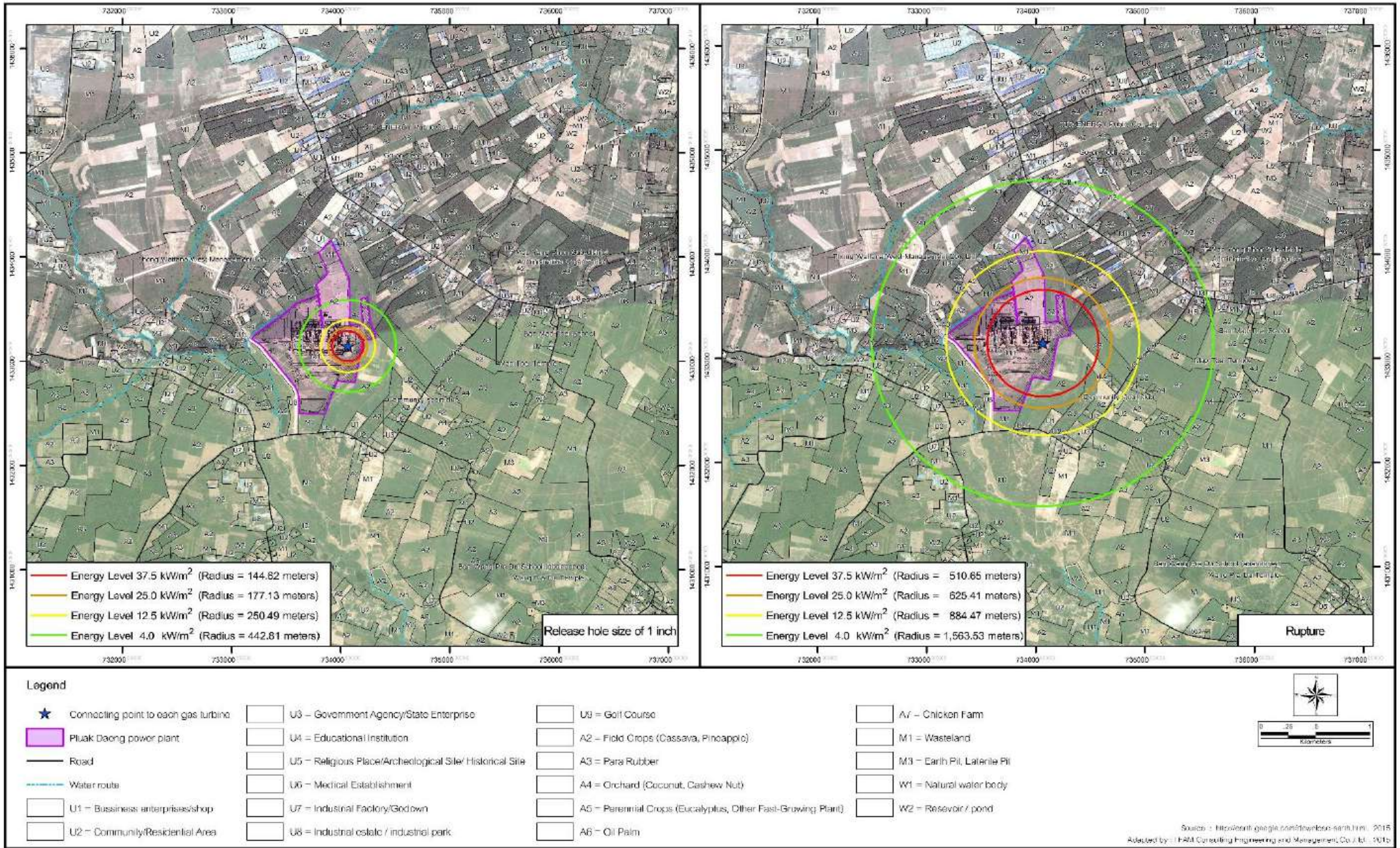


FIGURE 5.5.6-13 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN FIREBALL AROUND MAIN PIPELINE FROM FUEL OIL TRANSFER PUMP TO EACH INDIVIDUAL GAS TURBINE

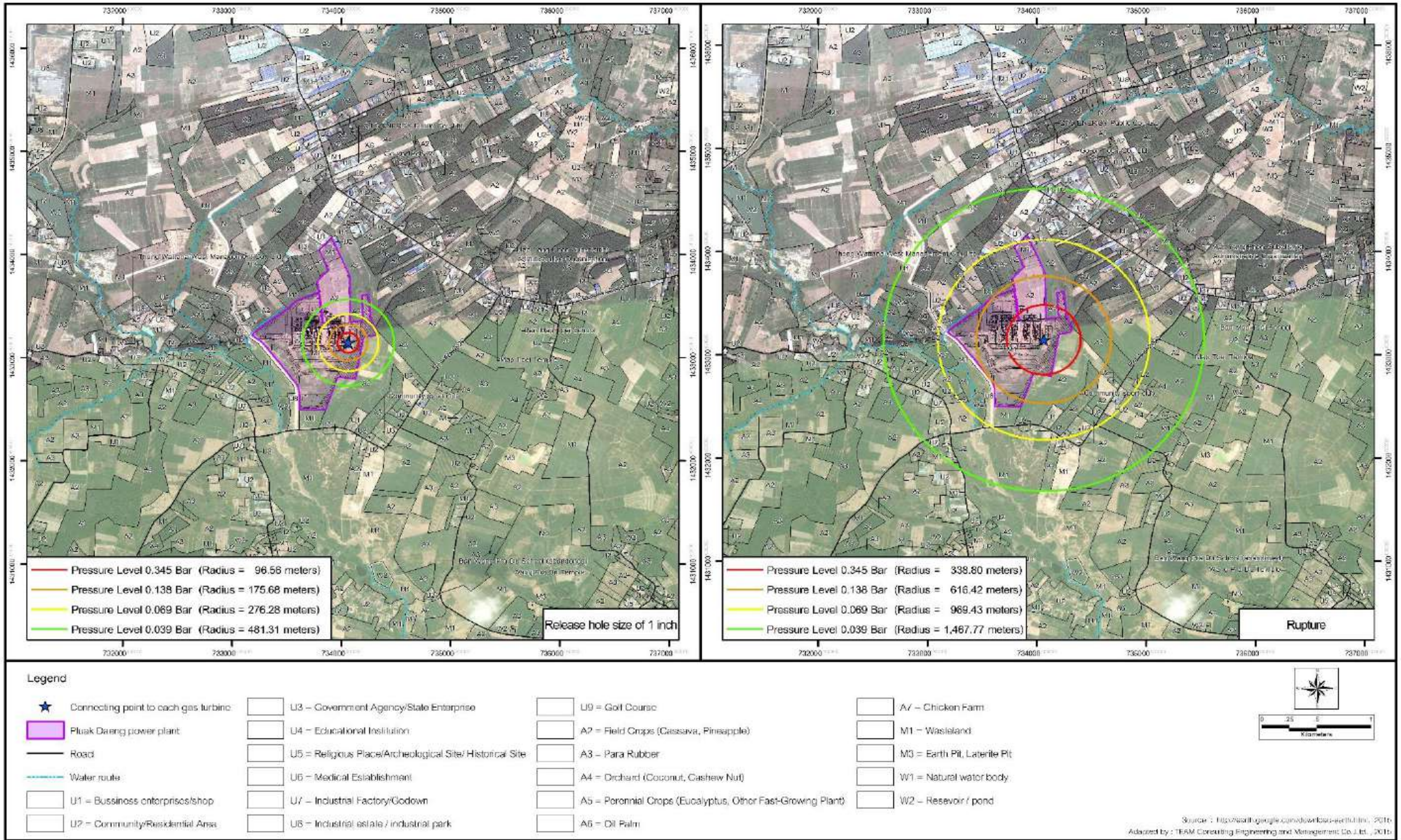


FIGURE 5.5.6-14 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN VCE AROUND MAIN PIPELINE FROM FUEL OIL TRANSFER PUMP TO EACH INDIVIDUAL GAS TURBINE

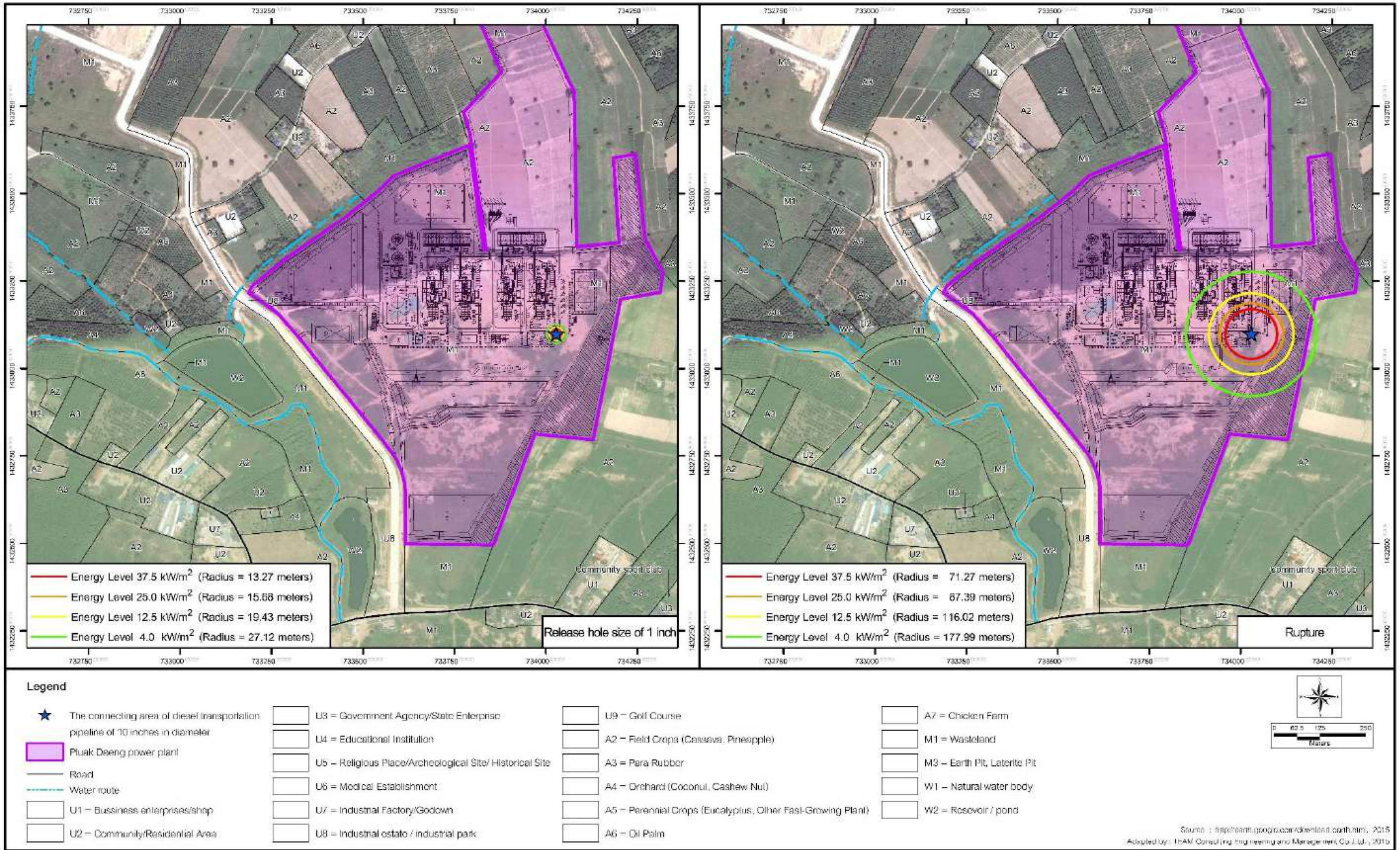


FIGURE 5.5.6-15 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN POOL FIRE AROUND MAIN PIPELINE FROM FUEL OIL TRANSFER PIPELINE OF 10 INCHES IN DIAMETER TO EACH INDIVIDUAL GAS TURBINE

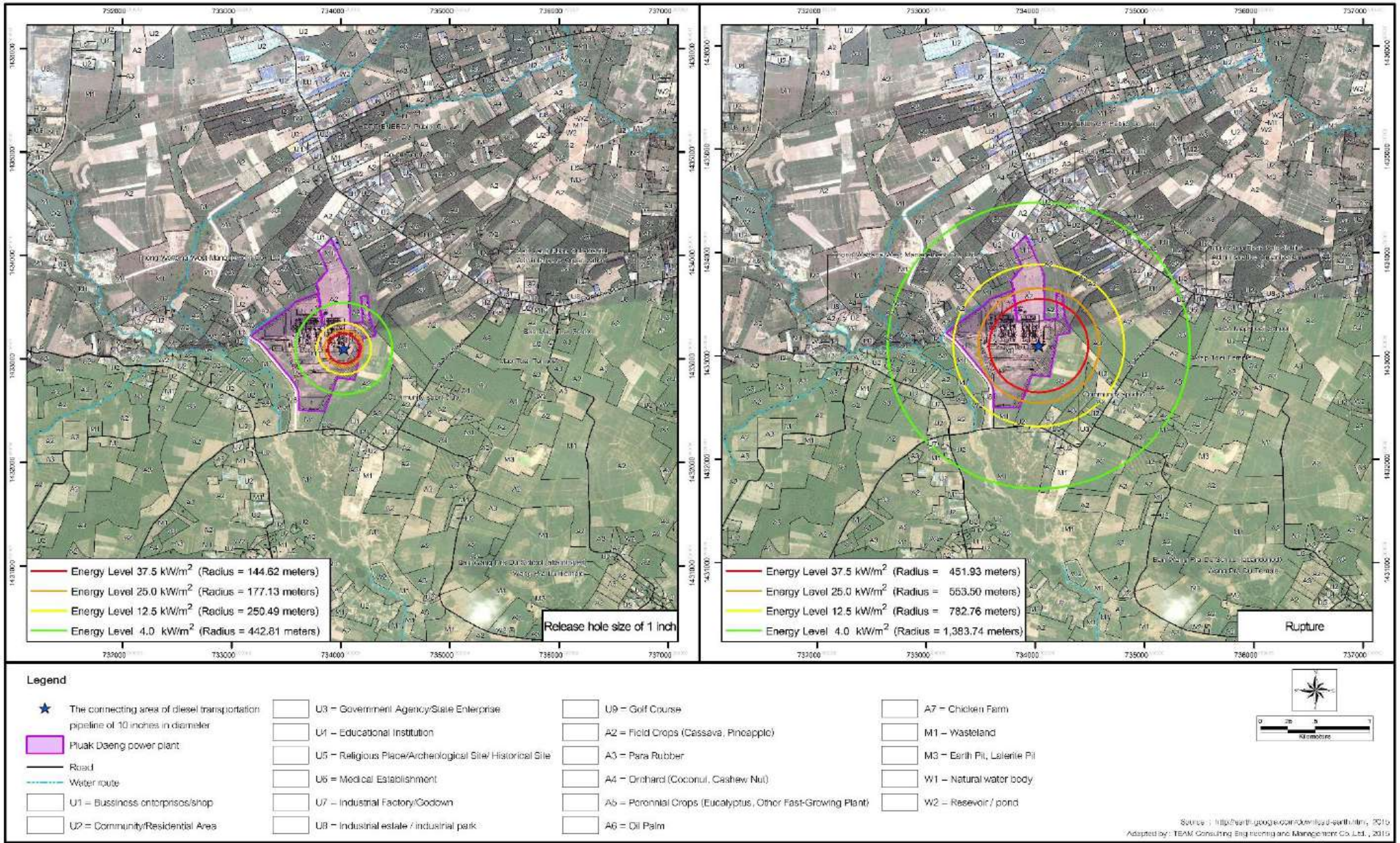


FIGURE 5.5.6-16 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN FIREBALL AROUND MAIN PIPELINE FROM FUEL OIL TRANSFER PIPELINE OF 10 INCHES IN DIAMETER TO EACH INDIVIDUAL GAS TURBINE

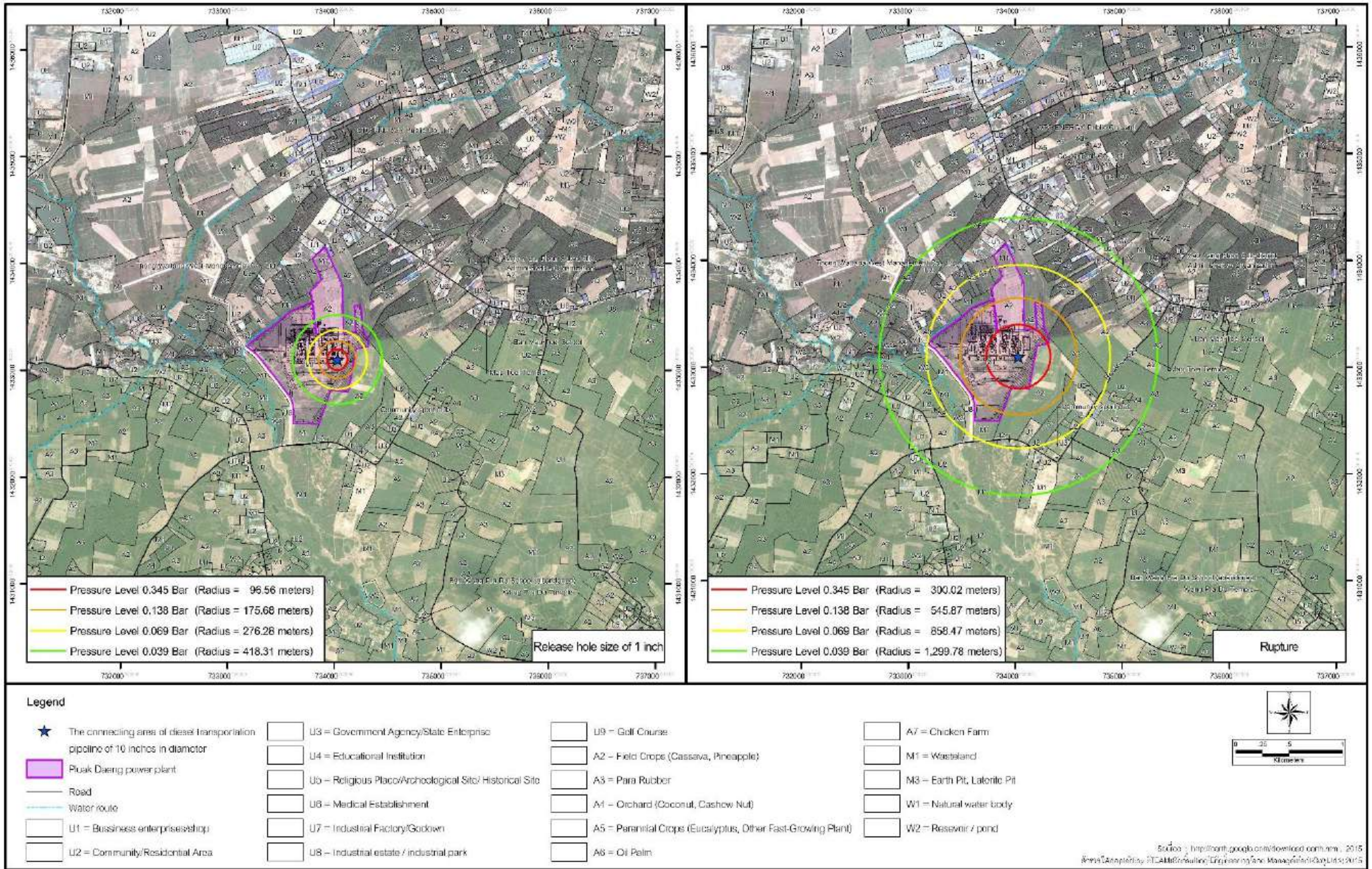


FIGURE 5.5.6-17 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN VCE AROUND MAIN PIPELINE FROM FUEL OIL TRANSFER PIPELINE OF 10 INCHES IN DIAMETER TO EACH INDIVIDUAL GAS TURBINE

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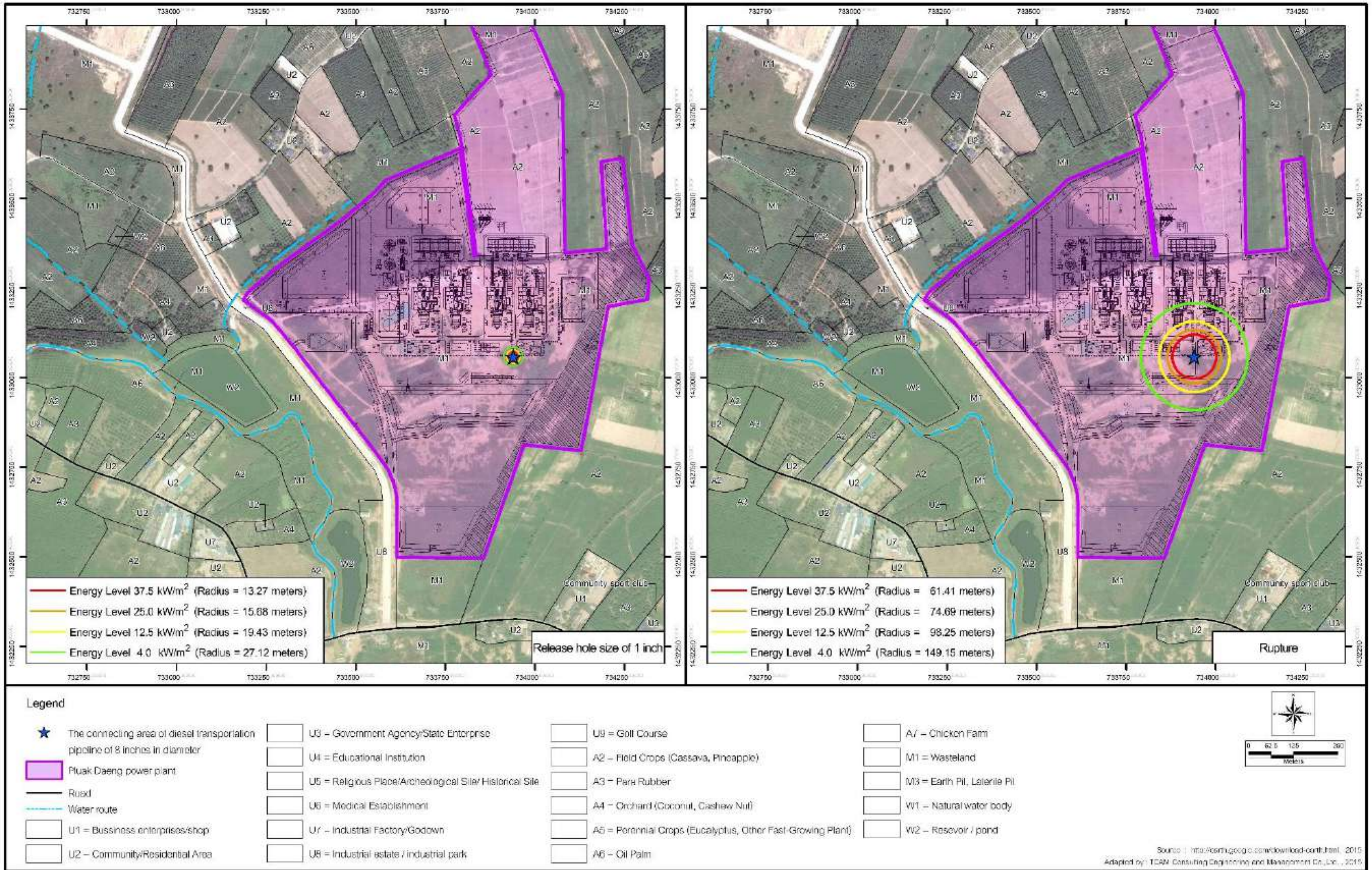
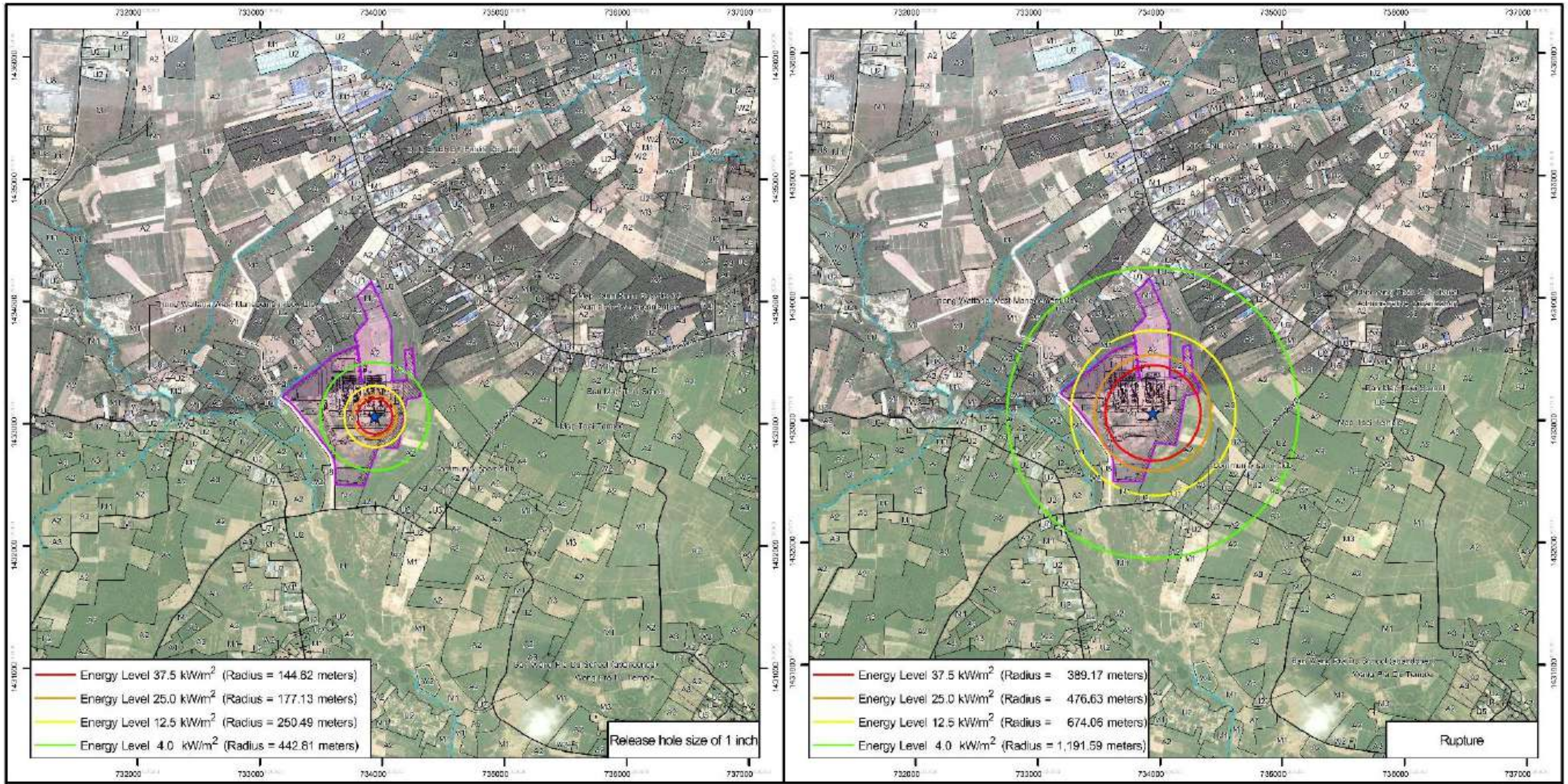


FIGURE 5.5.6-18 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN POOL FIRE AROUND MAIN PIPELINE FROM FUEL OIL TRANSFER PIPELINE OF 8 INCHES IN DIAMETER TO EACH INDIVIDUAL GAS TURBINE



Legend

- The connecting area of diesel transportation pipeline of 8 inches in diameter
- Pluak Daeng power plant
- Road
- Water route
- U1 = Bussiness enterprises/shop
- U2 = Community/Residential Area
- U3 = Government Agency/State Enterprise
- U4 = Educational Institution
- U5 = Religious Place/Archeological Site/ Historical Site
- U6 = Medical Establishment
- U7 = Industrial Factory/Godown
- U8 = Industrial estate / industrial park
- U9 = Golf Course
- A2 = Field Crops (Cassava, Pineapple)
- A3 = Para Rubber
- A4 = Orchard (Coconut, Cashew Nut)
- A5 = Perennial Crops (Eucalyptus, Other Fast-Growing Plant)
- A6 = Oil Palm
- A7 = Chicken Farm
- M1 = Wasteland
- M3 = Earth Pit, Laterite Pit
- W1 = Natural water body
- W2 = Resevoir / pond

0 .25 .5 1 Kilometers

Source : http://earth.google.com/download-earth.html, 2016
Adapted by : TEAM Consulting Engineering and Management Co.,Ltd., 2016

FIGURE 5.5.6-19 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN FIREBALL AROUND MAIN PIPELINE FROM FUEL OIL TRANSFER PIPELINE OF 8 INCHES IN DIAMETER TO EACH INDIVIDUAL GAS TURBINE

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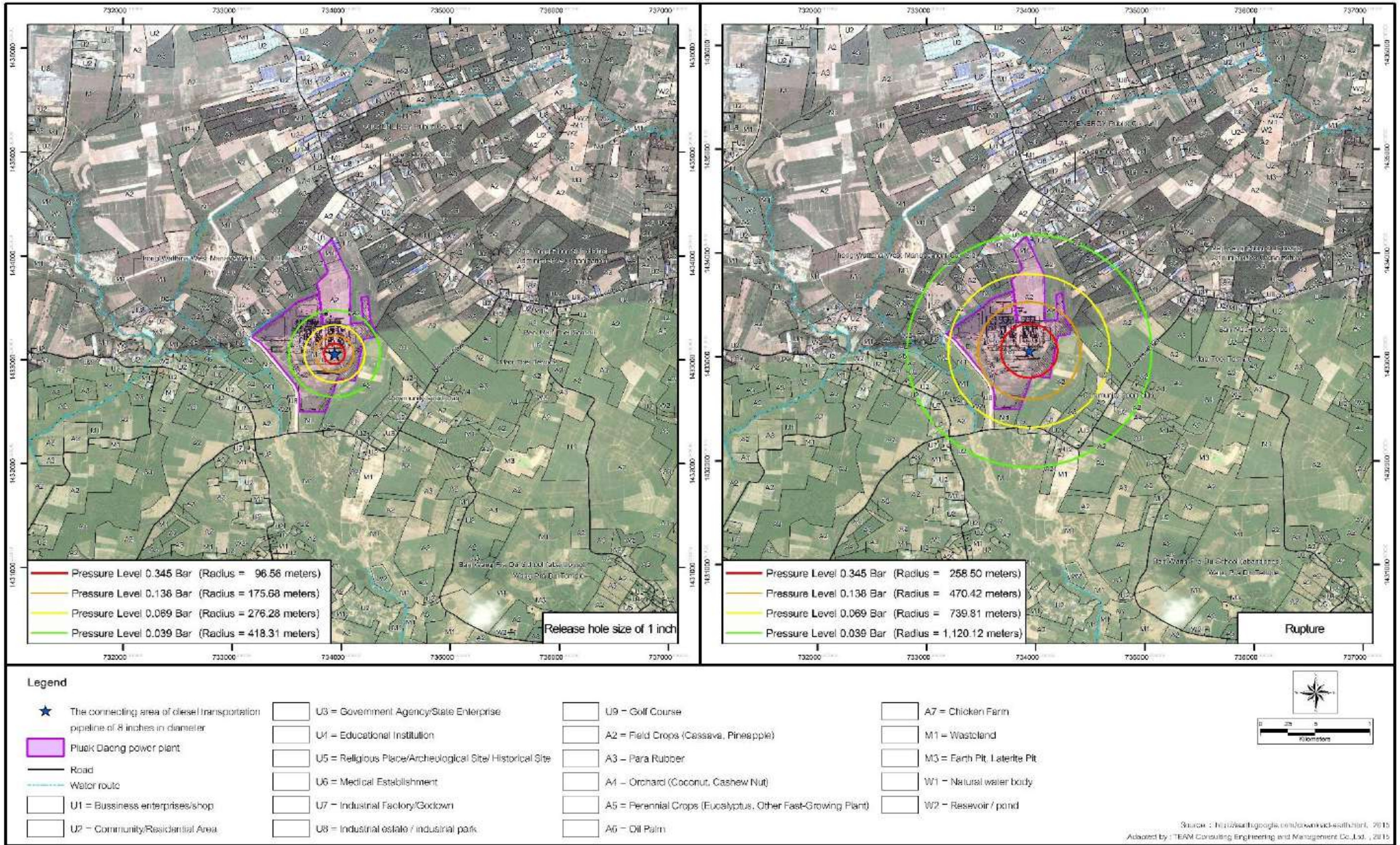

FIGURE 5.5.6-20 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN VCE AROUND MAIN PIPELINE FROM FUEL OIL TRANSFER PIPELINE OF 8 INCHES IN DIAMETER TO EACH INDIVIDUAL GAS TURBINE

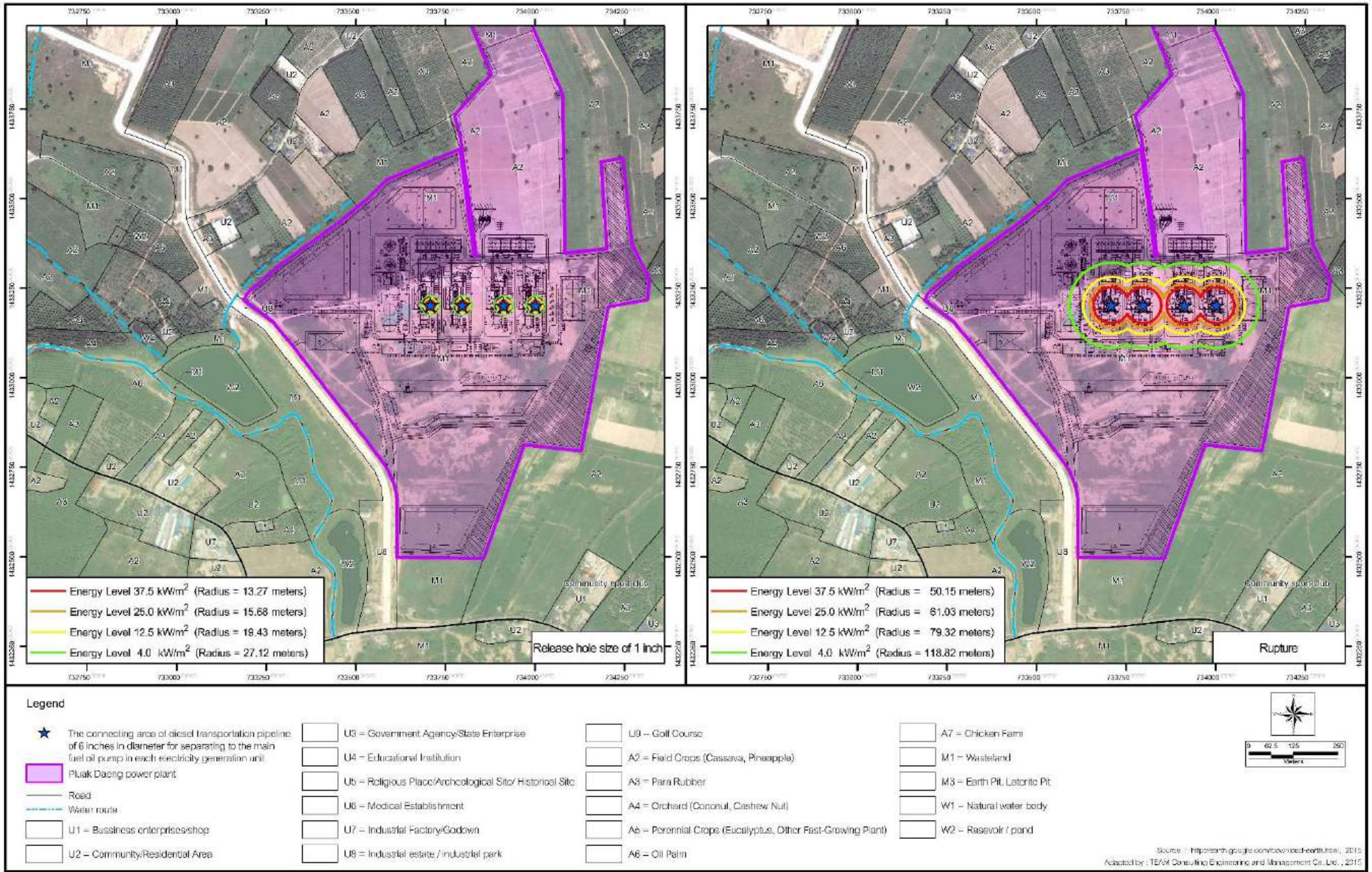

FIGURE 5.5.6-21 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN POOL FIRE AROUND MAIN PIPELINE FROM FUEL OIL TRANSFER PIPELINE OF 6 INCHES IN DIAMETER TO EACH INDIVIDUAL GAS TURBINE

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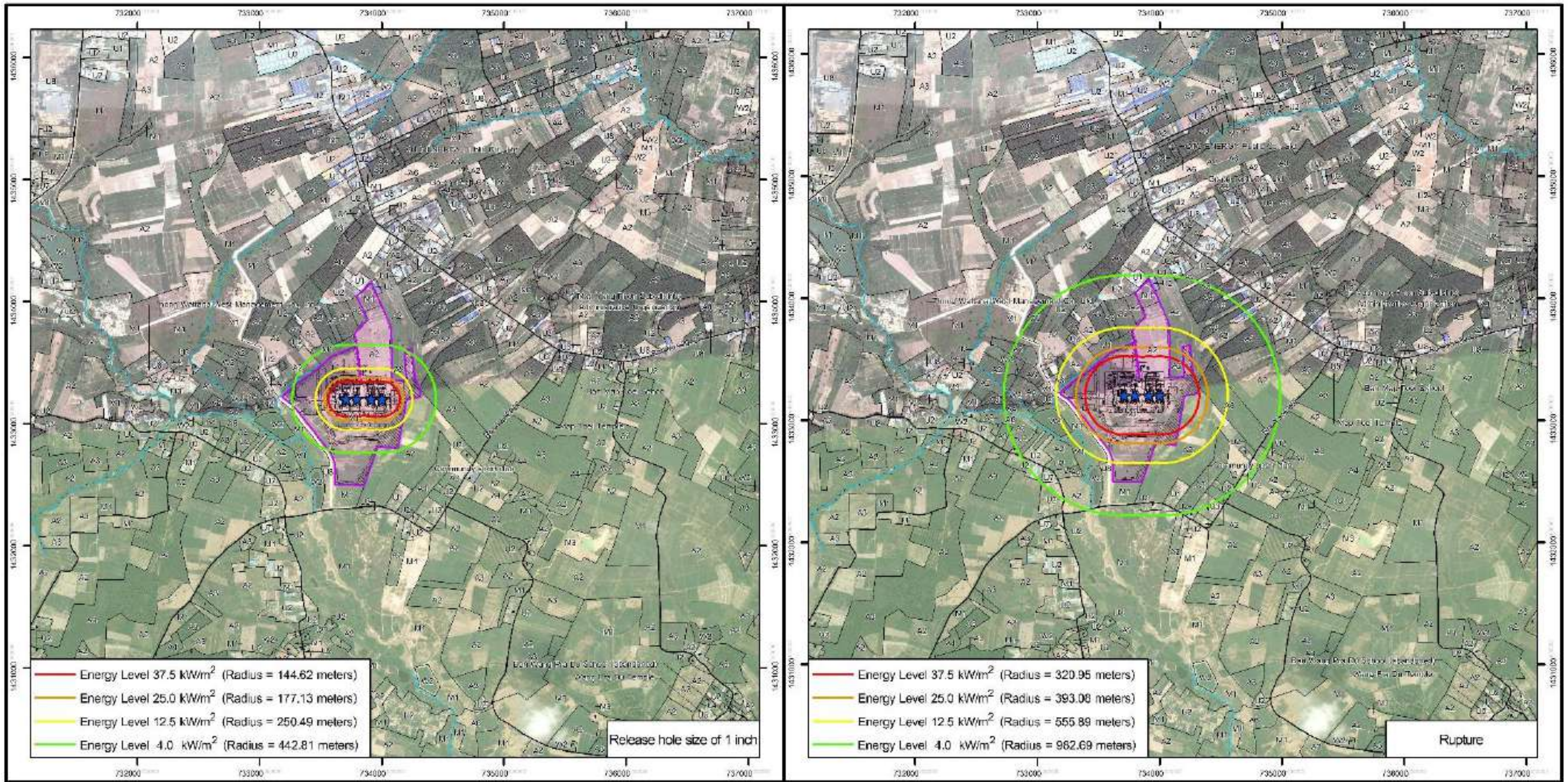
10P2800/Damrongsak.B/24-08-60/P2800-004 (English) 21) English.mxd



Legend

- ★ The connecting area of diesel transportation pipeline of 6 inches in diameter for separating to the main fuel oil pump in each electricity generation unit
- Pluak Daeng power plant
- Road
- Water route
- U1 = Bussiness enterprises/shop
- U2 = Community/Residential Area
- U3 = Government Agency/State Enterprise
- U4 = Educational Institution
- U5 = Religious Place/Archeological Site/ Historical Site
- U6 = Medical Establishment
- U7 = Industrial Factory/Godown
- U8 = Industrial estate / industrial park
- U9 = Golf Course
- A2 = Field Crops (Cassava, Pineapple)
- A3 = Para Rubber
- A4 = Orchard (Coconut, Cashew Nut)
- A5 = Perennial Crops (Eucalyptus, Other Fast-Growing Plant)
- A6 = Oil Palm
- A7 = Chicken Farm
- M1 = Wasteland
- M3 = Earth Pit, Laterite Pit
- W1 = Natural water body
- W2 = Resevoir / pond

Source : http://earth.google.com/download-earth.html, 2015
Adapted by : TEAM Consulting Engineering and Management Co. Ltd., 2015

FIGURE 5.5.6-22 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN FIREBALL AROUND MAIN PIPELINE FROM FUEL OIL TRANSFER PIPELINE OF 6 INCHES IN DIAMETER TO EACH INDIVIDUAL GAS TURBINE

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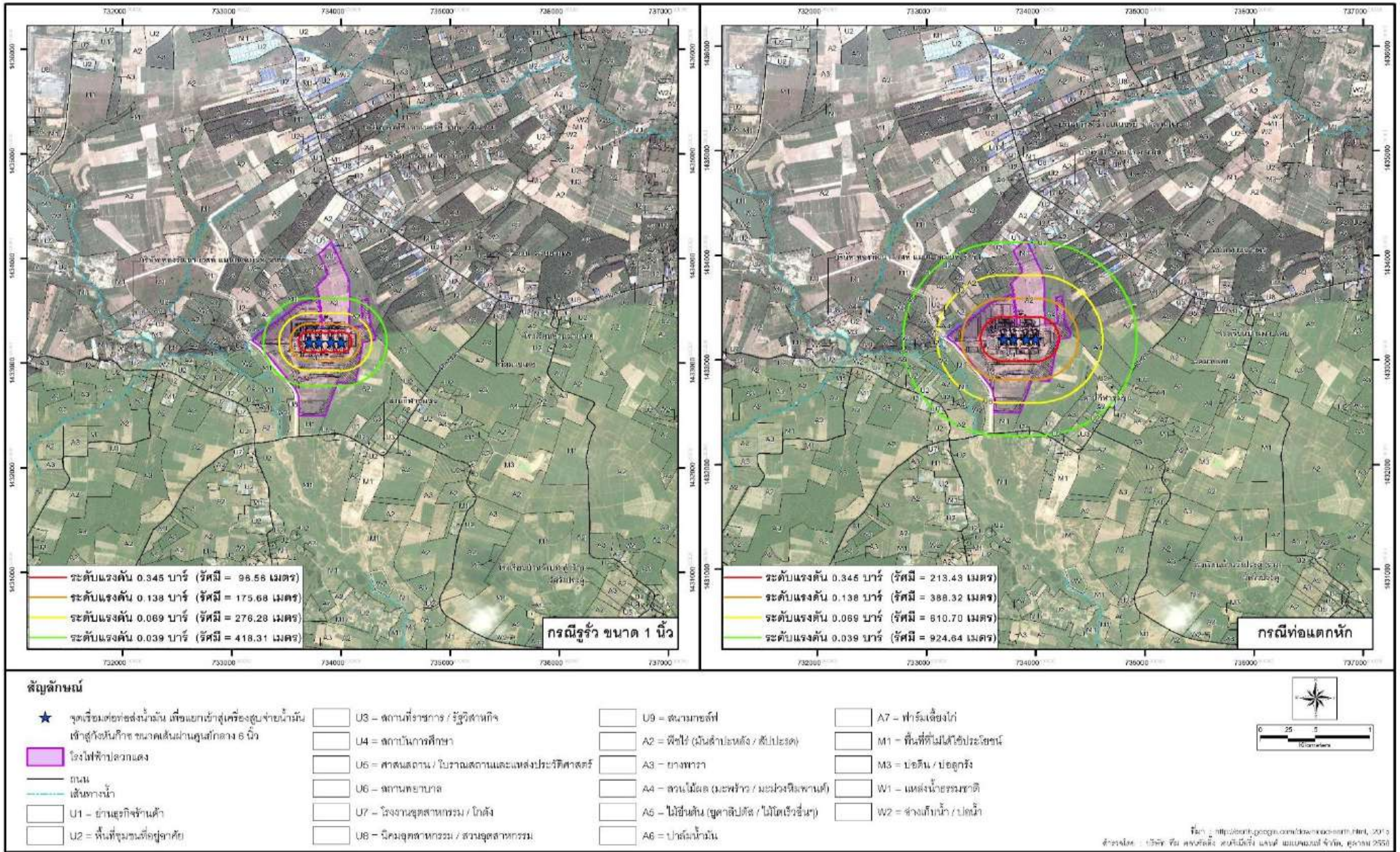

FIGURE 5.5.6-23 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN VCE AROUND MAIN PIPELINE FROM FUEL OIL TRANSFER PIPELINE OF 6 INCHES IN DIAMETER TO EACH INDIVIDUAL GAS TURBINE

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- The radius of thermal radiation at different energy levels from four diesel transportation pipelines of 5 inches in diameter and 45 meters in length each, connected from the main fuel oil pump to the gas turbine in each individual electricity generation unit, in the cases of ignition in the form of fireball and VCE through a release hole of 1 inch and a rupture. The details are shown from **Figure 5.5.6-24 to Figure 5.5.6-26**.

- **Diesel storage tank**

- The radius of thermal radiation at different energy levels from the area of the diesel storage tank, in the cases of ignition in the form of pool fire and VCE through a release hole of 1 inch and a rupture. The details of the radius of thermal radiation are shown from **Figure 5.5.6-27 to Figure 5.5.6-29**.

(2.3) Results of the major hazard assessment

In assessing the risk to major hazards, in line with the guidelines formulated by API, two factors are put into consideration – the frequency of the incident and the severity of the incident, as shown in **Figure 5.5.6-3**. Probability of mishap occurring to natural gas transmission pipeline, diesel transportation pipeline and diesel storage tank (in the case of a release hole of 1 inch, the size with the highest probability to happen) is investigated. Also, different natures of ignition are put into consideration with respect to their impacts on both the property and humans. The details are as follows:

(a) Gas transmission pipeline system

In the case of the accidental release resulting in jet fire

The energy level at 12.5 kilowatts/square meter is used in the assessment as this is the starting energy level at which can be deadly to humans. The probability of death is 1% if the victim is at the area exposed to such an energy level for one minute. Ten-second exposure to such an energy level can inflict skin burns. Risks in different scenarios as follows are summarized in **Table 5.5.6-8**

- For the pipeline connecting the MRS to the area of the gas compressor, 18 inches in diameter and 125 meters in length, probability of accidental release and consequent ignition in the form of jet fire is 8.20×10^{-6} time/year or 8.20 times in 1,000,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

- For the pipeline connecting the gas compressor to the area where the gas is relayed to the 12-inch in diameter pipeline, 18 inches in diameter and 147 meters in length, probability of accidental release and consequent ignition in the form of jet fire is 9.65×10^{-6} time/year or 9.65 times in 1,000,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

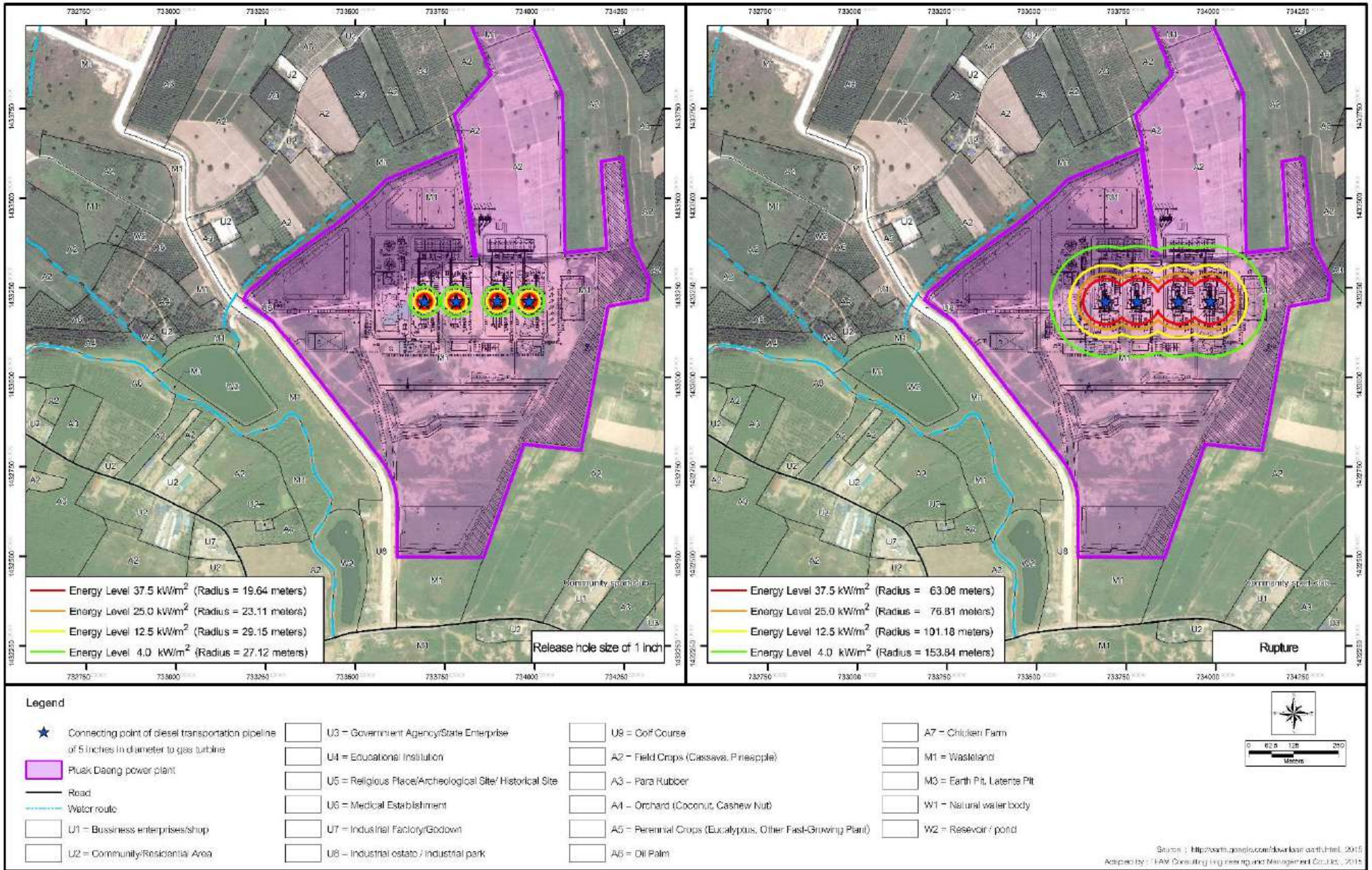

FIGURE 5.5.6-24 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN POOL FIRE AROUND MAIN PIPELINE FROM FUEL OIL TRANSFER PIPELINE OF 5 INCHES IN DIAMETER TO EACH INDIVIDUAL GAS TURBINE

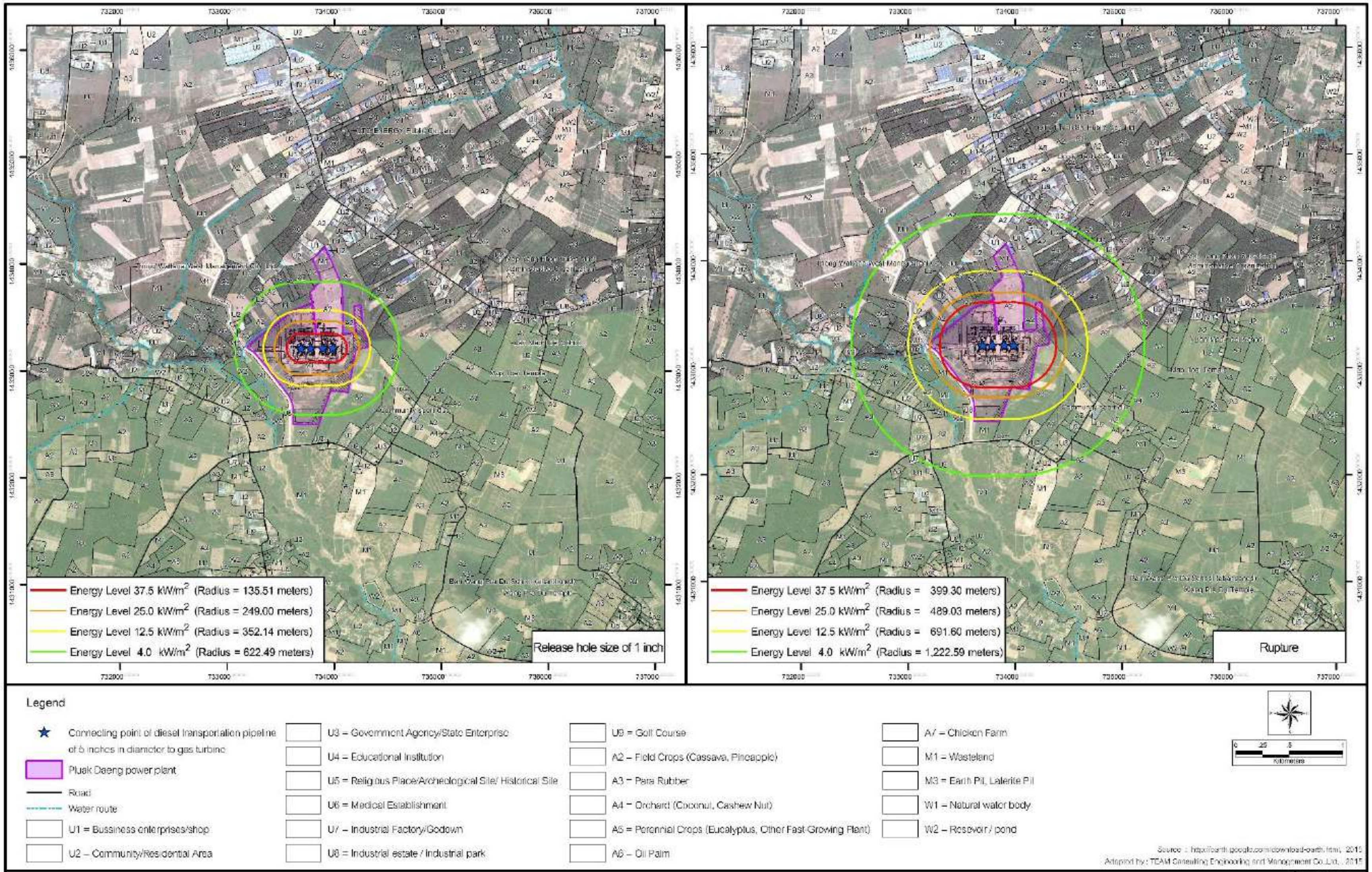

FIGURE 5.5.6-25 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN FIREBALL AROUND MAIN PIPELINE FROM FUEL OIL TRANSFER PIPELINE OF 5 INCHES IN DIAMETER TO EACH INDIVIDUAL GAS TURBINE

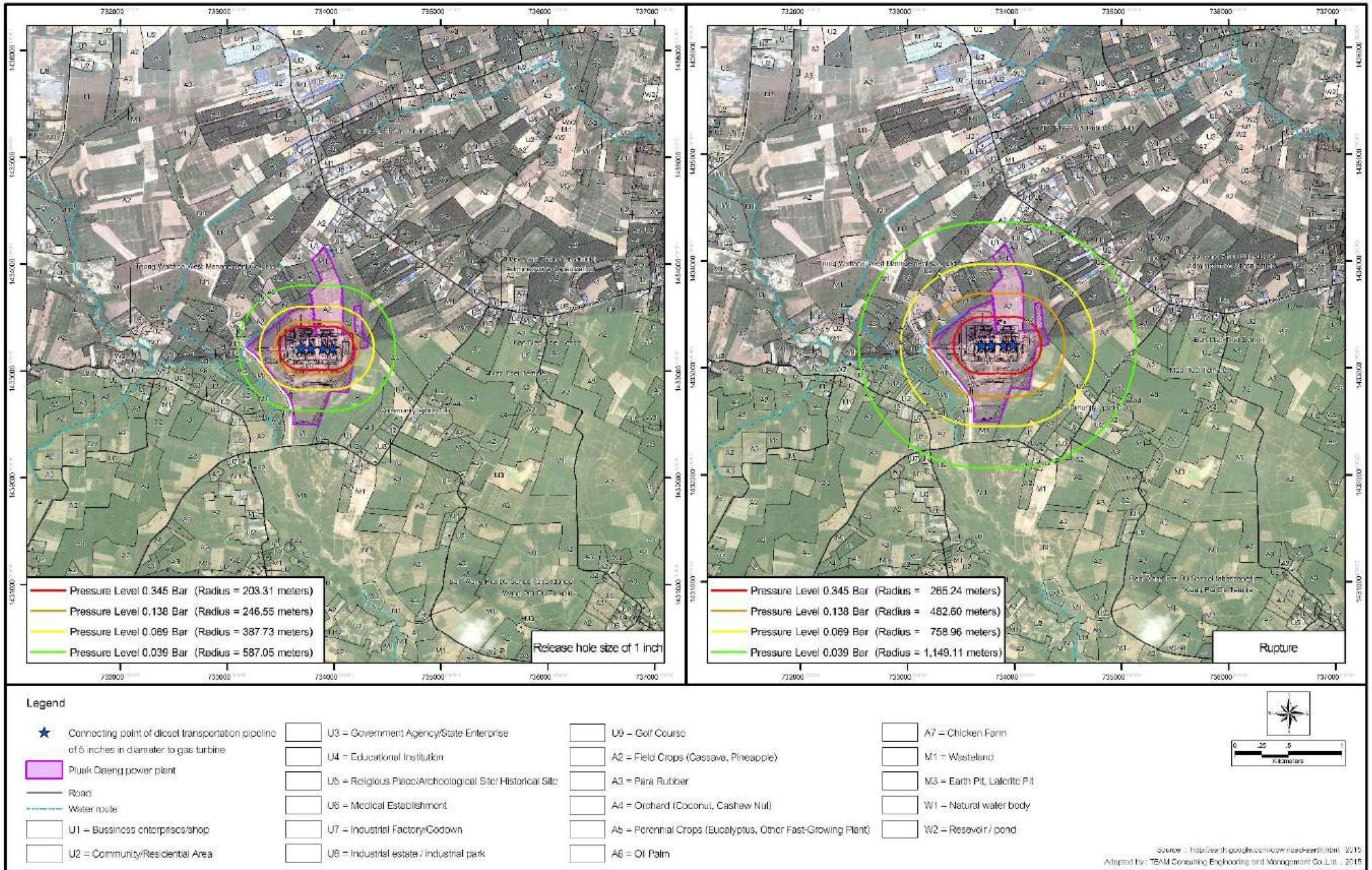

FIGURE 5.5.6-26 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN VCE AROUND MAIN PIPELINE FROM FUEL OIL TRANSFER PIPELINE OF 5 INCHES IN DIAMETER TO EACH INDIVIDUAL GAS TURBINE

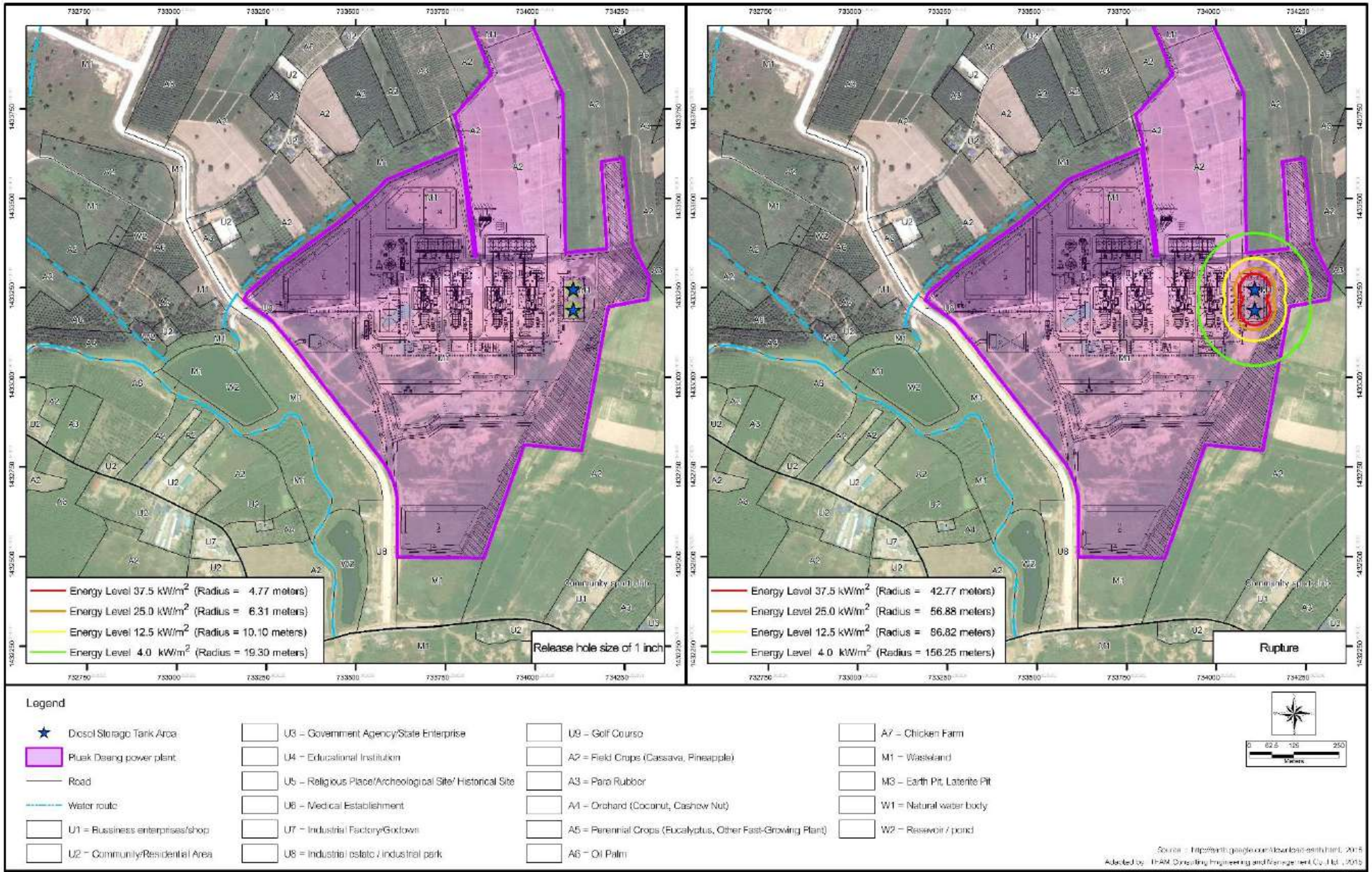

FIGURE 5.5.6-27 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN POOL FIRE AROUND DIESEL STORAGE TANK

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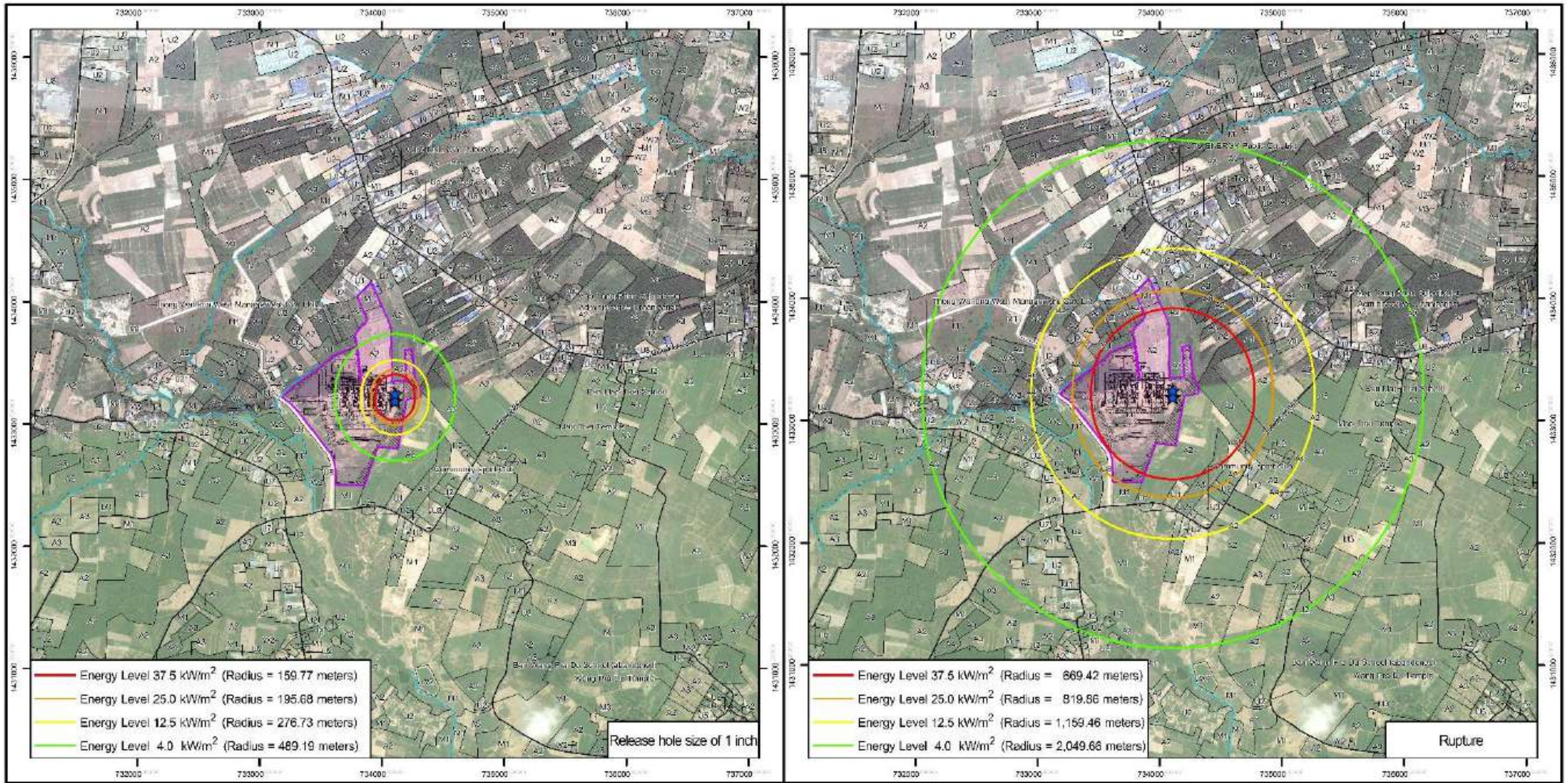

Legend

Diesel Storage Tank Area	U3 = Government Agency/State Enterprise	U9 = Golf Course	A7 = Chicken Farm
Pluak Daeng power plant	U4 = Educational Institution	A2 = Field Crops (Cassava, Pineapple)	M1 = Wasteland
Road	U5 = Religious Place/Archeological Site/ Historical Site	A3 = Para Rubber	M3 = Earth Pit, Laterite Pit
Water route	U6 = Medical Establishment	A4 = Orchard (Coconut, Cashew Nut)	W1 = Natural water body
U1 = Bussiness enterprises/shop	U7 = Industrial Factory/Godown	A5 = Perennial Crops (Eucalyptus, Other Fast-Growing Plant)	W2 = Resevoir / pond
U2 = Community/Residential Area	U8 = Industrial estate / industrial park	A6 = Oil Palm	

Source : http://earth.google.com/download-earth.html, 2015
Adapted by : TEAM Consulting Engineering and Management Co., Ltd., 2015

FIGURE 5.5.6-28 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN FIREBALL AROUND DIESEL STORAGE TANK

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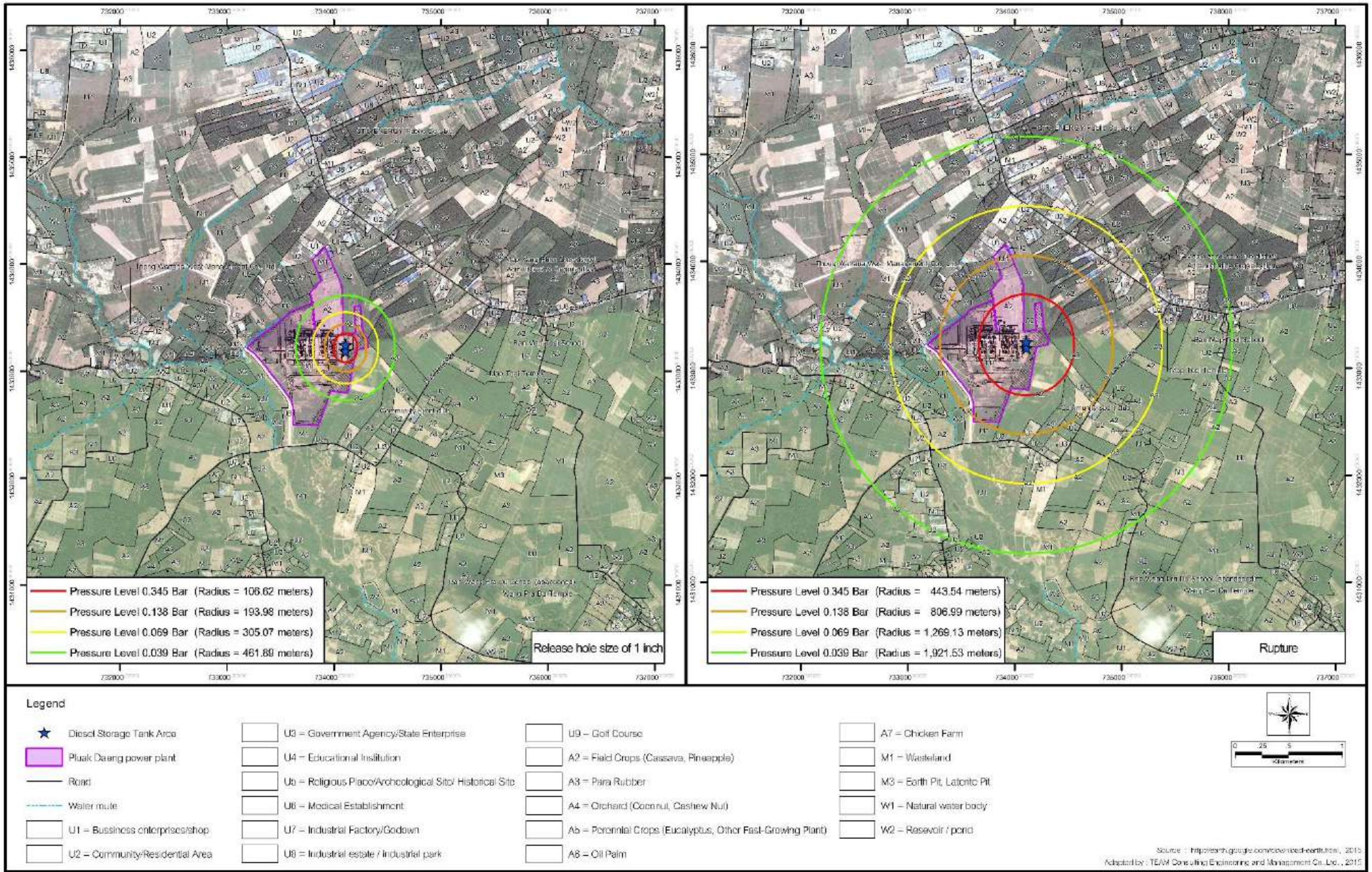


FIGURE 5.5.6-29 : IN CASE OF THE ACCIDENTAL RELEASE RESULTING IN VCE AROUND DIESEL STORAGE TANK

- For the pipeline connecting the gas compressor to the area where the gas is relayed to the 12-inch in diameter pipeline, 18 inches in diameter and 359 meters in length, probability of accidental release and consequent ignition in the form of jet fire is 2.36×10^{-5} time/year or 2.36 times in 100,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

- For the pipeline connecting the area where the gas is relayed from the 18-inch in diameter pipeline to the flow meter, 12 inches in diameter and 165 meters in length, probability of accidental release and consequent ignition in the form of jet fire is 1.65×10^{-5} time/year or 1.62 times in 100,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

- For the pipeline connecting the area where the gas is relayed from the 18-inch in diameter pipeline to the flow meter, 12 inches in diameter and 253 meters in length, probability of accidental release and consequent ignition in the form of jet fire is 2.49×10^{-5} time/year or 2.49 times in 1,000,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

- For the pipeline connecting the area where the gas is relayed from the 18-inch in diameter pipeline to the flow meter, 12 inches in diameter and 163 meters in length, probability of accidental release and consequent ignition in the form of jet fire is 1.60×10^{-5} time/year or 1.60 times in 1,000,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

- For the pipeline connecting the area where the gas is relayed from the 18-inch in diameter pipeline to the flow meter, 12 inches in diameter and 428 meters in length, probability of accidental release and consequent ignition in the form of jet fire is 4.21×10^{-5} time/year or 4.21 times in 1,000,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

TABLE 5.5.6-8
RESULTS OF THE ASSESSMENT OF THE RISK ASSOCIATED WITH THE PROJECT'S NATURAL GAS TRANSMISSION PIPELINE FAILURES

Release hole size	Probability of ignition in the form of jet fire (time/year)	Severity level of the incident in the case of accidental release and consequent ignition in the form of jet fire	Risk level
1. The pipeline connected from the gas metering station to the gas compressor : 18 inches in diameter, 125 meters in length			
1 inch	8.20×10^{-6} (Very Unlikely)	Project site (Minor)	low
rupture	4.10×10^{-7} (Very Unlikely)	Project site, industrial park site, ponds, crop fields, unused land (Minor)	low
2. The pipeline connected from the gas compressors to the branch point, from which gas is further relayed through the pipeline of 12 inches in diameter : 18 inches in diameter, 147 meters in length			
1 inch	9.65×10^{-6} (Very Unlikely)	Project site (Minor)	low
rupture	4.82×10^{-7} (Very Unlikely)	Project site, industrial park site, ponds, unused land (Minor)	low
3. The pipeline connected from the gas compressors to the branch point, from which gas is further relayed through the pipeline of 12 inches in diameter : 18 inches in diameter, 359 meters in length			
1 inch	2.36×10^{-5} (Very Unlikely)	Project site (Minor)	low
rupture	1.18×10^{-6} (Very Unlikely)	Project site, industrial park site, ponds, unused land (Minor)	low
4. The pipeline connected from the branch point, where the pipeline of 18 inches in diameter is connected to the flow meter : 12 inches in diameter, 165 meters in length			
1 inch	1.62×10^{-5} (Very Unlikely)	Project site (Minor)	low
rupture	1.08×10^{-6} (Very Unlikely)	Project site (Minor)	low
5. The pipeline connected from the branch point, where the pipeline of 18 inches in diameter are connected to the flow meter : 12 inches in diameter, 253 meters in length			
1 inch	2.49×10^{-5} (Very Unlikely)	Project site (Minor)	low
rupture	3.43×10^{-6} (Very Unlikely)	Project site (Minor)	low
6. The pipeline connected from the branch point, where the pipeline of 18 inches in diameter is connected to the flow meter : 12 inches in diameter, 163 meters in length			
1 inch	1.60×10^{-5} (Very Unlikely)	Project site (Minor)	low
rupture	1.07×10^{-6} (Very Unlikely)	Project site (Minor)	low

TABLE 5.5.6-8

RESULTS OF THE ASSESSMENT OF THE RISK ASSOCIATED WITH THE PROJECT'S NATURAL GAS TRANSMISSION PIPELINE FAILURES (CONT'D)

Release hole size	Probability of ignition in the form of jet fire (time/year)	Severity level of the incident in the case of accidental release and consequent ignition in the form of jet fire	Risk level
7. The pipeline connected from the branch point, where the pipeline of 18 inches in diameter is connected to the flow meter : 12 inches in diameter, 428 meters in length			
1 inch	4.21×10^{-5} (Very Unlikely)	project site (Minor)	low
rupture	2.81×10^{-6} (Very Unlikely)	project site (Minor)	low
8. The pipeline connected from the flow meter to the gas turbine : 12 inches in diameter, 40 meters in length			
1 inch	3.94×10^{-6} (Very Unlikely)	project site (Minor)	low
rupture	2.62×10^{-7} (Very Unlikely)	project site (Minor)	low

- For the pipeline connecting the flow meter to the gas turbine, 12 inches in diameter and 40 meters in length, probability of accidental release and consequent ignition in the form of jet fire is 3.94×10^{-6} time/year or 3.94 times in 1,000,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

(b) Diesel transportation pipeline system

In the case of the accidental release resulting in pool fire

- The energy level at 12.5 kilowatts/square meter is used in the assessment as this is the starting energy level at which it is fatal to humans. The probability of death is 1% if the victim is at the area exposed to such an energy level for more than one minute. Ten-second exposure to such an energy level can inflict skin burns. Risks in different scenarios as follows are summarized in **Table 5.5.6-9**.

- For the pipeline connected from the storage tank to the electricity generation unit, 12 inches in diameter and 104 meters in length, probability of accidental release and consequent ignition in the form of pool fire in the area of the storage tank is 4.08×10^{-6} time/year or 4.08 times in 1,000,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

TABLE 5.5.6-9

RESULTS OF THE ASSESSMENT OF THE RISK ASSOCIATED WITH THE PROJECT'S DIESEL TRANSMISSION PIPELINE FAILURES

Release hole size	Probability of ignition (time/year)			Severity level of the incident			Risk level
	Pool Fire	Fireball	VCE	Pool Fire	Fireball	VCE	
1. The pipeline connected from the diesel storage tank to the electricity generation unit : 12 inches in diameter, 104 meters in length							
1 inch	4.08×10^{-6} (Very Unlikely)	1.02×10^{-4} (Very Unlikely)	1.02×10^{-4} (Very Unlikely)	project site (Minor)	project site (Minor)	project site, crop fields (Minor)	low
rupture	2.73×10^{-7} (Very Unlikely)	6.82×10^{-6} (Very Unlikely)	6.82×10^{-6} (Very Unlikely)	project site (Minor)	project site, crop fields, rubber fields, unused land (Minor)	project site, crop fields, rubber fields, unused land (Minor)	low
2. The pipeline connected from the fuel oil transfer pump through the branch point to each gas turbine : 12 inches in diameter, 78 meters in length							
1 inch	3.07×10^{-6} (Very Unlikely)	7.68×10^{-5} (Very Unlikely)	7.68×10^{-5} (Very Unlikely)	project site (Minor)	project site, crop fields (Minor)	project site, crop fields (Minor)	low
rupture	2.05×10^{-7} (Very Unlikely)	5.12×10^{-6} (Very Unlikely)	5.12×10^{-6} (Very Unlikely)	project site (Minor)	project site, crop fields, unused land, industrial park site, ponds/canals, rubber fields, residential community areas (Minor)	project site, crop fields, rubber fields, residential community areas, fruit gardens, government compounds, ponds/canals, oil palm plantations, business and industrial park area (Major)	low
3. The diesel transmission pipeline of 10 inches in diameter, 128 meters in length							
1 inch	5.04×10^{-6} (Very Unlikely)	1.26×10^{-4} (Very Unlikely)	1.26×10^{-4} (Very Unlikely)	project site (Minor)	project site, crop fields (Minor)	project site, crop fields (Minor)	low
rupture	3.36×10^{-7} (Very Unlikely)	8.40×10^{-6} (Very Unlikely)	8.40×10^{-6} (Very Unlikely)	project site (Minor)	project site, unused land, crop fields, rubber fields, residential community areas, ponds/canals, business and industrial park area (Major)	project site, unused land, crop fields, rubber fields, residential community areas, ponds/canals, business and industrial park area (Major)	low

TABLE 5.5.6-9

RESULTS OF THE ASSESSMENT OF THE RISK ASSOCIATED WITH THE PROJECT'S DIESEL TRANSMISSION PIPELINE FAILURES (CONT'D)

Release hole size	Probability of ignition (time/year)			Severity level of the incident			Risk level
	Pool Fire	Fireball	VCE	Pool Fire	Fireball	VCE	
4. The diesel transmission pipeline of 8 inches in diameter , 114 meters in length							
1 inch	4.48×10^{-6} (Very Unlikely)	1.12×10^{-4} (Very Unlikely)	1.12×10^{-4} (Very Unlikely)	project site (Minor)	project site (Minor)	project site, crop fields (Minor)	low
rupture	2.99×10^{-7} (Very Unlikely)	7.48×10^{-6} (Very Unlikely)	7.48×10^{-6} (Very Unlikely)	project site (Minor)	project site, unused land, crop fields, rubber fields, ponds/canals, industrial park area (Minor)	project site, unused land, crop fields, rubber fields, residential community areas, ponds/canals, business and industrial park area (Major)	low
5. The diesel transmission pipeline of 6 inches in diameter, 129 meters in length							
1 inch	6.76×10^{-6} (Very Unlikely)	1.69×10^{-4} (Very Unlikely)	1.69×10^{-4} (Very Unlikely)	project site (Minor)	project site, crop fields (Minor)	project site, crop fields (Minor)	low
rupture	1.36×10^{-7} (Very Unlikely)	3.39×10^{-5} (Very Unlikely)	3.39×10^{-5} (Very Unlikely)	project site (Minor)	project site, unused land, crop fields, rubber fields (Minor)	project site, unused land, crop fields, rubber fields (Minor)	low
6. The diesel transmission pipeline of 6 inches in diameter, 175 meters in length							
1 inch	9.20×10^{-6} (Very Unlikely)	2.30×10^{-4} (Very Unlikely)	2.30×10^{-4} (Very Unlikely)	project site (Minor)	project site, crop fields (Minor)	project site, crop fields (Minor)	low
rupture	1.84×10^{-7} (Very Unlikely)	4.59×10^{-5} (Very Unlikely)	4.59×10^{-5} (Very Unlikely)	project site (Minor)	project site, unused land, crop fields, rubber fields (Minor)	project site, unused land, crop fields, rubber fields (Minor)	low
7. The diesel transmission pipeline of 6 inches in diameter, 169 meters in length							
1 inch	8.88×10^{-6} (Very Unlikely)	2.22×10^{-4} (Very Unlikely)	2.22×10^{-4} (Very Unlikely)	project site (Minor)	project site, crop fields (Minor)	project site, crop fields (Minor)	low
rupture	1.76×10^{-7} (Very Unlikely)	4.44×10^{-5} (Very Unlikely)	4.44×10^{-5} (Very Unlikely)	project site (Minor)	project site, unused land, crop fields, rubber fields (Minor)	project site, unused land, crop fields, rubber fields (Minor)	low

TABLE 5.5.6-9

RESULTS OF THE ASSESSMENT OF THE RISK ASSOCIATED WITH THE PROJECT'S DIESEL TRANSMISSION PIPELINE FAILURES (CONT'D)

Release hole size	Probability of ignition (time/year)			Severity level of the incident			Risk level
	Pool Fire	Fireball	VCE	Pool Fire	Fireball	VCE	
8. The diesel transmission pipeline of 6 inches in diameter , 257 meters in length							
1 inch	1.35×10^{-5} (Very Unlikely)	3.37×10^{-4} (Very Unlikely)	3.37×10^{-4} (Very Unlikely)	project site (Minor)	project site, crop fields (Minor)	project site, crop fields (Minor)	low
rupture	2.70×10^{-6} (Very Unlikely)	6.75×10^{-5} (Very Unlikely)	6.75×10^{-5} (Very Unlikely)	project site (Minor)	project site, unused land, crop fields, rubber fields (Minor)	project site, unused land, crop fields, rubber fields (Minor)	low
9. The diesel transmission pipeline of 5 inches in diameter, 45 meters in length							
1 inch	2.36×10^{-6} (Very Unlikely)	5.91×10^{-5} (Very Unlikely)	5.91×10^{-5} (Very Unlikely)	project site (Minor)	project site, crop fields (Minor)	project site, crop fields, unused land, (Minor)	low
rupture	4.72×10^{-6} (Very Unlikely)	1.18×10^{-5} (Very Unlikely)	1.18×10^{-5} (Very Unlikely)	project site (Minor)	project site, unused land, crop fields, rubber fields, residential community areas, ponds/canals, industrial park area (Minor)	project site, unused land, crop fields, rubber fields, residential community areas, ponds/ canals (Minor)	low

- For the pipeline connected from the fuel oil transfer pump to each individual gas turbine, 12 inches in diameter and 78 meters in length, probability of accidental release and consequent ignition in the form of pool fire is 3.07×10^{-6} time/year or 3.07 times in 1,000,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

- For the pipeline of 10 inches in diameter and 128 meters in length, probability of accidental release and consequent ignition in the form of pool fire is 5.04×10^{-6} time/year or 5.04 times in 1,000,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

- For the pipeline of 8 inches in diameter and 114 meters in length, probability of accidental release and consequent ignition in the form of pool fire is 4.48×10^{-6} time/year or 4.48 times in 1,000,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

- For the pipeline of 6 inches in diameter and 129 meters in length, probability of accidental release and consequent ignition in the form of pool fire is 6.76×10^{-6} time/year or 6.76 times in 1,000,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

- For the pipeline of 6 inches in diameter and 175 meters in length, probability of accidental release and consequent ignition in the form of pool fire is 9.20×10^{-6} time/year or 9.20 times in 1,000,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

- For the pipeline of 6 inches in diameter and 169 meters in length, probability of accidental release and consequent ignition in the form of pool fire is 8.88×10^{-6} time/year or 8.88 times in 1,000,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

- For the pipeline of 6 inches in diameter and 257 meters in length, probability of accidental release and consequent ignition in the form of pool fire is 1.35×10^{-5} time/year or 1.35 times in 100,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

- For the pipeline of 5 inches in diameter and 45 meters in length, probability of accidental release and consequent ignition in the form of pool fire is 2.36×10^{-6} time/year or 2.36 times in 1,000,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

In the case of the accidental release resulting in fireballs

The energy level at 12.5 kilowatts/square meter is used in the assessment as this is the starting energy level at which it is fatal to humans. The probability of death is 1% if the victim is at the area exposed to such an energy level for more than one minute. Ten-second exposure to such an energy level can inflict skin burns. Risks in different scenarios as follows are summarized in **Table 5.5.6-9**.

- For the pipeline connected from the storage tank to the electricity generation unit, 12 inches in diameter and 104 meters in length, probability of accidental release and consequent ignition in the form of fireballs in the area of the storage tank is 1.02×10^{-4} time/year or 1.02 times in 10,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

- For the pipeline connected from the fuel oil transfer pump to each individual gas turbine, 12 inches in diameter and 78 meters in length, probability of accidental release and consequent ignition in the form of fireballs is 7.68×10^{-5} time/year or 7.68 times in 100,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

- For the pipeline of 10 inches in diameter and 128 meters in length, probability of accidental release and consequent ignition in the form of fireballs is 1.26×10^{-4} time/year or 1.26 times in 10,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.
- For the pipeline of 8 inches in diameter and 114 meters in length, probability of accidental release and consequent ignition in the form of fireballs is 1.12×10^{-4} time/year or 1.12 times in 10,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.
- For the pipeline of 6 inches in diameter and 129 meters in length, probability of accidental release and consequent ignition in the form of fireballs is 1.69×10^{-4} time/year or 1.69 times in 10,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.
- For the pipeline of 6 inches in diameter and 175 meters in length, probability of accidental release and consequent ignition in the form of fireballs is 2.30×10^{-4} time/year or 2.30 times in 10,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level.
- For the pipeline of 6 inches in diameter and 169 meters in length, probability of accidental release and consequent ignition in the form of fireballs is 2.22×10^{-4} time/year or 2.22 times in 10,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.
- For the pipeline of 6 inches in diameter and 257 meters in length, probability of accidental release and consequent ignition in the form of fireballs is 3.37×10^{-4} time/year or 3.37 times in 10,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

- For the pipeline of 5 inches in diameter and 45 meters in length, probability of accidental release and consequent ignition in the form of fireballs is 5.91×10^{-5} time/year or 5.91 times in 100,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of ‘Very Unlikely’. Also, the incident severity is at a minor level.

In the case of the accidental release resulting in vapor cloud explosion (VCE)

The pressure level of 0.69 bar is used in the assessment as this is the starting pressure level at which it can be severely damaging to the constructions and production devices in the vicinity. Risks in different scenarios as follows are summarized in **Table 5.5.6-9**.

- For the pipeline connected from the storage tank to the electricity generation unit, 12 inches in diameter and 104 meters in length, probability of accidental release and consequent VCE development in the area of the storage tank is 1.02×10^{-4} time/year or 1.02 times in 10,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of ‘Very Unlikely’. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.
- For the pipeline connected from the fuel oil transfer pump to each individual gas turbine, 12 inches in diameter and 78 meters in length, probability of accidental release and consequent VCE development is 7.68×10-5 time/year or 7.68 times in 100,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of ‘Very Unlikely’. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.
- For the pipeline of 10 inches in diameter and 128 meters in length, probability of accidental release and consequent VCE development is 1.26×10^{-4} time/year or 1.26 times in 10,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of ‘Very Unlikely’. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.
- For the pipeline of 8 inches in diameter and 114 meters in length, probability of accidental release and consequent VCE development is 1.12×10^{-4} time/year or 1.12 times in 10,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of ‘Very Unlikely’. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

- For the pipeline of 6 inches in diameter and 129 meters in length, probability of accidental release and consequent VCE development is 1.69×10^{-4} time/year or 1.69 times in 10,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

- For the pipeline of 6 inches in diameter and 175 meters in length, probability of accidental release and consequent VCE development is 2.30×10^{-4} time/year or 2.30 times in 10,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level.

- For the pipeline of 6 inches in diameter and 169 meters in length, probability of accidental release and consequent VCE development is 2.22×10^{-4} time/year or 2.22 times in 10,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

- For the pipeline of 6 inches in diameter and 257 meters in length, probability of accidental release and consequent VCE development is 3.37×10^{-4} time/year or 3.37 times in 10,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

- For the pipeline of 5 inches in diameter and 45 meters in length, probability of accidental release and consequent VCE development is 5.91×10^{-5} time/year or 5.91 times in 100,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

(c) Diesel storage tank

- **In the case of the accidental release resulting in pool fire**

The energy level at 12.5 kilowatts/square meter is used in the assessment as this is the starting energy level at which it can be fatal to humans. The probability of death is 1% if the victim is at the area exposed to such an energy level for more than one minute. Ten-second exposure to such an energy level can inflict skin burns. Risks in different scenarios as follows are summarized in **Table 5.5.6-10**.

TABLE 5.5.6-10

RESULTS OF THE ASSESSMENT OF THE RISK ASSOCIATED WITH THE PROJECT'S DIESEL STORAGE TANK FAILURES

Release hole size	Probability of ignition (time/year)			Severity level of the incident			Risk level
	Pool Fire	Fireball	risk level	Pool Fire	Fireball	VCE	
1 inch	4×10^{-6} (Very Unlikely)	1×10^{-4} (Very Unlikely)	1×10^{-4} (Very Unlikely)	Project site (Minor)	Project site, crop fields (Minor)	Project site, crop fields (Minor)	low
rupture	2.8×10^{-9} (Very Unlikely)	7×10^{-8} (Very Unlikely)	7×10^{-8} (Very Unlikely)	Project site (Minor)	Project site, crop fields, rubber fields, residential community areas, fruit gardens, government compounds, ponds/canals, oil palm plantations, business and industrial park areas (Major)	Project site, crop fields, rubber fields, residential community areas, fruit gardens, government compounds, ponds/canals, oil palm plantations, business and industrial park areas (Major)	low

For the area where the diesel storage tanks are located, probability of accidental release and consequent ignition in the form of pool fire is 4.00×10^{-6} time/year or 4.00 times in 1,000,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

- **In the case of the accidental release resulting in fire balls.**

The energy level at 12.5 kilowatts/square meter is used in the assessment as this is the starting energy level at which it can be fatal to humans. The probability of death is 1% if the victim is at the area exposed to such an energy level for more than one minute. Ten-second exposure to such an energy level can inflict skin burns. Risks in different scenarios as follows are summarized in **Table 5.5.6-10**.

For the area where the diesel storage tanks are located, probability of accidental release and consequent ignition in the form of fire balls is 1.00×10^{-4} time/year or 1.00 time in 10,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

- **In the case of the accidental release resulting in vapor cloud explosion (VCE)**

The pressure level of 0.69 bar is used in the assessment as this is the starting pressure level at which it can be severely damaging to the constructions and production devices in the vicinity. Risks in different scenarios as follows are summarized in **Table 5.5.6-10**.

For the area where the diesel storage tanks are located, probability of accidental release and consequent VCE development is 1.00×10^{-4} time/year or 1.00 time in 10,000 years (release hole of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

5.5.6.2 Assessment of Major Hazards Resulting from Leakage of Chemical Substances

In assessing level of severity of major hazards resulting from mishaps occurring where chemical substances are used and stored, the Material Safety Data Sheet (MSDS) is referred to. Among the 12 types of chemical substances used in the project, three are listed in the Hazardous Material Act 1992 and the Labor Protection Act 1998 – which are sulfuric acid, sodium hydroxide, and corrosion inhibitor, as shown in **Table 5.5.6-11**. For oxygen scavenger, the one used in the project contains no hydrazine, similar to what is used in Gulf Group's other power plant projects in operation.

For the chemical substances that need to be stored within the project premises, specific storage areas are allotted for different types of chemical substances depending on their properties with consideration on safety from possible chemical reaction. Furthermore, flammable materials are isolated in particularly appointed areas. The measures in dealing with the storage of chemical substances are as follows:

(1) Safety data on every chemical substance used in the project are to be collected, filed and displayed on the notice board or label attached to the container of each chemical substance.

(2) Chemical substances which quickly react to each other such as acid and alkali, or flammable chemical substances are to be kept separately.

(3) The places where chemical substances are kept must be well ventilated for the air to be well-circulated.

(4) Curbs are to constructed around storage tanks large enough to contain the chemical substance accidentally released, preventing the spread of the chemical substance on the building floor or into the gutters

(5) Notices warning against any action causing sparks in the premises are to be placed.

(6) Appropriate and sufficient firefighting equipment is to be provided in the premises.

Probability of incidents is considered low for the following reasons. First of all, the locations where the chemical substances are kept and used are in the power plant compound accessible only to the power plant staff. Moreover, several measures are taken in managing the storage of chemical substances. Warning notices are to be placed. The material safety data sheet is to be prepared for the staff working in the said locations. To be provided to the staff whose duty involves transportation and use of chemical substances are safety and protective equipment such as safety shower and eyewash kits, protective masks, gloves; as well as appropriate tools for transporting chemical substances. Equipment required in cleaning and disposing of accidentally released chemical substances is also readily and sufficiently available. Advice regarding the material safety data sheet is also provided to new staff members in their induction.

TABLE 5.5.6-11

COMPARATIVE ANALYSIS OF THE PROJECT'S CHEMICAL SUBSTANCE USE BASED ON APPLICABLE ACTS (WITH REFERENCE TO MSDS)

Name/general name of the chemical substance	Status	Amount used (cubic meter/year)	Manner of storage	Hazardous Material Act 1992	Lethal Weapon Control Act 1987	Labor Protection Act 1998	Toxicity/hazard, and fire
Sodium Chlorite ($NaClO_2$, 25%)	liquid	20 (for raw water treatment system) 20 (for liquid cooling system)	contained in a PE tank of approximately 40 m^3 and stored in the raw water treatment building, with a concrete dike built around the tank	-	-	-	**1) Toxicity/hazard** - Inhalation may cause irritation to the mucous membranes in the respiratory passages - Skin contact may cause moderate irritation and rash - Contact with the eye may cause severe irritation - Ingestion of the substance may cause irritation to the mucous membranes in the oral and pharyngeal cavities, stomach ache, and ulcers **2) Fire** - The substance is nonflammable, but contact with other substances may cause ignition. - In case of fire, apply dry chemical - Heat and combination / contamination with acid may cause toxic plumes that inflict irritation.
HCl 35%	liquid	20 (for raw water treatment system) 20 (for liquid cooling system)	contained in a PE tank of approximately 40 m^3 and stored in the raw water treatment building, with a concrete dike built around the tank	-	-	✓	**1) Toxicity/hazard** - Inhalation of the vapor of the substance may cause coughing, difficulty in breathing, irritation in the nasal and pharyngeal cavities, as well as in the upper part of the respiratory passage. In severe cases, pulmonary edema symptom and respiratory system failure may ensue resulting in death.

TABLE 5.5.6-11

COMPARATIVE ANALYSIS OF THE PROJECT'S CHEMICAL SUBSTANCE USE BASED ON APPLICABLE ACTS (WITH REFERENCE TO MSDS) (CONT'D)

Name/general name of the chemical substance	Status	Amount used (cubic meter/year)	Manner of storage	Hazardous Material Act 1992	Lethal Weapon Control Act 1987	Labor Protection Act 1998	Toxicity/hazard, and fire
HCl 35% (Cont'd)							- Skin contact may cause irritation, rash, pain and burns, or blister in the case of exposure to the substance in high concentration. - Contact with the eye may inflict severe irritation and acute burns causing permanent damage to the eye. - Ingestion of the substance may cause irritation, pain and inflammation in the mouth, throat, esophagus, and alimentary canal; nausea, diarrhea, and possible death. **2) Fire** - When the substance is in contact with heat, hydrogen, which is inflammable, is emitted.
Ferric Chloride 40%	liquid	1,120	contained in a PE tank of approximately 120 m^3 and stored in the raw water treatment building, with a concrete curbs built around the tank	-	-	-	**1) Toxicity/hazard** - The substance may be absorbed through the skin and damage the skin. - Skin contact may cause burns. - Inhalation may cause very severe damage to the mucous membranes and the upper part of the respiratory passage. - Contact with the eye may cause irritation and burns. - Ingestion of the substance may cause burns and is harmful. **2) Fire** - The substance is nonflammable, but can emit toxic vapor when in contact with fire.

TABLE 5.5.6-11

COMPARATIVE ANALYSIS OF THE PROJECT'S CHEMICAL SUBSTANCE USE BASED ON APPLICABLE ACTS (WITH REFERENCE TO MSDS) (CONT'D)

Name/general name of the chemical substance	Status	Amount used (cubic meter/year)	Manner of storage	Hazardous Material Act 1992	Lethal Weapon Control Act 1987	Labor Protection Act 1998	Toxicity/hazard, and fire
Polymer	solid	40	contained in a bag inside an FRP tank of approximately 16 cubic meters and stored in the raw water treatment building, with a concrete dike built around the tank	-	-	-	**1) Toxicity/hazard** - Skin contact may cause burns, and may cause the skin to become red. - Contact with the eye may cause irritation. **2) Fire** - The substance is nonflammable.
Sodium hydroxide	liquid	245	contained in an FPR tank of approximately 30 cubic meters and stored in the raw water treatment building, with a concrete dike built around the tank	✓ 1/	-	✓	**1) Toxicity/hazard** - Inhalation may cause irritation, damage to the upper respiratory passage, sneezing, pain in the throat, runny nose, acute pneumonitis, shortness of breath and difficulty in breathing. - Skin contact may cause acute irritation, inflammatory wounds, and blisters. - Contact with the eye, owing to the corrosive property of the substance, may cause acute irritation and burns, which possibly results in blindness. - Ingestion may cause burns in the mouth, throat, stomach, which consequently inflict wounds, bleeding in the stomach, vomiting, diarrhea, low blood pressure, and possibly death. - In terms of carcinogenicity and other abnormalities, • Prolonged exposure may cause damage to the tissues.

TABLE 5.5.6-11

COMPARATIVE ANALYSIS OF THE PROJECT'S CHEMICAL SUBSTANCE USE BASED ON APPLICABLE ACTS (WITH REFERENCE TO MSDS) (CONT'D)

Name/general name of the chemical substance	Status	Amount used (cubic meter/year)	Manner of storage	Hazardous Material Act 1992	Lethal Weapon Control Act 1987	Labor Protection Act 1998	Toxicity/hazard, and fire
							2) Fire - The substance is nonflammable. However, when in contact with heat, or when melting, it will react violently with water, causing it to have reaction with metal, for example aluminum and consequently produce hydrogen, which is inflammable. - In case of fire, use firefighting materials/methods appropriate for the circumstances. No water is to be used in firefighting. Also, wear self-contained breathing apparatus (SCBA).
Sodium Bisulfite 1%	solid	15	Contained in a PE tank of approximately 1 cubic meter and stored in the mixed bed resin regeneration building, with a concrete dike built around the tank.	-	-	-	**1) Toxicity/hazard** - Inhalation may cause irritation to the mucous membranes in the respiratory passage, coughing, and difficulty in breathing - Skin contact may cause irritation - Contact with the eye may cause irritation, conjunctivitis, and sore eyes. Severe corneal damage may be inflicted, resulting in blindness. - Ingestion may cause the substance to react with acid resulting in toxic gas which may consequently inflict irritation to the respiratory system, nausea, vomiting, depression, stomach ache, irritation to the mucous membranes in the mouth, bronchus, esophagus, and intestinal/ digestive system.

TABLE 5.5.6-11

COMPARATIVE ANALYSIS OF THE PROJECT'S CHEMICAL SUBSTANCE USE BASED ON APPLICABLE ACTS (WITH REFERENCE TO MSDS) (CONT'D)

Name/general name of the chemical substance	Status	Amount used (cubic meter/year)	Manner of storage	Hazardous Material Act 1992	Lethal Weapon Control Act 1987	Labor Protection Act 1998	Toxicity/hazard, and fire
							2) Fire - The substance is nonflammable and non-explosive. - In case of fire, use firefighting materials/methods appropriate for the circumstances. No water is applied in firefighting. No water is to flow into the gutters or other water sources. - Additionally, full protective breathing apparatus and protective clothing must be worn to prevent contact with the skin and eyes.
RO Antiscalant	liquid	5	Contained in a PE tank of approximately 0.1 cubic meter and stored in the mixed bed resin regeneration building, with a concrete dike built around the tank.	No data	No data	No data	**1) Toxicity/hazard** - No data are provided on toxicity in case of inhaling and ingesting. - Prolonged skin contact may cause irritation - Prolonged contact with these may cause irritation. - In terms of carcinogenicity and other abnormalities, • Damage to teeth and cardiovascular system may be inflicted. **2) Fire** - The substance is nonflammable. - In case of fire, use firefighting materials/methods appropriate for the circumstances. - Ignition leads to production of oxide of carbon and oxide of phosphorus.

TABLE 5.5.6-11

COMPARATIVE ANALYSIS OF THE PROJECT'S CHEMICAL SUBSTANCE USE BASED ON APPLICABLE ACTS (WITH REFERENCE TO MSDS) (CONT'D)

Name/general name of the chemical substance	Status	Amount used (cubic meter/year)	Manner of storage	Hazardous Material Act 1992	Lethal Weapon Control Act 1987	Labor Protection Act 1998	Toxicity/hazard, and fire
Sulfuric Acid (H_2SO_4)	liquid	10	Contained in a carbon steel tank of approximately 3 cubic meters and stored in the mixed bed resin regeneration building, with a concrete dike built around the tank.	✓ 3/	-	✓	1) Toxicity/hazard - As the substance has corrosive property, inhalation may cause irritation in the respiratory passage, pulmonary edema symptom, sore throat, coughing, shortness of breath and difficulty in breathing. Inhalation of the substance in high concentration can be fatal. - As the substance has corrosive property, skin contact may cause burns and inflammatory pain. - As the substance has corrosive property, contact with the eye may cause conjunctivitis, sore eyes, and blurred vision. - Ingestion of the substance may cause nausea and vomiting, but no effect to the tissues. - In terms of carcinogenicity and other abnormalities, • Damage to teeth and cardiovascular system may be inflicted. 2) Fire - The substance is nonflammable. In the case of fire, apply carbon dioxide, dry chemical powder and then water. - Ignition leads to production of oxide of sulfur, which reacts to organic substance and consequently may cause fire and explosion.

TABLE 5.5.6-11

COMPARATIVE ANALYSIS OF THE PROJECT'S CHEMICAL SUBSTANCE USE BASED ON APPLICABLE ACTS (WITH REFERENCE TO MSDS) (CONT'D)

Name/general name of the chemical substance	Status	Amount used (cubic meter/year)	Manner of storage	Hazardous Material Act 1992	Lethal Weapon Control Act 1987	Labor Protection Act 1998	Toxicity/hazard, and fire
Citric Acid	solid	10	Contained in a PE tank of approximately 2 cubic meters and stored in the mixed bed resin regeneration building, with a concrete dike built around the tank. .	No data	No data	No data	**1) Toxicity/hazard** - Inhalation may cause irritation to the mucous membranes in the respiratory passage. - Skin contact may cause mild to moderate irritation and skin allergic reaction, which becomes evident upon re-exposure to this material. - Contact with the eye may cause mild to moderate irritation and possible injury. - Ingestion may cause irritation to the alimentary canal resulting in nausea, and vomiting. Excessive intake can cause dental damage; and calcium deficiency in blood, which will adversely affect the central nervous system and may result in tremor, convulsion and muscle spasticity. **2) Fire** - The substance is mildly inflammable when in contact with heat. - In case of small fire, use dry chemical. For big fire, use water spray, or chemical foam. Do not use water jet.
Oxygen Scavenger	liquid	15	contained in a stainless tank of approximately 1,000 liters and kept in the compound of the	-	-	-	**1) Toxicity/hazard** - The substance is corrosive and may cause irritation to the respiratory system if inhaled. - Prolonged skin contact may cause irritation. - Prolonged contact with the eye may cause irritation.

TABLE 5.5.6-11

COMPARATIVE ANALYSIS OF THE PROJECT'S CHEMICAL SUBSTANCE USE BASED ON APPLICABLE ACTS (WITH REFERENCE TO MSDS) (CONT'D)

Name/general name of the chemical substance	Status	Amount used (cubic meter/year)	Manner of storage	Hazardous Material Act 1992	Lethal Weapon Control Act 1987	Labor Protection Act 1998	Toxicity/hazard, and fire
			chemical substance storage building, with a tray put under it to prevent accidental release				- Ingestion may cause irritation to the alimentary canal resulting in nausea, and vomiting. - In terms of carcinogenicity and other abnormalities, • Damage to teeth and cardiovascular system may be inflicted. 2) Fire - The substance is nonflammable. - In case of fire, use carbon dioxide, dry chemical powder and then water. - In case of fire, use firefighting materials/methods appropriate for the circumstances. Additionally, full protective breathing apparatus and protective clothing must be worn to prevent contact with the skin and eyes. - Ignition leads to production of oxide of nitrogen and oxide of carbon.
Aqueous Ammonia 25 %	liquid	45	Contained in a stainless tank of approximately 1,000 liters and kept in the compound of the chemical substance storage building, with a tray put under it to	-	-	-	**1) Toxicity/hazard** - Inhalation may cause irritation to the respiratory passage, and if in high concentration, may inflict inflammatory wounds, pulmonary edema and death. The concentration level which can be lethal is 5,000 ppm - Skin contact cause irritation and inflammatory wounds.

TABLE 5.5.6-11

COMPARATIVE ANALYSIS OF THE PROJECT'S CHEMICAL SUBSTANCE USE BASED ON APPLICABLE ACTS (WITH REFERENCE TO MSDS) (CONT'D)

Name/general name of the chemical substance	Status	Amount used (cubic meter/year)	Manner of storage	Hazardous Material Act 1992	Lethal Weapon Control Act 1987	Labor Protection Act 1998	Toxicity/hazard, and fire
			prevent accidental release.				- Contact with the eye may cause irritation, and sore eyes. Damage may be inflicted, resulting in blindness. Clean water should be applied to the eye within 15 minutes of the contact. - Ingestion may cause irritation to the esophagus and stomach and may as well inflict abdominal perforation and peritonitis resulting in painful ache in the mouth, chest, abdomen, coughing, vomiting and unconsciousness. - In terms of carcinogenicity and other abnormalities, • Prolonged exposure causes damage to mucous membranes, upper respiratory passage, eyes, and skin. 2) Fire - The substance vapor may suspend in poorly-ventilated areas. - In case of fire, use firefighting materials/methods appropriate for the circumstances. - Cool containers in contact with fire with flows of water and flush clean the spill or vapor that has not yet combusted. - In case of fire, wear self-contained breathing apparatus (SCBA) approved by the National Institute for Occupational Safety and Health (NIOSH) together with a full face mask.

TABLE 5.5.6-11

COMPARATIVE ANALYSIS OF THE PROJECT’S CHEMICAL SUBSTANCE USE BASED ON APPLICABLE ACTS (WITH REFERENCE TO MSDS) (CONT’D)

Name/general name of the chemical substance	Status	Amount used (cubic meter/year)	Manner of storage	Hazardous Material Act 1992	Lethal Weapon Control Act 1987	Labor Protection Act 1998	Toxicity/hazard, and fire
Trisodium Phosphate	solid	30	Contained in a stainless tank of 500 liters and kept in the compound of the chemical substance storage building, with a tray put under it to prevent accidental release.	-	-	-	**1) Toxicity/hazard** – Inhalation may cause severe irritation and burns in the nasal cavity, throat, and respiratory passage, coughing, difficulty in breathing, and can be lethal. – Skin contact may cause irritation, rash, and burns. Absorption through the skin may cause coughing and breathing difficulty. – Contact with the eye may cause irreversible damage. Symptoms include burns, tears, conjunctivitis, swelling, and corneal damage resulting in blindness. – Ingestion may cause irritation to the stomach and intestines resulting in nausea, vomiting, diarrhea, and abdominal pain. In the case of haematemesis, burns will be inflicted causing damage to the tissues in the mouth, throat, and alimentary canal, resulting in coughing and breathing difficulty in severe cases. – In terms of carcinogenicity and other abnormalities, • The substance is non-carcinogenic • Damage to the nose, throat, respiratory passage, eyes, and lungs can be inflicted.

TABLE 5.5.6-11

COMPARATIVE ANALYSIS OF THE PROJECT'S CHEMICAL SUBSTANCE USE BASED ON APPLICABLE ACTS (WITH REFERENCE TO MSDS) (CONT'D)

Name/general name of the chemical substance	Status	Amount used (cubic meter/year)	Manner of storage	Hazardous Material Act 1992	Lethal Weapon Control Act 1987	Labor Protection Act 1998	Toxicity/hazard, and fire
							2) Fire - The substance is nonflammable. - In case of fire, use firefighting materials/methods appropriate for the circumstances. - In case of fire, wear self-contained breathing apparatus (SCBA) approved by the National Institute for Occupational Safety and Health (NIOSH) together with a full face mask. - Decomposition of the substance during the ignition results in a toxic substance being produced, which causes irritation. - In case of decomposition, phosphorus oxide and sodium oxide will be produced.
Scale and Corrosion Inhibitor	liquid	120	Contained in a PE tank of approximately 2 cubic meters and kept in the compound of the chemical substance building, with a concrete dike built around the tank.	✓[3/]	-	✓	**1) Toxicity/hazard** - No data are available on toxicity or, hazard from inhalation and ingestion of the substance. - Skin contact may cause irritation. - Contact with the eye may cause irritation. - No data are available on Carcinogenicity nor other abnormalities. **2) Fire** - The substance is nonflammable. - In case of fire, use firefighting materials/methods appropriate for the circumstances.

TABLE 5.5.6-11

COMPARATIVE ANALYSIS OF THE PROJECT'S CHEMICAL SUBSTANCE USE BASED ON APPLICABLE ACTS (WITH REFERENCE TO MSDS) (CONT'D)

Name/general name of the chemical substance	Status	Amount used (cubic meter/year)	Manner of storage	Hazardous Material Act 1992	Lethal Weapon Control Act 1987	Labor Protection Act 1998	Toxicity/hazard, and fire
							- In case of fire, wear self-contained breathing apparatus (SCBA).

Remark : - Not identified as hazardous material according to Hazardous Material Act 1992, Lethal Weapon Control Act 1987, and Labor Protection Act 1998 Hazardous materials are categorized with respect to control necessities as follows:

[1/] Hazardous material Type 1 is the hazardous material of which the manufacturing, importation ,exportation, or possession must be in compliance with applicable criteria and manners.

[2/] Hazardous material Type 2 is the hazardous material of which the manufacturing, importation ,exportation, or possession must be notified to the relevant authorities and be in compliance with applicable criteria and manners.

[3/] Hazardous material Type 3 is the hazardous material of which the manufacturing, importation ,exportation, or possession must be authorized.

[4/] Hazardous material Type 4 is the hazardous material of which the manufacturing, importation ,exportation, or possession is prohibited.

[5] Hazardous material Type 5 is the hazardous material for which health check-ups for the employees must be arranged by the employer by virtue of the Ministry of Labor Announcement thereon, 2009

Source : Gulf PD Co., Ltd., 2016

5.5.6.3 Assessment of Major Hazards Resulting from Mechanical Failure

(1) Screening of things that pose risks and may be hazardous in the project

Screening things that pose risks and may be hazardous in the project or listing them helps lead to revision of the project's fundamental production process by assessing the manners and procedures of production with likelihood of serious incidents. The data collected are to be verified prior to being further employed in the major hazard assessment.

Regarding the project's electricity production process, things that pose risks and may be hazardous include the gas turbine, steam boiler, steam turbine, electricity generator, and electricity transformer, for example.

(2) Identification of hazards

Listing things that pose risks and may be hazardous in the project helps lead to identification of risks and hazards. To analyze the causes and results of the faults identified and define the nature of the related mishaps, Fault Tree Analysis (FTA) is employed. FTA is a tool for safety analysis whereby undesired outcomes from an initiating event are assessed. The causes of the initiating event are also assessed with respect to their natures represented by symbols such as 'And Gate', 'Or Gate', or others (**Table 5.5.6-12**). Possible sequences of events that could result in an incident are analyzed until preventive measures can be formulated. Steps in the Fault Tree Analysis are as follows:

(a) Select a failure possible to happen as the 'top event'.

(b) Assess the failure - which may happen because of only one of certain possible event inputs, represented by the symbol "or".

(c) In case the failure happens because of several possible event inputs, this is represented by the symbol "and".

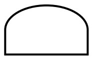
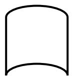
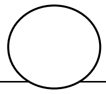
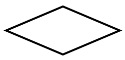
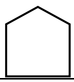
(d) The event input identified may happen because of another possible event input or several possible event inputs, for which the symbol "or" or "and" is used depending on the case.

(e) The final input can be as follows:

- Basic event
- Undeveloped event (can be because it is of insufficient consequence or because information is unavailable)
- External event(including natural phenomena such as thunder and lightning)

The results of hazard identification are shown from **Figure 5.5.6-30 to Figure 5.5.6-33.**

TABLE 5.5.6-12
SYMBOLS USED IN HAZARD IDENTIFICATION ANALYSIS

Symbol	Name	Meaning
	AND Gate	An event occurs if several input conditions are met
	Or Gate	An event occurs as long as one of the input events takes place
	Basic Event	A basic initiating fault requiring no further investigation for its cause.
	Fault Tree Event	An intermediate event that causes another event to happen, leading to the failure which is the top event
	Undeveloped Event	An intermediate event requiring no further investigation for its cause because of a lack of supporting information.
	External Event	An external event or factor causing a failure to occur

Source : Regulations of Department of Industrial Works on criteria in hazard identification, risk assessment, and formulation of risk management plans, 2000

(3) Risk assessment

Risk assessment involves the analysis of the probability and severity of identified hazards. In this study, major hazards having been identified are to be analyzed with respect to their risk level - whether they are at a low, acceptable, high, or unacceptable level of risk. The data acquired are to be used in the risk control management. From the hazard identification, possible hazards include explosion of the steam boiler, steam turbine, electricity generator; and accidental release of chemical substances. The criteria and results of the assessment are in accordance with those stipulated in the Regulations of Department of Industrial Works on criteria in hazard identification, risk assessment, and formulation of risk management plans (2000). In the assessment the probability of the incident is multiplied by the severity level that impacts an individual/community/ environment and property, as follows

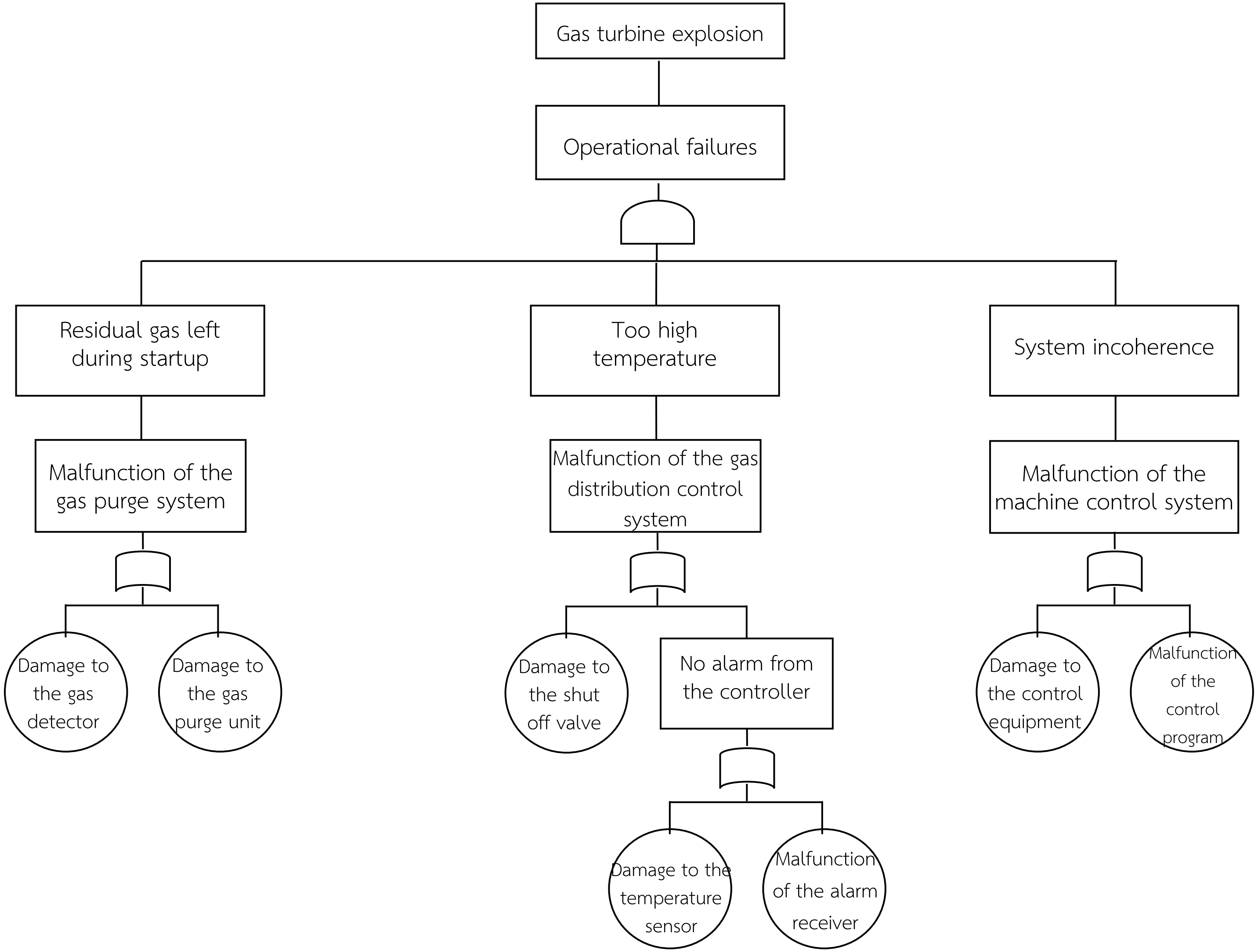


FIGURE 5.5.6-30 : FAULT TREE ANALYSIS IN THE CASE OF GAS TURBINE EXPLOSION

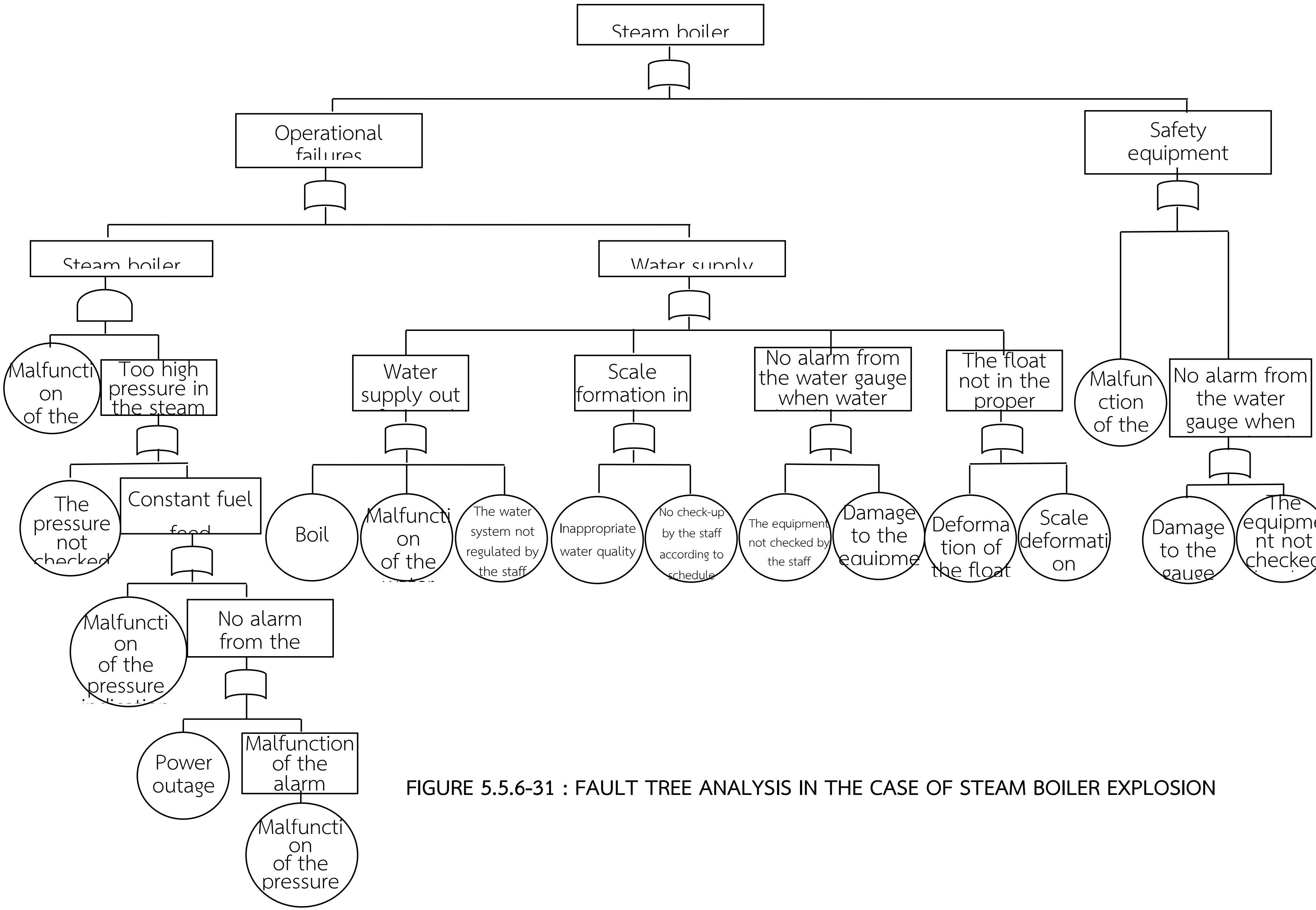


FIGURE 5.5.6-31 : FAULT TREE ANALYSIS IN THE CASE OF STEAM BOILER EXPLOSION

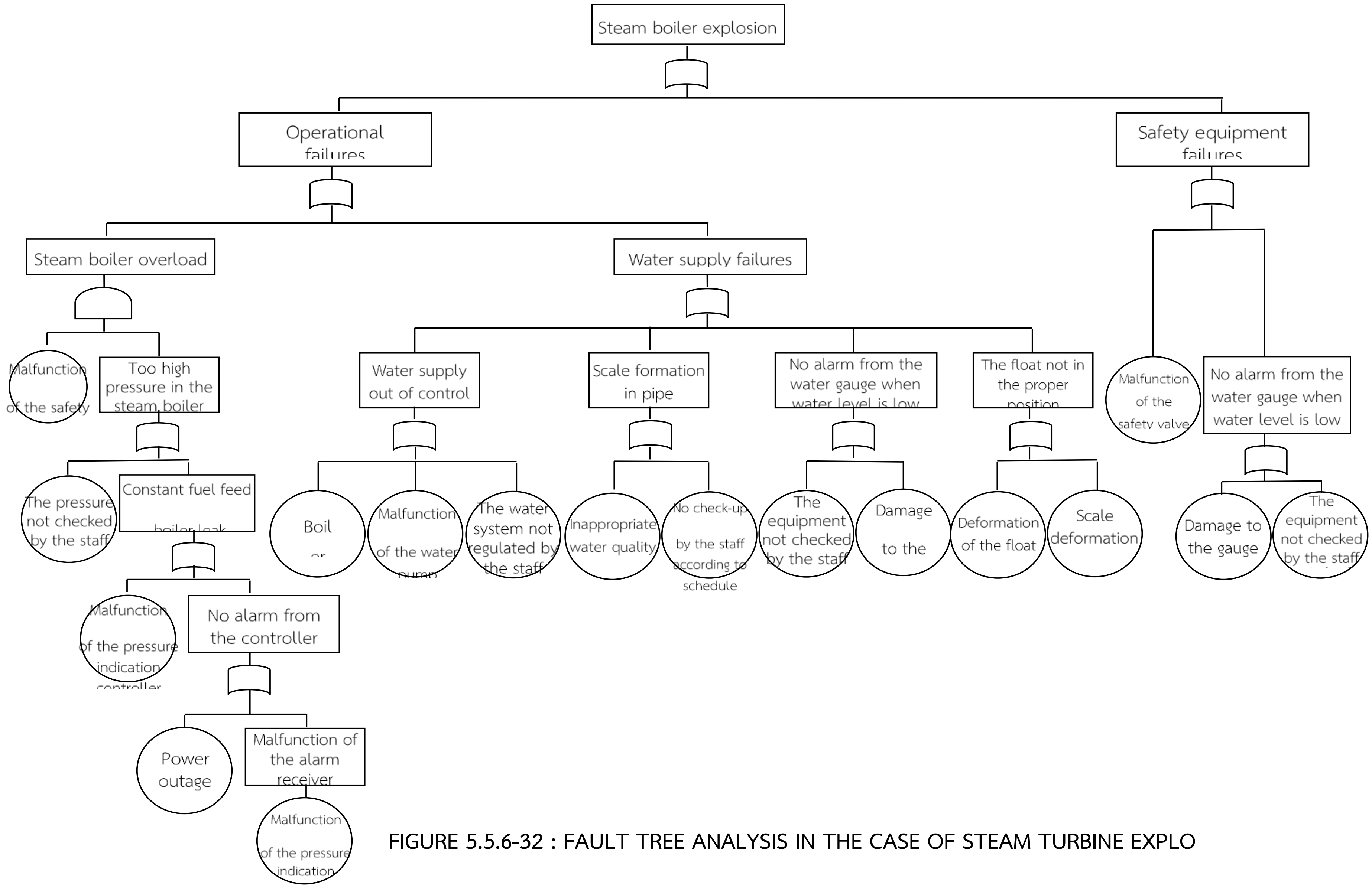


FIGURE 5.5.6-32 : FAULT TREE ANALYSIS IN THE CASE OF STEAM TURBINE EXPLO

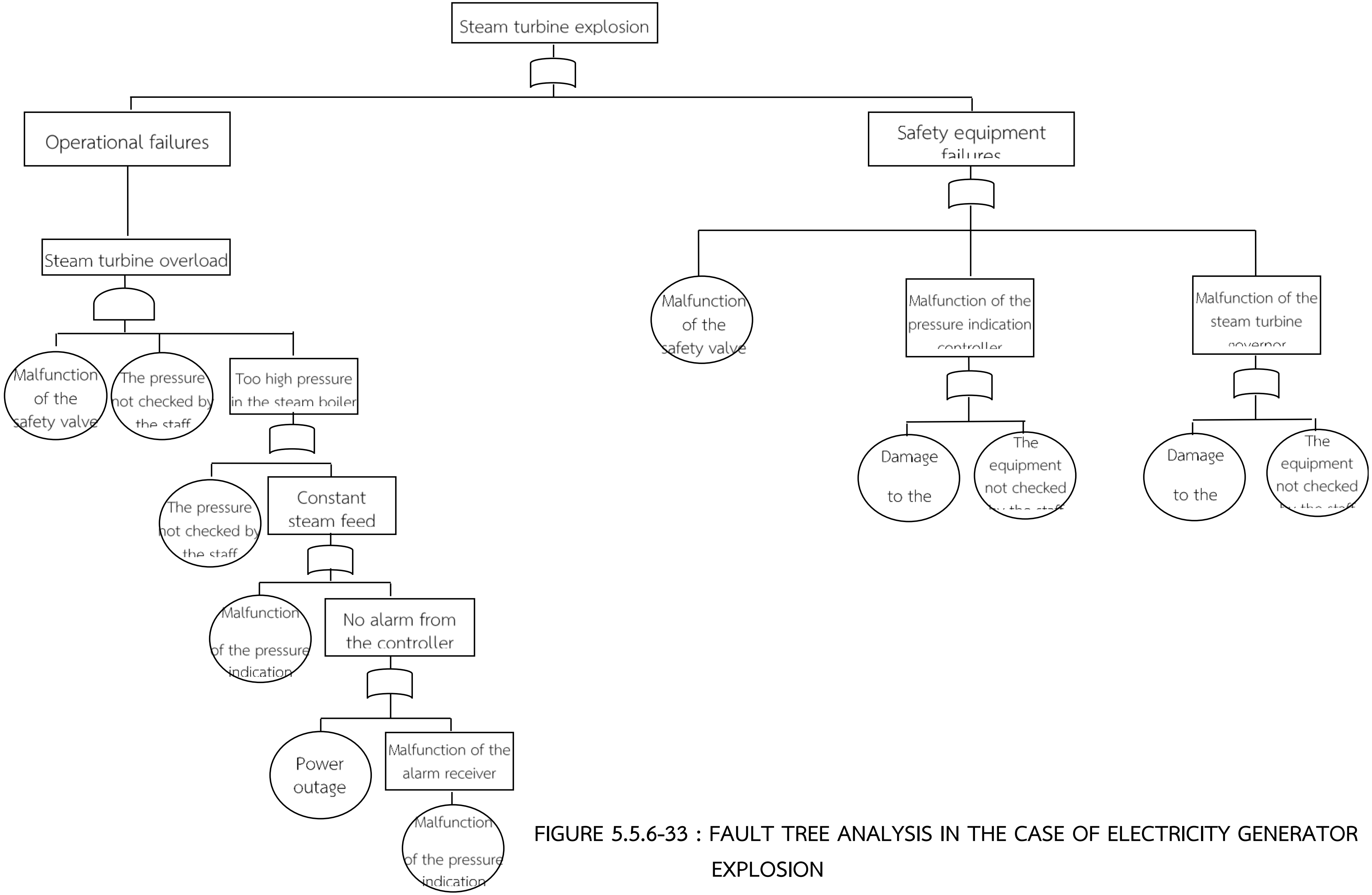


FIGURE 5.5.6-33 : FAULT TREE ANALYSIS IN THE CASE OF ELECTRICITY GENERATOR EXPLOSION

(a) Four levels of failure probability are defined, as follows:

Level	Definition
1	rare probability of occurrence – for example never in more than ten years
2	low probability of occurrence – for example once in 5-10 years
3	moderate probability of occurrence – for example once in 1-5 years
4	high probability of occurrence – for example more than once in a year

(b) Levels of failure severity are defined based on its impact on an individual/community/environment and property, as follows:

(b1) Levels of failure severity based on its impact on an individual

Level	Severity	Definition
1	low	The failure could result in minor injury for which only first aid administration is required.
2	moderate	The failure could result in injury requiring medical treatment.
3	high	The failure could result in severe injury or illness.
4	very high	The failure could result in disability or death.

(b2) levels of failure severity based on its impact on a community

Level	Severity	Definition
1	low	The failure could incur no or only negligible impact on the communities nearby.
2	moderate	The failure could have impact on the communities nearby, but can be manageable in a short period of time.
3	high	The failure could have impact on the communities nearby, and it takes time to manage.
4	very high	The failure could have extensive impact on the communities nearby and needs to be tackled by the government.

Remark : **I**mpact on the communities include disturbances, injuries or illnesses incurred to the people, and damage to property.

(b3) Levels of failure severity based on its impact on the environment

Level	Severity	Definition
1	low	The failure could incur marginal impact on the environment and is manageable.
2	moderate	The failure could have moderate impact on the environment, but can be manageable in a short period of time.
3	high	The failure could have impact on the environment, and it takes time to manage.
4	very high	The failure could have extensive impact and it takes a lot of resources and time to manage.

Remark : Impact on the environment means the deterioration of the environment and the destruction of ecosystems such as air, water, and soil.

(b4) Levels of failure severity based on its impact on the property

Level	Severity	Definition
1	low	The failure could incur no or only negligible damage to the property.
2	moderate	The failure could incur moderate damage to the property, but will not disrupt the production process.
3	high	The failure could incur considerable damage to the property, and will disrupt some parts of the production process.
4	very high	The failure could incur severe damage to the property, and will completely disrupt the production process.

Remark : The levels of property damage can be defined and adapted according to each plant's production capacity.

(c) Levels of risk are defined by the results of the probability of the incident multiplied by the severity level that impacts an individual/community/environment and property. If the levels of risk affecting individuals, communities, property or the environment are different, the highest risk level shall be selected as the outcome of the assessment of the risk in question. Four levels of risk are classified as follows:

Level	Severity	Definition
1	1-2	The risk is of low level.
2	3-6	The risk is of acceptable level and revision of the control measures is required.
3	8-9	The risk is of high level and mitigative action is required.
4	12-16	The risk is of unacceptable level, immediately requiring a cease in operation and corrective action to reduce the risk.

According to data on the possible hazards resulting from mechanical failures, as shown in **Table 5.5.6-13 and Table 5.5.6-14**, the failure rates, which are the numbers of times the failures identified can occur in a year are as follows:

Failure caused by an individual	=	1×10^{-3} time per year
Failure due to the safety valve	=	0.02 time per year
Failure due to the steam boiler	=	9.3981×10^{-3} time per year
Failure due to the pressure indication controller	=	1.15 time per year
Failure due to the relay	=	0.08 time per year
Failure due to the temperature sensor	=	0.94 time per year
Failure due to the water gauge	=	8.2 × 10-6 time per year
Failure due to power outage	=	10 time per year
Failure due to the nuts, bolts, or seals	=	1.708×10^{-3} time per year

As shown in **Table 5.5.6-14**, the failure rates, which are the numbers of times the failures occur in a year are as follows:

Failure due to malfunction of the pump	=	0.026 time per year
Failure due to steam turbine governor	=	0.0026 time per year
Instrument failure	=	0.0087 time per year

The levels of risk or failure probability due to the equipment mentioned above are evaluated in accordance with the criteria and results stipulated in the Regulations of the Department of Industrial Works on criteria in hazard identification, risk assessment, and formulation of risk management plans (2000). Four levels of failure probability are defined, as follows:

Level	definition
1	rare probability of occurrence – for example never in more than ten years
2	low probability of occurrence – for example once in 5-10 years
3	moderate probability of occurrence – for example once in 1-5 years
4	high probability of occurrence – for example more than once in a year

The levels of risk or failure probability due to the equipment aforementioned are shown in **Table 5.5.6-13** and **Table 5.5.6-14**.

Failure caused by an individual	level of failure probability = 1
Failure due to the safety valve	level of failure probability = 1
Failure due to the steam boiler	level of failure probability = 1
Failure due to the pressure indication controller	level of failure probability = 3
Failure due to the relay	level of failure probability = 1

TABLE 5.5.6-13
FREQUENCY PROBABILITY OF INCIDENTS OCCURRING DUE TO MECHANICAL FAILURES

Type of mechanical failures	Frequency (time/year)	Level of failure probability
Smith and Warwick (1981)		
Power Failure (PEA)	10	4 (high probability of occurrence)
Limit switch failure	1×10^{-4}	1 (rare probability of occurrence)
Level switch failure	8.2×10^{-6}	1 (rare probability of occurrence)
Operator Error	1×10^{-3}	1 (rare probability of occurrence)
Pressure control fault	1×10^{-4}	1 (rare probability of occurrence)
Solenoid valve fail to close	1×10^{-3}	1 (rare probability of occurrence)
Level alarm failure	8.2×10^{-6}	1 (rare probability of occurrence)
Vent Gas failure	2×10^{-5}	1 (rare probability of occurrence)
Inter-unit pipe (general)	3.5×10^{-7}	1 (rare probability of occurrence)
Emergency gen. Fault	1×10^{-5}	1 (rare probability of occurrence)
Mechanical failure	7×10^{-3}	1 (rare probability of occurrence)
P. Trip signal	5.4×10^{-4}	1 (rare probability of occurrence)
No immediate ignition	1.4×10^{-3}	1 (rare probability of occurrence)
Immediate ignition	0.9386	3 (moderate probability of occurrence)
Sudden Weather Change	1×10^{-2}	1 (rare probability of occurrence)
Third Party Error	1×10^{-3}	1 (rare probability of occurrence)
Impulse lines (blocked or leaking)	0.09	1 (rare probability of occurrence)
Pressure switch	0.13	2 (low probability of occurrence)
Cable (fractured or severed)	0.03	1 (rare probability of occurrence)
Loss of electric power Steam	0.05	1 (rare probability of occurrence)
Relay (complete with wire)	0.08	1 (rare probability of occurrence)
Solenoid valve	0.30	3 (moderate probability of occurrence)
Loss of electric power	0.05	1 (rare probability of occurrence)
Trip valve	0.25	3 (moderate probability of occurrence)
Air Supply line (block, broken)	0.02	1 (rare probability of occurrence)
Loss of air supply	0.02	1 (rare probability of occurrence)
Relay, etc., as above	0.08	1 (rare probability of occurrence)
Pressure relief valve	0.02	1 (rare probability of occurrence)
Flame-failure detector	1.69	4 (high probability of occurrence)

Source : ILO (International Labor Organization, Major Hazard Control), 1998

TABLE 5.5.6-13
FREQUENCY PROBABILITY OF INCIDENTS OCCURRING DUE TO MECHANICAL FAILURES (CONT'D)

Type of mechanical failures	Frequency (time/year)	Level of failure probability
Less, 1983; King ,1990		
Pressure vessels (general)	0.026	1 (rare probability of occurrence)
Pressure vessels (high standard)	2.56×10^{-3}	1 (rare probability of occurrence)
Pipes	1.71×10^{-3}	1 (rare probability of occurrence)
Pipe joints	4.27×10^{-3}	1 (rare probability of occurrence)
Gaskets	4.27×10^{-3}	1 (rare probability of occurrence)
Bellows	0.043	1 (rare probability of occurrence)
Diaphragms (metal)	0.043	1 (rare probability of occurrence)
Diaphragms (rubber)	0.068	1 (rare probability of occurrence)
Unions	3.42×10^{-3}	1 (rare probability of occurrence)
Hoses (heavily stressed)	0.342	1 (rare probability of occurrence)
Hoses (lightly stressed)	0.0342	1 (rare probability of occurrence)
Relief valves (leakage)	0.017	1 (rare probability of occurrence)
Relief valves (blockage)	4.27×10^{-3}	1 (rare probability of occurrence)
Valves (hand-operated)	0.128	2 (low probability of occurrence)
Valves (ball)	4.27×10^{-3}	1 (rare probability of occurrence)
Seals (rotating)	0.0598	1 (rare probability of occurrence)
Seals (sliding)	0.0256	1 (rare probability of occurrence)
Seals ("o" ring)	1.708×10^{-3}	1 (rare probability of occurrence)
Filters (blockage)	8.544×10^{-3}	1 (rare probability of occurrence)
Filters (leakage)	8.544×10^{-3}	1 (rare probability of occurrence)
Pins	0.128	2 (low probability of occurrence)
Nuts	1.708×10^{-3}	1 (rare probability of occurrence)
Bolts	1.708×10^{-3}	1 (rare probability of occurrence)
Boiler (all types)	9.398×10^{-3}	1 (rare probability of occurrence)
Pressure-indicating controller	1.15	4 (high probability of occurrence)
Pressure-recovery controller	1.29	4 (high probability of occurrence)
Flow-indicating controller	1.51	4 (high probability of occurrence)
Flow-recording controller	2.14	4 (high probability of occurrence)
Level-indicating controller	2.37	4 (high probability of occurrence)
Level-recording controller	2.25	4 (high probability of occurrence)
Temperature-indicating controller	0.94	3 (moderate probability of occurrence)
Temperature-recording controller Trip initiator	1.99	4 (high probability of occurrence)

Source : ILO (International Labor Organization, Major Hazard Control), 1998

TABLE 5.5.6-14
PROBABILITY OF MECHANICAL FAILURES

Equipment involved	Nature of failure	Failure rate	Level of failure probability
Batteries Power supplies	No output	3×10^{-6} time/hour	1 (rare probability of occurrence)
Circuit breakers	Failure to operate Premature transfer	1×10^{-3} time/hour 1×10^{-6} time/hour	4 (high probability of occurrence) 1 (rare probability of occurrence)
Diesel (complete plant) (emergency loads) Diesel (engine only)	Failure to start Failure to run Failure to run	3×10^{-2} time/day 3×10^{-3} time/hour 3×10^{-4} time/hour	4 (high probability of occurrence) 4 (high probability of occurrence) 4 (high probability of occurrence)
Electric Motors	Failure to start Failure to run Failure to run-extreme environment	3×10^{-4} time/day 1×10^{-5} time/year 1×10^{-3} time/hour	2 (low probability of occurrence) 1 (rare probability of occurrence) 4 (high probability of occurrence)
Fuses	Premature, open Failure to open	1×10^{-6} time/hour 1×10^{-5} time/hour	1 (rare probability of occurrence) 1 (rare probability of occurrence)
Gaskets	Leak	3×10^{-6} time/hour	1 (rare probability of occurrence)
Flanges, Closures, Elbows	Leak/rupture	3×10^{-7} time/hour	1 (rare probability of occurrence)
Instrumentation(amplification, annunciators,	Failure to operate	1×10^{-6} time/hour	1 (rare probability of occurrence)
transducers, calibration, combination)	Shifts	3×10^{-5} time/hour	3 (moderate probability of occurrence)
Pipe >3”, high quality	Rupture (section)	1×10^{-10} time/hour	1 (rare probability of occurrence)
Pipes <3”	Rupture	1×10^{-9} time/hour	1 (rare probability of occurrence)
Pumps	Failure to start Failure to run-normal Failure to run-extreme environment	1×10^{-3} time/day 3×10^{-5} time/hour 1×10^{-3} time/hour	3 (moderate probability of occurrence) 3 (moderate probability of occurrence) 4 (high probability of occurrence)

TABLE 5.5.6-14
PROBABILITY OF MECHANICAL FAILURES (CONT'D)

Equipment involved	Nature of failure	Failure rate	Level of failure probability
Relays	Failure to energize	1×10^{-4} time/day	1 (rare probability of occurrence)
	Failure-no contact to close	3×10^{-7} time/hour	1 (rare probability of occurrence)
	Short Across NO/NC contact	1×10^{-8} time/hour	1 (rare probability of occurrence)
	Open NC contact	1×10^{-7} time/hour	1 (rare probability of occurrence)
Solid State Devices	Fails to function	3×10^{-6} time/hour	1 (rare probability of occurrence)
	Shorts	1×10^{-6} time/hour	1 (rare probability of occurrence)
Hi Power Application	Fails to function	1×10^{-6} time/hour	1 (rare probability of occurrence)
Low Power Application	Short	1×10^{-7} time/hour	1 (rare probability of occurrence)
Switches	Limit: fail to operate	3×10^{-4} time/day	2 (low probability of occurrence)
Switches	Limit: fail to operate	3×10^{-4} time/day	2 (low probability of occurrence)
	Torque: fail to operate	1×10^{-4} time/day	1 (rare probability of occurrence)
	Pressure: fail to operate	1×10^{-4} time/day	1 (rare probability of occurrence)
	Manual: fail to operate	1×10^{-4} time/day	1 (rare probability of occurrence)
	Manual: contacts short	1×10^{-8} time/hour	1 (rare probability of occurrence)
Transformers	Open	1×10^{-6} time/hour	1 (rare probability of occurrence)
	Short	1×10^{-6} time/hour	1 (rare probability of occurrence)
Manually operated valve	Fails to operate (plug)	1×10^{-3} time/day	3 (moderate probability of occurrence)
	Failure to remain open	1×10^{-4} time/day	1 (rare probability of occurrence)
	External leak-rupture	1×10^{-8} time/hour	1 (rare probability of occurrence)
Solenoid operated valve	Fails to operate	1×10^{-3} time/day	3 (moderate probability of occurrence)

TABLE 5.5.6-14
PROBABILITY OF MECHANICAL FAILURES (CONT'D)

Equipment involved	Nature of failure	Failure rate	Level of failure probability
Air operated valve	Fails to operate	3×10^{-4} time/day	4 (high probability of occurrence)
	Failure to remain open	1×10^{-4} time/day	3 (moderate probability of occurrence)
	External leak-rupture	1×10^{-8} time/hour	1 (rare probability of occurrence)
Check valve	Failure to open	1×10^{-4} time/day	1 (rare probability of occurrence)
	Reverse to remain open	1×10^{-7} time/hour	1 (rare probability of occurrence)
	External leak-rupture	1×10^{-8} time/hour	1 (rare probability of occurrence)
Vacuum valve	Fails to operate	3×10^{-5} time/day	1 (rare probability of occurrence)
	Rupture	1×10^{-8} time/hour	1 (rare probability of occurrence)
Valve: orifices, flow, meters, (test)	Rupture	1×10^{-8} time/hour	1 (rare probability of occurrence)
Valves (relief)	Failure to open	1×10^{-5} time/day	1 (rare probability of occurrence)
	Premature open	1×10^{-5} time/hour	1 (rare probability of occurrence)
Weld	Leak	3×10^{-9} time/hour	1 (rare probability of occurrence)

Source: Cryogenic and Oxygen Deficiency Hazard Safety: ODH Risk Assessment Procedures, 27th Feb 2006 (update 13 Feb 2009) SLAC-1-730-0A06C-001-R001.

Failure due to the temperature sensor	level of failure probability = 1
Failure due to the water gauge	level of failure probability = 1
Failure due to the nuts, bolts, or seals	level of failure probability = 1
Failure due to malfunction of the pump	level of failure probability = 1
Failure due to steam turbine governor	level of failure probability = 1
Instrument failure	level of failure probability = 1

For failure due to power outage, the level of failure probability is 1, for there is emergency generator in the project.

(4) Results of risk assessment

From the analysis of the causes of possible failures which can consequently incur major hazards, the results as well as relevant preventive measures are summarized as follows:

- **Explosion of the gas turbine**

Because the results of the risk assessment of explosion of the gas turbine, which can occur due to several causes as shown in **Table 5.5.6-15**, reveal different risk levels; the higher risk level is chosen for the assessment. The risk of gas turbine explosion is thus at the level of 2, which is regarded as an acceptable risk. However, revision of the control measures is required as follows:

- Check-up of the gas detector of the gas turbine is to be conducted regularly.
- Check-up and maintenance of the purge system of the gas turbine are to be conducted according to schedule.
- Check-up and maintenance of the gas distribution control system of the gas turbine are to be conducted according to schedule.
- Check-up of the operation of the temperature sensor of the gas turbine is to be conducted regularly.
- Check-up of the controller of the gas turbine is to be conducted regularly to ensure its operational consistency.
- Check-up and maintenance of the control equipment of the gas turbine are to be conducted according to schedule.
- Equipment and control system to be used must have been approved in accordance with international standards.

TABLE 5.5.6-15

CAUSES OF THE EVENTS LEADING TO POSSIBLE GAS TURBINE EXPLOSION, AND THE COUNTERMEASURES

Causes of the events leading to major hazards	Hazards or subsequent events	Preventive and control measures	Risk assessment			
			Likelihood	Severity	Consequence	Risk level
In the case of operational failures						
Residual gas left during startup • Damage to the pressure indication controller	• Gas turbine explosion	• Check-up of the gas detector of the gas turbine to be conducted regularly	1	4	4	2
• Damage to the gas detector	• Gas turbine explosion	• Check-up and maintenance of the purge system of the gas turbine to be conducted according to schedule	1	4	4	2
Too high temperature • Damage to the shut off valve	• Gas turbine explosion	• Check-up and maintenance of the gas distribution control system of the gas turbine to be conducted according to schedule	1	4	4	2
• Damage to the temperature sensor	• No alarm from the controller	• Check-up of the operation of the temperature sensor of the gas turbine to be conducted regularly	3	1	3	2
• Malfunction of the alarm receiver	• No alarm from the controller	• Check-up of the controller of the gas turbine to be conducted regularly to ensure its operational consistency	1	1	1	1
System incoherence • Damage to the control equipment	• Gas turbine explosion	• Check-up and maintenance of the control equipment of the gas turbine to be conducted according to schedule	1	4	4	2
• Failure in the control system	• Gas turbine explosion	• Equipment and control system to be used having been approved in accordance with international standards	1	4	4	2

- **Explosion of the steam turbine**

Because the results of the risk assessment of explosion of the steam turbine, which can occur due to several causes as shown in **Table 5.5.6-16**, reveal different risk levels; the higher risk level is chosen for the assessment. The risk of steam turbine explosion is thus at the level of 2, which is regarded as an acceptable risk. However, revision of the control measures is required as follows:

- Check-up of the condition of the safety valve is to be conducted regularly.
- The rupture disc is to be installed for the steam turbine as a safety measure in case the pressure exceeds the limit.
- Training is to be provided regularly in order that the staff can perform their work properly.
- Check-up of the condition of the steam turbine governor is to be conducted regularly.
- Check-up of the pressure indication controller is to be conducted regularly.
- Check-up of emergency generator is to be conducted regularly.
- Check-up of the controller of the steam turbine is to be conducted regularly to ensure its operational consistency.
- Experts are to be on duty all the time the system is on.

- **Explosion of the steam boiler**

Because the results of the risk assessment of explosion of the steam boiler, which can occur due to several causes as shown in **Table 5.21-37**, reveal different risk levels; the higher risk level is chosen for the assessment. The risk of the steam boiler explosion is thus at the level of 2, which is regarded as an acceptable risk. However, revision of the control measures is required as follows:

- Check-up of the condition of the safety valve is to be conducted regularly.
- The safety valve of the steam boiler must meet the standards set by the American Society of Mechanical Engineers – ASME, and those by the Department of Industrial Works.
- Training is to be provided regularly in order that the staff can perform their work properly.
- Check-up of the pressure indication controller is to be conducted regularly.
- Check-up of emergency generator is to be conducted regularly.

TABLE 5.5.6-16

CAUSES OF THE EVENTS LEADING TO POSSIBLE STEAM TURBINE EXPLOSION, AND THE COUNTERMEASURES

Causes of the events leading to major hazards	Hazards or subsequent events	Preventive and control measures	Risk assessment			
			likelihood	Severity	Consequence	Risk level
• Malfunction of the steam turbine governor	• Steam turbine explosion	• Check-up of the condition of the steam turbine governor is to be conducted regularly	1	4	4	2
• Malfunction of the component equipment in the steam turbine governing system	• Steam turbine explosion	• Training to be provided regularly in order that the staff can perform their work properly	1	4	4	2
• No check-up of the component equipment in the steam turbine governing system by the staff	• Steam turbine explosion	• Training to be provided regularly in order that the staff can perform their work properly • Experts to be on duty all the time the system is on	1	4	4	2

- Check-up of the controller of the steam boiler is to be conducted regularly to ensure its operational consistency.
- Check-up of the condition of the water pump is to be conducted regularly.
- There must be a water pump in reserve for the steam boiler.
- In case of malfunction of the water pump, the system must be off until the repair is done.
- Check-up of the water gauge is to be conducted regularly to ensure its operational consistency.
- Experts are to be on duty all the time the system is on.
- The scale condition is to be checked regularly.

- **Explosion of the electricity generator**

Because the results of the risk assessment of explosion of the electricity generator, which can occur due to several causes as shown in **Table 5.5.6-18**, reveal different risk levels; the higher risk level is chosen for the assessment. The risk of the electricity generator explosion is thus at the level of 2, which is regarded as an acceptable risk. However, revision of the control measures is required as follows:

- The operation of the overcurrent protection relay system must be checked to ensure that the current is in the preset limit.
- Training is to be provided regularly in order that the staff can perform their work properly.
- Check-up of the temperature sensing coil is to be conducted regularly.
- The temperature controller must be checked to ensure that it the temperature is in the predetermined limit.
- The sensor in reserve must be checked to ensure its ready-for-use condition.
- Procedures concerning the operation of electrical equipment are to be clearly delineated.
- The condition is to be established that electricity from different generators is not to be combined unless first synchronized.
- The synchronized system and the interlock system must be checked to ensure its operational consistency.
- The operation of the protection equipment for example the overcurrent protection relay, voltage relay for leakage protection, and other types of relays, must be checked.

TABLE 5.5.6-17

CAUSES OF THE EVENTS LEADING TO POSSIBLE STEAM BOILER EXPLOSION, AND THE COUNTERMEASURES

Causes of the events leading to major hazards	Hazards or subsequent events	Preventive and control measures	Risk assessment			
			Likelihood	Severity	Consequence	Risk level
In the case of operational failures						
Steam boiler overload						
• Malfunction of the safety valve	• Steam boiler explosion	• Check-up of the condition of the safety valve to be conducted regularly • The safety valve of the steam boiler must meet the standards set by ASME (Section 1-Power boiler), and those by the Department of Industrial Works.	1	4	4	2
• The pressure not checked by the staff	• Rise in steam pressure	• Training to be provided regularly in order that the staff can perform their work properly	1	1	1	1
• Malfunction of the pressure indication controller	• Constant fuel feed	• Check-up of the pressure indication controller to be conducted regularly	3	1	3	2
• System power failure	• No alarm from the controller	• Check-up of emergency generator to be conducted regularly	1	1	1	1
• Malfunction of the pressure indication controller	• No alarm from the controller	• Check-up of the controller to be conducted regularly to ensure its operational consistency	3	1	3	2
Water supply system failures						
• Boiler leak	• Steam boiler explosion	• Check-up of the condition of the steam boiler to be conducted regularly.	1	4	4	2

TABLE 55.6-17

CAUSES OF THE EVENTS LEADING TO POSSIBLE STEAM BOILER EXPLOSION, AND THE COUNTERMEASURES (CONT'D)

Causes of the events leading to major hazards	Hazards or subsequent events	Preventive and control measures	Risk assessment			
			Likelihood	Severity	Consequence	Risk level
• Malfunction of the water pump	• Steam boiler explosion	• Check-up of the condition of the water pump to be conducted regularly. • There must be a water pump in reserve for the steam boiler. • In case of malfunction of the water pump, the system to be off until the repair is done.	1	4	4	2
• The water system not regulated by the staff then	• Steam boiler explosion	• Training to be provided regularly in order that the staff can perform their work properly	1	4	4	2
• Malfunction of the water gauge	• Steam boiler explosion	• Check-up of the water gauge to be conducted regularly to ensure its operational consistency	1	4	4	2
• The water gauge not checked by the staff	• Steam boiler explosion	• Training to be provided regularly in order that the staff can perform their work properly	1	4	4	2
In the case of operational failures						
• Inappropriate water quality	• Steam boiler explosion	• Training to be provided regularly in order that the staff can perform their work properly • Experts to be on duty all the time the steam boiler system is on.	1	4	4	2
• No check-up by the staff according to schedule	• Steam boiler explosion	• Training to be provided regularly in order that the staff can perform their work properly	1	4	4	2

TABLE 55.6-17

CAUSES OF THE EVENTS LEADING TO POSSIBLE STEAM BOILER EXPLOSION, AND THE COUNTERMEASURES (CONT'D)

Causes of the events leading to major hazards	Hazards or subsequent events	Preventive and control measures	Risk assessment			
			Likelihood	Severity	Consequence	Risk level
In the case of safety equipment failures						
• Malfunction of the safety valve	• Steam boiler explosion	• Check-up of the condition of the safety valve to be conducted regularly • two sets of safety valves on hand – one set in reserve	1	4	4	2
• Malfunction of the water gauge	• Steam boiler explosion	• Training to be provided regularly in order that the staff can perform their work properly	1	4	4	2
• The water gauge not checked by the staff	• Steam boiler explosion	• Training to be provided regularly in order that the staff can perform their work properly • Experts to be on duty all the time the system is on	1	4	4	2

TABLE 5.5.6-18

CAUSES OF THE EVENTS LEADING TO POSSIBLE ELECTRICITY GENERATOR EXPLOSION, AND THE COUNTERMEASURES

Causes of the events leading to major hazards	Hazards or subsequent events	Preventive and control measures	Risk assessment			
			Likelihood	Severity	Consequence	Risk level
In the case of operational failures						
Electricity generator overload						
• Malfunction of the overcurrent protection relay system	• Explosion resulting from the coil burning and the consequent short circuit	• The operation of the overcurrent protection relay system must be checked to ensure that the current is in the preset limit.	1	4	4	2
• The meter not checked by the staff	• Overcurrent	• Training to be provided regularly in order that the staff can perform their work properly	1	1	1	1
• Malfunction of the temperature sensing coil	• Temperature of the coil higher than the predetermined limit, thus the relay system not opening the circuit • The coil overheating, resulting in the insulator burning and explosion	• Check-up of the temperature sensing coil to be conducted regularly • The temperature controller must be checked to ensure that it the temperature is in the predetermined limit • The sensor in reserve must be checked to ensure its ready-for-use condition	1	4	4	2
In the case of operation control system failures						
• While the system is on and when electricity is supplied from outside • Failure of the interlock system	• Explosion at the controller • Explosion at the electricity generator	• Procedures concerning the operation of electrical equipment to be clearly delineated. • The condition to be established that electricity from different generators is not to be combined unless first synchronized. • The synchronized system and the interlock system must be checked to ensure its operational consistency.	1	4	4	2

TABLE 5.5.6-18

CAUSES OF THE EVENTS LEADING TO POSSIBLE ELECTRICITY GENERATOR EXPLOSION, AND THE COUNTERMEASURES (CONT'D)

Causes of the events leading to major hazards	Hazards or subsequent events	Preventive and control measures	Risk assessment			
			Likelihood	Severity	Consequence	Risk level
In the case of electric fault in the system						
• Damage to the transformer • Fault in the electricity supply system and malfunction of the prevention system • Malfunction of the prevention system	• Valent short circuit at the power box resulting in the explosion of both the power box and the electricity generator	• Training to be provided regularly in order that the staff have good understanding concerning the functions of the equipment • The operation of the protection equipment for example the overcurrent protection relay, voltage relay for leakage protection, and other types of relays must be checked. • Check-up of the protection system in power system to be scheduled in the annual maintenance plan and also at a regular basis to ensure that all the electric equipment in the protection system functions properly.	1	4	4	2

- Check-up of the protection system in power system is to be scheduled in the annual maintenance plan and also at a regular basis to ensure that all the electric equipment in the protection system functions properly.

5.5.7 Summary of the Major Hazard Assessment

The study reveals that in case of accidental release of natural gas and diesel which results in ignition, the radius of the heat radiation is mostly within the compound of the power plant in the project. Furthermore, from the risk probability analysis, the project's risk levels are considered low. Hence, probability of major hazards owing to this cause is very low.

With respect to hazards owing to chemical substances and explosion of equipment and machinery, with reference to the hazard analysis conducted in accordance with the Department of Industrial Works' guideline, probability of the hazards is found to be at a low and acceptable level. In addition, for utmost safety, measures on safety management have been developed for the project encompassing the design, installation, operation and annual inspection phases.

Mitigation Measures

(1) Construction Phase

- Specify natural gas pipeline and diesel pipeline interconnecting area as restrictive areas. Hot work shall be prohibited in the area. A warning sign shall be installed in that restrictive area. In the event that it is necessary to enter into the area, permit work governance shall be required with strict inspection and control.
- A barrier shall be provided for the welding area. Furthermore, a warning sign indicating restriced area shall be installed and a work permit system shall be adopted.
- Before the construction begins, the contractors shall establish and send the operation plan of safety and occupational health to Gulf PD Co., Ltd. for approval. Controls shall be performed to be in line with the operation plan.
- Adequate personal protective equipment shall be provided for all staff, and shall be suitable for working conditions.
- A safety officer shall be provided to control and check operating conditions and ensure workers wear suitable personal protective equipment while working.
- Adequate portable chemical fire extinguishers shall be provided in the areas where construction activities may cause fire.
- First aid, basic medical supplies and an ambulance shall be provided in case of emergency according to Ministry of Labour regulation on Labour Welfare at workplace, B.E.2548.

- A warning sign shall be installed in the hazardous area. Working in the area for a prolonged period of time without wearing personal protective equipment shall be prohibited.
- Coordination with nearby hospitals shall be made to carry patients in emergency cases.

(2) Operation Phase

Preventive measures for natural gas and diesel fuel transmission pipeline system in the project area

- The Metering and Regulation Station (MRS) is a restrictive area. Hot work shall be prohibited in the area. A warning sign shall be installed in the Metering and Regulation Station (MRS) area. In the event that it is necessary to enter into the area, permit work governance shall be required with strict inspection and control.
- Maintenance of natural gas and diesel fuel transmission pipeline system and equipment shall be performed for readiness to use. Regular monitoring shall be done for safety.
- The thickness and level of wear of the natural gas pipeline shall always be checked.
- Leakage survey on natural gas and diesel fuel transmission pipeline system shall be performed according to involved standards.
- Hazardous zones shall be defined. Furthermore, control and preventive measures shall be established and strictly followed for safety purpose. For example, smoking prohibition zone or hot work area shall be permitted, etc.
- The natural gas leak detection system shall be provided using a gas meter to detect gas leak at the joint above the ground level at the Metering and Regulation Station (MRS) and gas compressor manual for project safety procedures.
- The sign indicating pipeline alignment and warning shall be provided to prevent any action in the area above the pipeline, which may affect the pipeline. The person who notice an abnormal situation shall keep the responsible person informed.
- Working regulations shall be established and applicable for safety while performing natural gas pipeline work.
- The shutdown control system and relief valve shall be provided to correctly and rapidly check abnormal pressure in the pipe.
- A diesel oil drum/tank shall be placed in a concrete dike, which can accommodate 100% of the fuel oil from the largest drum/tank in case the drum/tank is broken according to the ministerial regulation of Ministry of Industry, B.E.2556 on oil depot.

- The oil pumping station for truck shall be surrounded by a concrete dike so that the leached oil stains will be conveyed to the wastewater collection pipe and the oil separator, respectively.

Monitoring measures

- Hazardous areas shall be defined. The persons who enter into hazardous areas shall strictly follow the control and preventive measures for safety, such as
  - No smoking
  - A lighter, match or object that sparks a fire shall not be allowed in the designated hazardous areas.
  - Materials that stimulate combustion shall not be brought into or stored in hazardous areas.
  - Combustible materials shall not be brought into or stored in hazardous areas, such as yellow phosphorus or white phosphorus and magnesium alloys, etc.
  - Hot work like welding, metal cutting, etc. shall be permitted from the authorized person first.
  - Safety measures shall be planned before starting operations.
  - Uninvolved persons shall not be allowed to enter into hazardous areas.

Prevention and suppression plan for emergency and fire that causes by natural gas

1) Objectives
   - To prevent fire due to natural gas
   - To prepare and take appropriate action when a fire breaks out
2) Basic information that should be known

To be safe while operating on natural gas, it is necessary to realize properties of natural gas that cause hazard and general instructions.

- Natural gas properties and the properties that cause hazard
  - Natural gas used for power generation units is mainly methane, that is called dry gas.
  - Vapor density of natural gas equals to 0.6 compared with the air weight (Air =1).
  - Methane is in the form of vapor in normal temperature and atmospheric pressure.
  - Compared with other gases, liquid methane expands many times if vaporized.

- A mixture of methane and air which is flammable is called "Flammable and Explosive Limit", ranging from 5.0-14.0% (Low to High Limit).

- Hazard from use of natural gas
  - Flow and emission to the atmosphere is harmful. (Methane is dangerous when it mixes with the air in appropriate amount.)
  - Natural gas is colorless and not harmful to humans. However, exposure to a mass of gas may cause loss of consciousness as result of suffocation
- Instructions in case of gas leak
  - Approach to a fire or the position of gas leak shall be in the windward side
  - All persons shall leave the areas where a mass of gas and gas move. In addition, flammable objects shall be eliminated immediately
  - Staff who are required to work in the gas leak area shall be provided. Other people shall be at least 200 feet away from the gas leak area.
- In case of gas leak but incombustible.
  - : A valve shall be turned off to stop gas leak.
  - : Water spraying shall be done in the reverse direction of the gas to reduce vapor. Spraying may be done to change into the safe direction.
  - : In the event that gas leakage or a mass of gas cannot be stopped, flames shall be controlled through injecting considerable volume of water into hot metal, such as pipe, or hot surface of metal, etc.
  - : Ignition sources shall be avoided.
- In case of gas leak and combustible
  - : A valve shall be turned off to stop gas leak.
  - : A fire extinguisher shall not be used until the gas leak is completely stopped.
  - : Water shall be injected into a very hot area, such as concrete, metal surface. Combustion shall be allowed at drains.
  - : If the combustion takes place at the valve which is the equipment that stops gas leak, water spraying at the valve shall be done. The person who will turn off the valve shall wear fire fighter suits.

: Dry chemical fire extinguisher is workable for small volume of gas. The dry chemicals shall be injected into gas leakage position. Additionally, CO2 shall be used for fire extinguishment of gas in a very low pressure.

: In case of an uncontrollable leak, vapor shall be controlled through injecting water to protect the equipment around the area where gas leak takes place.

- Prevention of hazard in case of gas leak

: When gas leak is recognized, all electrical equipment of non- explosion proof type in the leak area shall be stopped.

: The valve shall be turned off to stop gas leak.

: Sources of ignition, such as flame, heat, spark, etc. shall be controlled.

: Air- Fuel Ratio at the leak position shall be measured in order to know hazardous level. Ventilation shall be performed to let gas dispersed outside.

: Operators who do not wear protective outfit while working should check the clothing by themselves. This is because their clothing may be stained with gas, which may be dispersed and harmful after the operation is complete.

- Detection for the position where gas may leak

- The position where gas leak will be measured shall be determined.
- The serial number of all valves and flanges to be checked shall be determined in order to create the check table.
- The check table including check duration shall be created.
- Gas leak shall be checked by a gas leak detector.
- Maintenance or repairing of equipment or pipe that gas flows shall be performed.

: The area shall be enclosed before repairing the equipment or pipe that the gas flows.

: Ventilation shall be sufficient in the area of repair work.

: Fuel-Air Ratio shall be intermittently measured before starting the repair work and while performing the repair work.

: Repair tool or equipment shall be non-sparking type.

: Good maintenance shall be performed, such as regular check of facilities, check and measurement of the thickness of pipe, which may cause leakage, etc.

- The annual emergency drills shall be performed at the power plant and with Pluak Daeng Industrial Park. Besides, training on emergency preparedness and response shall be provided for personnel at least once a year.

Emergency preparation plan for oil spill

Diesel oil transfer measures in the public health/occupational health and safety action plan during the operation phase shall be followed.

CHAPTER 6

ANALYSIS OF ALTERNATIVES

CHAPTER 6
ANALYSIS OF ALTERNATIVES

The analysis of alternative has been conducted for the proposed project as follows:

6.1 POWER PLANT

(1) Criteria for Location Selection: The reasons for alternative consideration of the project implementation within Chon Buri and Rayong Provinces are mainly due to high electricity demand of the provinces and the target area located is in vicinity of Bangkok, the national economic center. The advantages of such location for the provinces and for the entire nation are as follows:

- Majority of the Small Power Producers (SPP) are mostly located in the area of Industrial Estate or Industrial Park, where high electricity demand from industries in the area exists. Insufficient electricity in the Industrial area may cause black-out or electricity shortage which directly affects the industries, and local people.
- All of the Independent Power Producers (IPP) supply their electricity to EGAT to help maintaining national power stability.

In order to conduct the project implementation with least impacts on the environment and make feasible the design and investment, the consideration of project site location alternatives is an extremely important procedure. Meanwhile, the Office of the Natural Resources and Environmental Policy and Planning has specified the concept for studying alternative location of project site which is a process for initial screening for marking decision to choose the most suitable location of the project area. However, the project implementation may cause direct impacts to environmental quality and any vulnerable environmental parameters such as air quality, water quality, and community etc., during construction and operation periods. Those impacts may result in concerns about wastewater quality and air quality. Thus, the project site location selection must be thoughtfully conducted to prevent and mitigate any impacts to community and its environment. In addition, the selected location must possess feasible engineering, construction and maintenance as well as appropriate investment. Accordingly, the criteria of the project location consideration are specified as follows:

- Mainly utilize the areas of the industrial parks to mitigate impacts on people’s land use
- Avoid historic areas or archaeological sites
- Located in the areas with energy network or natural gas pipeline
- Have feasible engineering for both construction and maintenance

- Have enough basic infrastructure to support the need of the project
- Cause the least impact on sensitive environmental areas such as communities, religious places, schools, governmental offices and hospitals
- Avoid the areas specified in the attachment of the Notification of the Ministry of Natural Resources and Environment as specific conservative areas which have been protected by laws.

The project location selection has been conducted based on the above mentioned criteria. The selected project site is in the area of the Pluak Daeng Industrial Park which has been developed to support and facilitate industrial plants with provided basic infrastructure facilities.

After review and consideration of EIA report of Pluak Daeng Industrial Park Project, Expansion Phase 1, of Rojana Industrial Park Rayong 2 Co., Ltd., which had been approved by ONEP according to the letter No. Thor Sor 1009.3/15746 dated 29th December 2015, the relevant issues are summarized as follows:

- After review of the town planning laws and prescriptions for future land use in Rayong, the project site is not within the current Comprehensive Plan of Rayong Province and is located in an industrial park; therefore, impacts on community locations and other areas can be minimized.
- After review of the areas of power network or natural gas pipeline alignment, the project site is near the natural gas transmission pipeline of PTT Public Company Limited (PTT), and EGAT's transmission line alignment.
- After examination of factory categories and types to be established in Pluak Daeng Industrial Park according to the environmental impact prevention and mitigation measures of Pluak Daeng Industrial Park Project, Expansion Phase 1, of Rojana Industrial Park Rayong 2 Co., Ltd., which had been approved by ONEP on 29th December 2015, Pluak Daeng Power Plant Project is found to be among the target industries of Pluak Daeng Industrial Park and categorized as supporting industries, as presented in **Appendix 3T**

(2) Criteria for Fuel Selection: Natural gas is an extremely important source of energy in terms of reducing environmental pollution. Thus, the use of gas turbines and steam turbines are accepted as major source of electricity generation. Particularly high efficiencies can be achieved through combining gas turbines with a steam turbine in combined cycle mode. Natural gas burns cleaner than other fossil fuels, such as oil and coal, and produces less carbon dioxide per unit energy released. For an equivalent amount of heat, burning natural gas produces about 30% less carbon dioxide than burning petroleum and about 45% less than burning coal. Combined cycle power generation using natural gas is thus the cleanest source of power available using fossil fuels, and this technology is widely used wherever gas can be obtained at a reasonable cost.

(3) Criteria for Technology Selection: According to the project location consideration coupling with the project development friendly to environment and community for sustainability, the project has adopted the criteria for alternative consideration defined by the Office of Natural Resources and Environmental Policy and Planning (ONEP) to appraise alternative methods of the project implementation. So, factors adopted by the project for consideration on methods of project implementation are as follows:

(a) Electricity Generation Technologies

Currently, electricity generation technologies are divided into 3 main types and the details of each alternative power plant are as follows:

- **Fossil Fuel Power Plant**

Fossil fuel power plant is presently the most widely used type. Thermal power from fuel combustion is changed into mechanical energy which is then used to rotate a turbine to produce electricity. The plant type can be subdivided by type of machinery.

- **Thermal Power Plants**

The principle of a thermal power plant is to boil water into steam at very high temperature and pressure to rotate a steam turbine which is attached to a generator, thereby producing electricity. The steam is then condensed in the condenser and fed to the boiler again.

- **Combined Cycle Power Plants**

Combined cycle power plant has better efficiency than the thermal power plant because it is a two-step generation process whereby thermal power is changed into mechanical energy. Gas turbine is an additional turbine in this type of power plant, using either natural gas or diesel oil as fuel. Firstly, natural gas or diesel is injected into the combustion chamber, producing high-pressure hot gas to drive a gas turbine. This turbine is connected to a generator to produce two-thirds of electrical output. The hot exhaust gases are then fed into a heat recovery steam generator (HRSG), and steam will be used to drive a steam turbine to produce one-third electricity. Cogeneration plants are predominant in Thailand such as Rayong power plant, Wang Noi power plant, and Kaeng Khoi 2 power plant.

- **Gas Turbine Power Plants**

Similar to combined cycle power plants, gas turbine power plants have gas turbines but without boiler. Hot exhaust gases will be released without recovery and reuse; therefore, the generation cost is high in case of diesel fuel. However, the cost is slightly lower in case of natural gas fired generation. This type of power plant generally runs only during peak demand periods because it can be started and stopped quickly. It has lower efficiency than a thermal power plant and a combined cycle power plant. However, gas turbine power plants are still needed to supply auxiliary electricity during short periods of peak demand. When the power demand decreases, the power generation can stop. The existing gas turbine power plants include Lan Krabue power plant, Surat Thani power plant, Glow SPP2 power plant in Rayong Province, etc.

- **Diesel Power Plants**

Diesel engine is used for electricity generation. This type of power plant is small, with high generation cost. Nowadays, it is not used in power generation system in Thailand except at EGAT’s power plant in Mae Hong Son Province. Furthermore, industrial plants or large buildings generally have a backup generator, using diesel engines, for electricity generation in case of the electricity authority’s power system failure.

- **Hydropower Plants**

The hydropower generation principle is to store water at a high elevation and then release water under high pressure via penstock to the powerhouse at a lower elevation. Water flows through a turbine, activating a generator to produce electricity. The hydropower generation does not produce gaseous pollutants such as oxides of nitrogen, sulphur dioxide, etc. Moreover, there is no fuel cost for power generation and water release from power generation process can be used for consumption and irrigation purposes. The existing hydropower plants include Bhumibol hydropower plant, Sirikit hydropower plant, Srinagarindra hydropower plant, and Lamtakong Jolabha Vadhana hydropower plant, etc.

- **Renewable Power Plants**
  - **Wind Power Plants**

Wind power or wind turbine plants are classified as a type of renewable power plants because wind energy is used to turn the turbine blades, spinning a shaft and driving the generator. The plant is mainly located at a site with strong and constant flow of wind throughout the year. At present, this type of power plant is not widely implemented in the country, requiring considerable development. However, several wind power plants are currently operational, e.g. Wind turbines with a capacity of 192 kW at Laem Phromthep, Phuket Province; West Wind Power Plants Huai Bong 2 and Huai Bong 3, each with 103.5-MW capacity, in Dan Khun Thot district, Nakhon Ratchasima Province, etc.

  - **Solar Power Plants**

Solar power plants are also classified as a type of renewable power plants, similar to wind power plants. To generate electricity, solar panels will be installed on rooftops or at places/areas prepared to receive highest solar energy. The output is direct current (DC) electricity which cannot be used for household electrical appliances; therefore, it must be converted into alternating current (AC) electricity. However, it can be connected to the grid system of Metropolitan Electricity Authority (MEA) or Provincial Electricity Authority (PEA).

After the consideration of technology alternatives, **combined cycle power plant** has been selected because of its better efficiency and the most efficient use of existing resources as heat in combustion turbine exhaust gases is recovered and used for electricity generation.

In conclusion, to provide the power generation of 2,500 MW net capacity to the reliability level required by the power purchase agreement throughout the power purchase agreement term of 25 years, the fossil fueled power plant is therefore considered for this project. Of all the fossil fuel alternatives, the natural gas is selected as primary fuel for this project since natural gas, when compared with other fossil fuel, results in the least GHG per kWh generated.

For technology used for power generation using natural gas, the large gas turbine combined cycle is selected as it provides the best efficiency compared with smaller gas turbine combined cycle, or reciprocating engine, or thermal power plant with steam turbine only. The best efficiency selected

(b) Controlling Technology

Air pollution during the operation phase of combined cycle power plant is generated from combustion turbine. The main pollutant is oxides of nitrogen (NO_x), the emission quantity of which depends on the NO_x emission control technology for gas turbines.

Oxides of nitrogen are produced from nitrogen-oxygen reaction during combustion. There are two sources of nitrogen: atmospheric nitrogen and fuel-bound nitrogen. Oxides of nitrogen from combustion are mainly formed from atmospheric nitrogen ("Thermal NO_x") while NO_x formation from fuel-bound nitrogen is insignificant, especially in the event that natural gas or diesel has low nitrogen content. Technologies have been principally developed to control Thermal NO_x.

Dry Low NO_x (DLN) technology is selected for controlling oxides of nitrogen (NO_x) created during the natural gas fired electricity generation. Water injection technology will be used to control the NO_x formation during diesel fuelled generation.

Dry Low NO_x Combustor technology selected by the project developer will provide better control of NO_x emission, based on the principle that thermal NO_x emissions are reduced if the combustion temperature is lower. The Dry Low NO_x technology is designed to premix fuel and air (Lean Premix technology) prior to combustion, leading to lower combustion temperature and reduced formation of nitrogen oxides, compared to the Diffusion Combustor technology in which fuel is directly injected into combustion air, resulting in higher combustion temperature.

Water injection technology, selected for controlling NO_x formation during use of diesel as fuel, will be similarly based on the principle that thermal NO_X emissions are reduced if the combustion temperature is lower. Water injection into the combustion chamber will reduce temperature and the formation of nitrogen oxides.

CHAPTER 7

INFORMATION DISCLOSURE, PUBLIC CONSULTATIONS AND PARTICIPATIONS

CHAPTER 7

INFORMATION DISCLOSURE, PUBLIC CONSULTATIONS AND PARTICIPATIONS

7.1 INTRODUCTION

Public participation in the environmental impact assessment (EIA) process allows all parties involved in the project development to exchange their information in order to create mutual understanding, leading to development of project in a suitable manner and accepted by all stakeholders. The Pluak Daeng Power Plant Project is located in Pluak Daeng Industrial Park, Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province. Since the project must establish a relationship with the surrounding communities, it is necessary to conduct public participation activities together with the project study and development processes in order to build correct understanding about the project development and listen to public opinions for correcting the project details which may cause social and environmental impacts. By this way, the project will be smoothly implemented in the long run and coexist with its nearby communities in a sustainable manner.

7.2 Objectives

(1) To disseminate clear and correct information and updates about the project to the general public, related organizations, and stakeholders

(2) To present the project information, environmental study results (e.g. probable impacts from the project implementation), environmental impact prevention and mitigation measures, and environmental impact monitoring measures

(3) To give opportunities to the target groups to express their opinions about the project development from the start of the project

(4) To exchange opinions and listen to suggestions on environmental study

(5) To allow the public, related organizations, and stakeholders to take part in considering and checking the environmental impact prevention and mitigation measures, and environmental impact monitoring measures

(6) To evaluate the opinions and acceptance of people, related organizations, and stakeholders for further determining the action plans in the next steps

7.3 GUIDELINES

The following was referred to as the guidelines for implementation of public participation activities of this project.

(1) Rule of the Office of the Prime Minister on Public Consultation, B.E. 2548 (2005)

The state agency in charge of the state's project shall disseminate information to the public prior to the commencement of the project and may also conduct public consultation using the suitable method. The notification of the method and the project's area shall be posted openly at a noticeboard of the state agency for a period of not less than fifteen days prior to the commencement date of the public consultation. Upon the completion of public consultation, the state agency shall prepare a public consultation report and notify such report to the public within fifteen days as from the completion date of public consultation.

(2) Guidelines for Public Participation in Social Impact Assessment of the Office of Natural Resources and Environmental Policy and Planning, B.E. 2557 (2014)

The project owner shall proceed with the public consultation at least twice: the first public consultation at the start of the project for consultation of study scope; and the second public consultation during the preparation of the draft report, draft environmental impact prevention and mitigation measures, and draft environmental impact monitoring measures. The suitable methods will be applied. The collected opinions will be considered to evaluate the impacts in order to address or solve the problems. The appropriate environmental impact prevention and mitigation measures, and environmental impact monitoring measures will be also proposed as a part of the environmental impact assessment report.

7.4 PUBLIC PARTICIPATION PROCESS

Public participation process consisted of 3 major steps: preparation step; public participation implementation step; and report preparation step.

7.4.1 Preparation Step

The activities in this step were as follows.

(1) Survey and Collection of the Existing Data: Data on the existing conditions of communities, e.g. way of life, culture, and relationship were collected, as well as other related data, for example, list of villages, list of local leaders at district, sub-district, and village levels, including local environmental organizations/groups. The data were considered to divide the target groups in compliance with the existing situation of communities.

(2) **Classification of Stakeholders:** It was the important step to identify the parties involving in public participation activities. Determination of stakeholders was based on the principle of inclusiveness to encompass as many related parties as possible. The Consultant divided the stakeholders into 7 groups in compliance with the Guidelines for Public Participation in Social Impact Assessment of the Office of Natural Resources and Environmental Policy and Planning, B.E. 2557 (2014) as presented in **Table 7.4-1**.

(a) **Affected people** are divided into two groups: 1. group of people who loses benefits from the project (e.g. community leaders and people in the areas expected to be impacted by the project development), and 2. group of people who benefits from the project (e.g. entrepreneurs conducting commercial business and services relating to project activities, and people living in the surrounding areas of the project.)

(b) **The entities responsible for EIA report preparation**: Gulf PD Company Limited, and TEAM Consulting Engineering and Management Ltd.

(c) **The agencies in charge of considering EIA report**: The agency in charge of making decision on project approval and the agency in charge of issuing relevant licenses. In this case, they are ONEP and Office of the Energy Regulatory Commission.

(d) **Government agencies at different levels (provincial, district, and local)**: Rayong provincial office for natural resource and environment, Rayong provincial energy office, local administrative organization, etc.

(e) **Environmental non-governmental organizations (ENGO), non-governmental organizations (NGO), local educational institutions, tertiary academic institutions, and independent scholars**: ENGOs are registered with the Department of Environmental Quality Promotion, NGOs which are in the project area or use the project area; local educational institutions and tertiary academic institutions in the project area; and independent scholars including specialists and external scholars

(f) **Mass media** in different fields (central and local media)

(g) **General public** interested in the project plays a role of observer.

(3) **Study Area:**

The study area of Pluak Daeng Power Plant Project in Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province encompasses the area within the radius of 5 km from the project location (**Figure 7.4-1**). However, all related parties were allowed to take part in the project development without limiting only those within the radius of the project area.

Table 7.4-1
Division of Stakeholder Groups

Stakeholder Groups		Project Stakeholder Groups
Division of Stakeholder Groups	Components of Stakeholder Groups	
1. Affected people	• Group of people who loses benefits from the project • Group of people who benefits from the project	• Community leaders and people residing in the project area Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province - Village no.1 Ban Map Toei - Village no 2.Ban Noen Sawan - Village no 3.Ban Map Yang Phon - Village no 5.Ban Wang Tan Mon - Village no 6.Ban Map Yang Mai - Village no 7.Ban Chak Oi Pluak Daeng Sub-district, Pluak Daeng District, Rayong Province - Village no.4 Ban Wang Ta Phin - Village no 6.Ban Thap Tong Mae Nam Khu Sub-district, Pluak Daeng District, Rayong Province - Village no.4 Ban Chak Man Thet - Village no 7.Ban Wang Pradu Phana Nikhom Sub-district, Nikhom Phatthana District, Rayong Province - Village no 4.Ban Khao Ma Phut - Village no 5.Ban Khlong Phlu - Village no 6.Ban Nong Rakam - Village no 7.Ban Wang Pla - Village no 8.Ban Soi13
2. The entities responsible for EIA report preparation	• Project owner • Juristic entity entitled to EIA report preparation	• Gulf PD Company Limited • TEAM Consulting Engineering and Management Ltd .
3. The agencies in charge of considering EIA report	• The agency considering EIA report • The approval authority unit	• Office of Natural Resources and Environmental Policy and Planning (ONEP) • Office of the Energy Regulatory Commission (ERC)

Table 7.4-1
Division of Stakeholder Groups (Cond't)

Stakeholder Groups		Project Stakeholder Groups
Division of Stakeholder Groups	Components of Stakeholder Groups	
4. Government agencies at different levels	• Central/provincial/local government agencies	• Government agencies at provincial level of Rayong Province: Provincial Governor, representative of the provincial office for natural resource and environment, representative of the provincial energy office, representative of the provincial fisheries office, representative of the provincial public health office, etc . • Government agencies at district level of Pluak Daeng District : representative of district public health office, representative of district agriculture office, representative of district community development office, etc. • Government agencies at sub-district level within the radius of 5 km from the project location) covering 4 sub-districts :Map Yang Phon, Pluak Daeng, Mae Nam Khu, and Nikhom Phatthana :(Chief Executives of Sub-district Administrative Organizations in the study area
5. Environmental non-governmental organizations, non-governmental organizations, local educational institutions, tertiary academic institutions, and independent scholars	• Local educational institutions • Dok Krai Fishery Resource Management Group	• Representatives of educational institutions in the study area • Chairman and representative of Dok Krai Fishery Resource Management Group
6. Mass media	• Mass media in different fields) central and local (	• Local newspapers
7. General public	• "General public" interested in the project plays a role of observer.	• People in general who are interested in the project)They may not live in the study areas(.

Source: TEAM Consulting Engineering and Management Ltd., 2016

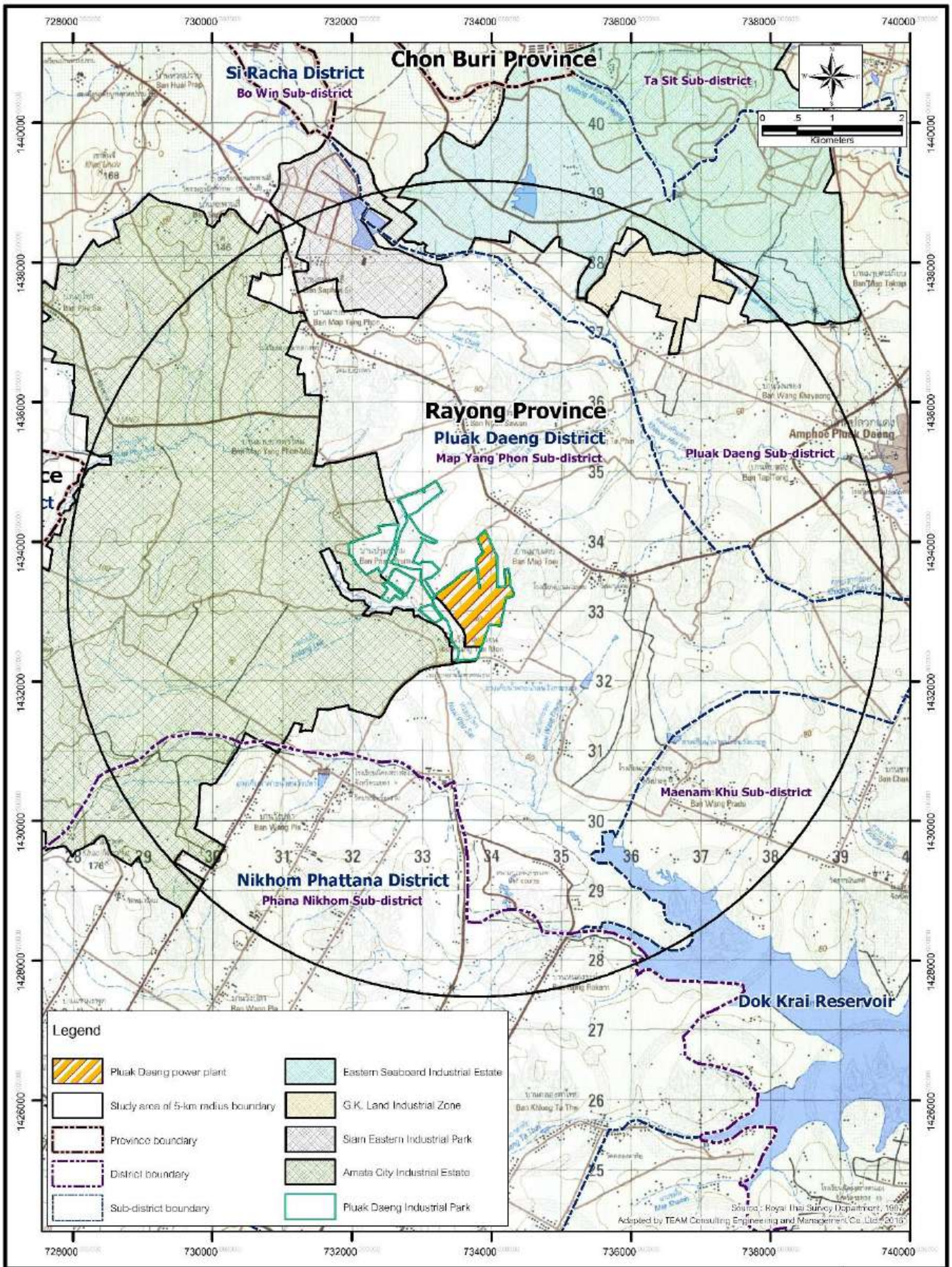


FIGURE 7.4-1 : AREA FOR PUBLIC PARTICIPATION ACTIVITIES

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7.4.2 Public Participation Implementation Step

According to the Guidelines for Public Participation in Environmental Impact Assessment of the Office of Natural Resources and Environmental Policy and Planning (ONEP), two public consultations were held to listen to people's opinions.

- **The 1st Public Consultation at the Start of the Project**: Stakeholders were informed of preliminary project information, e.g. study scope, and their opinions were collected.
- **The 2nd Public Consultation during EIA Report Preparation:** It provided opportunity for stakeholders to express their comments and suggestions on the draft EIA report, draft environmental impact prevention and mitigation measures, and draft environmental impact monitoring measures.

Activities of public participation in this study are disseminate information and collect opinions at the start of the project and step of preparation of the draft report, draft environmental impact prevention and mitigation measures, and draft environmental impact monitoring measures. The activities are as follows.

7.4.2.1 Public Participation Activities

Several public participation activities were used by selecting the suitable approaches for each target group. Emphasis was placed on creation of correct understanding about the project among local people first by implementing different activities, e.g. meetings with related government agencies, public consultation with people and related parties, power plant visit, survey of socio-economic conditions and opinions about the project development, participation in community activities/return of benefits to communities. Details of each activity are described below.

Meetings with Related Government Agencies: The major objectives of this activity were to provide the project information, ask for suggestions for implementation of public consultation, and listen to comments and suggestions about the project development. This activity was conducted before public consultation.

Public Consultation with People and Related Parties: The major objectives of this activity were to notify the project information, create the correct understanding about the project development, and gather public opinions about the project development. At least two public consultations were conducted in accordance with the Guidelines for Public Participation in Environmental Impact Assessment of the Office of Natural Resources and Environmental Policy and Planning.

Power Plant Visit: The objectives of this activity were to build the accurate knowledge and understanding about the project development, and to collect opinions of people in local communities and their response to the project development.

Survey of Socio-Economic Conditions and Opinions about the Project Development: It was another way for Pluak Daeng Power Plant Project to know the response of local communities towards the project development through the collected concerns, comments, and suggestions. These opinions would be considered to determine the measures to relieve their anxieties about the project implementation. Questionnaires were used as a survey tool. Details of socio-economic survey are presented in **Item 4.18 Socio-Economic Conditions in Chapter 4**.

Participation in Community Activities/Return of Benefits to Communities: With the intention to sustainably coexist with its surrounding communities, the project will return benefits to communities by mutually conducting activities with local communities in order to build good relationship with them and to create a channel for communication between communities and the project.

7.4.2.2 Public Relations Materials/Production of the Project Public Relations Materials

There are two types of public relations materials for Pluak Daeng Power Plant Project.

(1) Personal Media comprise personnel of Gulf PD Company Limited and environmental consulting company (EIA report preparation team of this project is TEAM Consulting Engineering and Management Ltd.). They have duties to explain, clarify, disseminate the project information, and create correct understanding among the target groups in order to achieve the project objectives throughout the study and EIA report preparation period.

(2) Document Media include PR documents which contain the project details throughout the study and EIA report preparation period, PR signs before organization of two public consultations, PowerPoint presentations, questionnaires for each public consultation, and socio-economic survey forms. PR documents for this project were produced at least two times as follows.

- **1st Set: PR Documents** consisting of:
  - Rationale and necessity for project development
  - Project owner and environmental consulting company
  - Project information, including project location, size of project area, electricity generating capacity, volumes of water for consumption and effluent, power generating process, etc.
  - Scope and guidelines for environmental impact study, e.g. rationale and necessity of environmental study, scope of works and study

method, criteria for identifying locations for environmental quality measurement, environmental quality measurement locations, etc.
  - Project implementation plan
  - Communication channels of the project
- 2nd **Set: Documents for Public Consultation** consisting of:
  - Rationale, necessity, and objectives of the project
  - Project owner and environmental consulting company
  - Project information, including project location, activities, and study area
  - Project outcomes: existing environmental conditions, EIA result, draft environmental impact prevention and mitigation measures, and draft environmental impact monitoring measures
  - Communication channels of the project

7.4.3 Report Preparation Step

Upon completion of all public participation activities, the Consultant would take into consideration the suggestions and comments gathered from the public participation process to determine the environmental impact prevention and mitigation measures and the environmental impact monitoring measures for the project. Also local communities and accurate technical principles would be also considered during the report preparation step. The Consultant would then prepare summary of the results of public consultations from all forums, questions, and explanations to questions for further dissemination to the public within 15 days from the first and the second public consultations.

7.5 EXPECTED RESULTS

(1) Public relations and the project information are disseminated in a correct and continual manner.

(2) Public participation could be a communication channel between the project and the target groups.

(3) People has knowledge and understanding about the project implementation and probable impacts, including environmental impact prevention and mitigation measures, and environmental impact monitoring measures.

(4) There are exchange of opinions about the project, listening to anxieties about probable impacts, including opinions and suggestions about the project development.

(5) Provision of correct project information could build of good relationship with local communities.

7.6 PUBLIC PARTICIPATION PLAN

The public participation activities were conducted in conformity with related regulations, rules and guidelines on public participation from the start of the project until completion of the draft EIA report preparation as summarized in **Table 7.6-1**.

TABLE 7.6-1
SUMMARY OF PUBLIC PARTICIPATION ACTIVITY PLAN

Activity	Activity Description	Schedule	Number of Participants (Person)
The 1st Meetings with Related Government Agencies	1. **The 1st Meetings with Related Government Agencies:** To introduce the project and discuss about the project details with provincial/local government agencies	Between December, 2015 – January, 2016	2
The 1st Public Consultation with People and Related Parties	2. **The 1st Public Consultation (Provincial Level)** with related provincial and district government agencies	27th January 2016	
	3. **The 1st Public Consultation (Sub-district Level)** with people and related parties at sub-district level to define the EIA scope	25th -27th January 2016	582
	4. **The 1st Public Consultation with Dok Krai Fishery Resource Management Group** to present the project details, EIA scope and approaches	8th March 2016	31
Survey of Socio-Economic Conditions and Opinions about the Project Development	5. **Survey of Socio-Economic Conditions and Opinions about the Project Development:** individual interview/survey to inquire about people's anxieties, comments, and opinions about the project development	Between February – March, 2016	605
Power Plant Visit	6. **Visit to Power Plant of Gulf Group:** To build understanding among representatives of local communities by informing them of power generating process, and collecting their opinions and responses to the project development	March, 2016	402

TABLE 7.6-1

SUMMARY OF PUBLIC PARTICIPATION ACTIVITY PLAN (CONT'D)

Activity	Activity Description	Schedule	Number of Participants (Person)
The 2nd Meetings with Related Government Agencies	7. **The 2nd Meeting with Related Government Agencies:** To present details of the project environmental study results and draft environmental impact prevention and mitigation measures, and to solicit recommendations about the public consultation with people and related parties	3rd May 2016	4
	8. **The 2nd Public Consultation (Provincial Level)** with related provincial, district, and sub-district government agencies to present environmental study results, draft environmental impact prevention and mitigation measures, and draft environmental impact monitoring measures	25th May 2016	25
	9. **The 2nd Public Consultation (Sub-district Level):** To present environmental study results, draft environmental impact prevention and mitigation measures, and draft environmental impact monitoring measures	25th -27th May 2016	686
	10. **The 2nd Public Consultation with Dok Krai Fishery Resource Management Group**: To present environmental study results, draft environmental impact prevention and mitigation measures, and draft environmental impact monitoring measures	13th June 2016	34

7.7 PUBLIC PARTICIPATION ACTIVITY RESULTS

7.7.1 The 1st Meetings with Related Government Agencies

The meetings with representatives of related provincial government agencies were scheduled between December 2015 and January 2016 prior to the 1st public consultation. The objectives of this activity were to inform the preliminary project information to related agencies; to consult them about public consultation activities; to acknowledge the problems and obstacles from the reaction of local communities in the study area to the project. The agencies/ representatives that the Consultant had the meetings with were Rayong Provincial Governor and Head of Rayong Provincial Energy Office. Discussion topics/ opinions/ concerns about the project development can be summarized below.

Agency	Discussion Topics/Opinions/Concerns
Agency: Provincial Energy Office Position of Representative : Head of Rayong Provincial Energy Office Meeting Date/Month/Year : 14th December 2015 	- Sources of natural gas - Sources of water used in the project - Water use in the project should not affect the surrounding communities. - Public consultation should cover all related parties.
Agency : Rayong Provincial Office Position of Representative: Rayong Provincial Governor Meeting Date/Month/Year : 5th January 2016 	- Public consultation should cover all related parties, especially those at local level. - The project should build correct understanding with people around the project area.

7.7.2 The 1st Public Consultation with People and Related Parties

The objectives of this activity were to introduce the project, and to present the study scope and approaches to stakeholders. Public consultation was organized at five forums during 25th-27th January 2016 as follows.

(1) The 1st Public consultation (provincial level) with related government agencies at provincial and district levels (1 forum)

(2) The 1st Public consultation (sub-district level) with related government agencies at sub-district level, sub-district headmen, village headmen, and local people in the study area (4 forums)

Details of this activity and the number of participants are presented in **Table 7.7-1**. The target groups of the public consultation cover 7 groups of stakeholders according to the Guidelines for Public Participation in Social Impact Assessment of the Office of Natural Resources and Environmental Policy and Planning, B.E. 2549 (2006), as shown in **Table 7.7-2**. There were 605 participants, comprising representatives of government agencies at different levels (e.g. representatives of provincial government agencies), chief executives of sub-district administrative organizations (SAO), members of SAO councils, sub-district headmen, village headmen, representatives of local people in the study area and people who are interested in the project.

TABLE 7.7-1

DATE, TIME, VENUE AND NUMBER OF PARTICIPANTS OF THE 1ST PUBLIC CONSULTATION

Date/Month/Year	District	Sub-district	Venue	Number of Participants
25th Jan 2016	Pluak Daeng	Map Yang Phon	Ban Map Toei School	188
26th Jan 2016		Pluak Daeng	Meeting room at Pluak Daeng SAO	169
		Mae Nam Khu	Chak Man Thet Temple	134
27th Jan 2016	-	-	Phakdi Si Songkhram Conference Room, 4th floor, Rayong Provincial City Hall	23
	Nikhom Phatthana	Phana Nikhom	Office of Phana Nikhom Sub-district Headman	91
Total 5 forums				**605**

Remark: Excluding staff of Gulf PD Company Limited and the Consultant

TABLE 7.7-2

PARTICIPANTS IN THE 1ST PUBLIC CONSULTATION DIVIDED BY GROUPS OF STAKEHOLDERS ACCORDING TO THE GUIDELINES FOR PUBLIC PARTICIPATION AND SOCIAL IMPACT ASSESSMENT IN ENVIRONMENTAL IMPACT ASSESSMENT PROCESS

Group of Stakeholders	Forum/Number of Participants (Person)				
	Provincial Forum	Sub-district Forum			
		Map Yang Phon Sub-district	Pluak Daeng Sub-district	Mae Nam Khu Sub-district	Phana Nikhom Sub-district
1. Affected People					
- SAO chief executives and SAO council members	-	5	14	9	11
- Community leaders/people in the study area	-	132	52	104	65
2. The entities responsible for EIA report preparation					
- Gulf PD Company Limited (Project Owner)	7	10	8	6	14
- TEAM Consulting Engineering and Management Co., Ltd. (Consultant)	5	5	5	5	5
3. The agencies in charge of considering EIA report					
- ONEP	-	-	-	-	-
4. Government agencies at different levels					
- Government agencies at provincial level	11	-	-	-	-
- Government agencies at district level	6	1	-	-	-
- Government agencies at sub-district level	-	12	26	5	3
- Public health offices	2	-	-	-	-

TABLE 7.7-2

PARTICIPANTS IN THE 1ST PUBLIC CONSULTATION DIVIDED BY GROUPS OF STAKEHOLDERS ACCORDING TO THE GUIDELINES FOR PUBLIC PARTICIPATION AND SOCIAL IMPACT ASSESSMENT IN ENVIRONMENTAL IMPACT ASSESSMENT PROCESS (CONT'D)

Group of Stakeholders	Forum/Number of Participants (Person)				
	Provincial Forum	Sub-district Forum			
		Map Yang Phon Sub-district	Pluak Daeng Sub-district	Mae Nam Khu Sub-district	Phana Nikhom Sub-district
5. Environmental non-governmental organizations (ENGO), non-governmental organizations (NGO), local educational institutions, and independent scholars					
- Local educational institutions	-	2	-	1	-
- Dok Krai Fishery Resource Management Group	-	-	-	4	-
6. Mass media					
- Local mass media	1	2	1	1	-
7. People interested in the project	3	34	76	10	12
Total	**35**	**203**	**182**	**145**	**110**

Prior to the 1st Public Consultation, the Consultant sent the letters of invitation to the target groups and requested for assistance from local government agencies, relevant sub-district headmen and village headmen to post the public consultation schedule notices in conspicuous places at least 15 days in advance from 7th January 2016 as illustrated in **Photo 7.7-1**. (Examples of the letter of invitation and the letter of request for posting the notice of public consultation schedule are presented in **Appendix 7A-1**).

Media for the Public Consultation

- Personal Media: Representatives of Gulf PD Company Limited and TEAM Consulting Engineering and Management Co., Ltd.
- Document Media: PowerPoint presentations, PR documents for the project, and questionnaires for each public consultation **(Appendix 7A-2).**

Conclusions of the 1st public consultation with people and related parties are as follows:

(1) The 1st Public Consultation (Provincial Level)

It was held on Wednesday 27th January 2016, during 9.30-12.00 hrs. at Phakdi Si Songkhram Conference Room, on the 4th floor, Rayong Provincial City Hall. There were 23 participants (excluding staff of Gulf PD Company Limited and the Consultant). Representatives of provincial and district government offices attended the public consultation, for example, Head of Rayong Provincial Energy Office, Nikhom Phatthana Senior Assistant District Chief Officer, representative of Pluak Daeng District, Head of Pluak Daeng District Agricultural Office, Superintendent of Pluak Daeng Police Station, representative of Pluak Daeng Hospital, etc. (List of participants is presented in **Appendix 7A-3**.) The Deputy Provincial Governor chaired the public consultation which ran smoothly (**Photo 7.7-2**).

After presentation of the EIA scope and approaches, participants had opportunity to express their opinions via two methods: (1) inquiry in the public consultation forum and (2) questionnaire.

(a) Summary of Inquiries, Comments, and Suggestions on EIA Scope and Approaches by Related Government Agencies during the Public Consultation (Provincial Level)

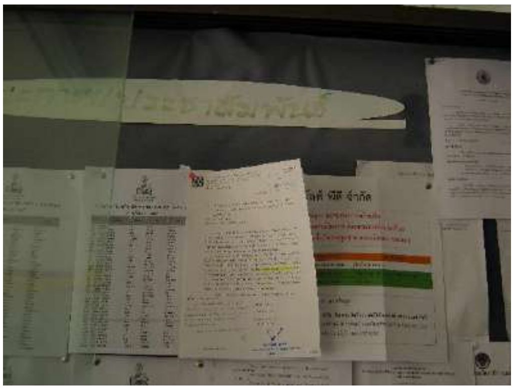
After presentation of the project details, EIA scope and approaches, participants had opportunity to make inquiries and express their comments and suggestions as summarized in **Table 7.7-3**.

Rayong Provincial Public Relations Office

Rayong Provincial Industrial Office

Rayong Provincial Office for Natural Resource and Environment

Rayong Provincial Energy Office



Pluak Daeng District Office

Mae Nam Khu Sub-district Administrative Organization

PHOTO 7.7-1: POSTING OF NOTICES ON INVITATION TO THE 1st PUBLIC CONSULTATION (EIA SCOPE AND APPROACHES)

PHOTO 7.7-2 : ATMOSPHERE OF THE 1st PUBLIC CONSULTATION (PROVINCIAL LEVEL)

TABLE 7.7-3

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA SCOPE AND APPROACHES BY RELATED GOVERNMENT AGENCIES DURING THE PUBLIC CONSULTATION (PROVINCIAL LEVEL)

Inquiries, Comments, and Suggestions	Explanations in the Forum/Additional Explanations	Utilization
- Where do the natural gas and diesel oil for electricity generating come from?	➢ Natural gas will be transmitted via the pipeline of PTT Public Company Limited. Currently, Gulf PD Company Limited is in the process of negotiating with PTT on the natural gas fields. Diesel oil will come from the oil depot which is nearest to the project area. However, it is under the study process. When the conclusion is reached, it will be informed to the subsequent public consultation.	- Additional details of this issue will be given in the 2nd public consultation.
- Project details should be clearly presented, for example, electricity generating process from the first to the final steps, fuel sources, transmission routes of both natural gas and diesel, safety system, and emergency plan. - The provide information is not sufficient. More project information/ details should be clearly presented in the subsequent meeting (if any).	➢ At present, Gulf PD Company Limited is in the process of conducting detailed design of the power plant. This public consultation aimed to collect preliminary opinions. Clear details will be given to the Consultant and presented in the next public consultation together with the study result.	- Additional details of this issue will be given in the 2nd public consultation.
- Where is the machinery of the project imported from?	➢ It is expected that the machines will be imported from Japan. The company's other power plants which are currently in operation use machines from several countries, e.g. Germany and Switzerland.	- Additional details of this issue will be given in the 2nd public consultation.

TABLE 7.7-3

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA SCOPE AND APPROACHES BY RELATED GOVERNMENT AGENCIES DURING THE PUBLIC CONSULTATION (PROVINCIAL LEVEL) (CONT'D)

Inquiries, Comments, and Suggestions	Explanations in the Forum/Additional Explanations	Utilization
- The project should have details about the structure, power generating capacity and system of the power plant.	➢ The project has clear details about electricity generating system and technology. It is the combined cycle power plant which uses both natural gas and steam to generate electricity. The selected technology will enable the project to generate 2,920 MW of electricity. The EIA will be conducted based on this electricity generating capacity. However, only 2,500 MW will be sold to EGAT according to the power supply agreement.	- Additional details of this issue will be given in the 2nd public consultation.
- What pollutants the electricity generating will cause and how can the project prevent these pollutants?	➢ Combustion to generate electricity will cause NO_x, SO_2, and small quantity of particulate matters. The project will control emission of these pollutants into the atmosphere not to exceed the benchmarks established by the National Environmental Board. Despite the emission control, the Consultant will also study the impacts of emitted pollutants on the atmosphere around the power plant and will determine the environmental impact prevention, and mitigation measures, and environmental impact monitoring measures.	- Additional details of this issue will be given in the 2nd public consultation. - The environmental impact prevention and mitigation measures, and environmental impact monitoring measures for ambient air quality control will be determined.
- Although the pollutants emitted by the project will not exceed the established benchmarks, will continual emission cause pollutants to accumulate and exceed the benchmarks?	➢ According to the EIA requirements, air pollutants from all sources in the study area must be assessed together with emissions of the project. If the air pollutant emissions from the project are greater than the established	- The environmental impact prevention and mitigation measures, and environmental impact monitoring measures for ambient air quality control will be determined.

TABLE 7.7-3

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA SCOPE AND APPROACHES BY RELATED GOVERNMENT AGENCIES DURING THE PUBLIC CONSULTATION (PROVINCIAL LEVEL) (CONT'D)

Inquiries, Comments, and Suggestions	Explanations in the Forum/Additional Explanations	Utilization
- Several power plants already exist in Puak Daeng District. If there is another large-scale power plant, people are worried about the increase in air pollution level.	air quality standards, the project must control the emissions not to exceed the standards. When the power plant starts operation, air quality must be monitored throughout the project period at the locations determined by the Consultant. By monitoring, quantity of ambient air pollutants will be derived and the monitoring results must be submitted to ONEP and Rayong provincial office for natural resource and environment.	
- Will the project operation be against the town planning law?	➢ Formulation of Pluak Daeng town plan is underway and not promulgated yet. However, formulation of the provincial plan is already completed but in the legislative process. However, at present, the government exercised the order under Section 44 of the Interim Constitution to exempt enforcement of comprehensive plan for the activities under the Power Development Plan (PDP2015) 2015-2036, the Alternative Energy Development Plan, the Fuel Management Plan, and the Natural Gas Management Plan. Thus, the construction of the Pluak Daeng Power Plan Project which is included in the PDP is not against the town planning law.*	- Additional study will be conducted. - Additional details of this issue will be given in the 2nd public consultation.

TABLE 7.7-3

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA SCOPE AND APPROACHES BY RELATED GOVERNMENT AGENCIES DURING THE PUBLIC CONSULTATION (PROVINCIAL LEVEL) (CONT'D)

Inquiries, Comments, and Suggestions	Explanations in the Forum/Additional Explanations	Utilization
- Consideration should be made whether the project will obstruct water passage.	➢ The project is located in Pluak Daeng Industrial Park. EIA including drainage for the industrial park was conducted and the EIA report was approved by ONEP. Besides, the Consultant will study the drainage in the project area. The discharge rate of stormwater after the project operation should be similar to that before the project development.	- Additional study will be conducted and additional details of this issue will be given in the 2nd public consultation. - The environmental impact prevention and mitigation measures, and environmental impact monitoring measures for drainage and flood control will be determined.
- The project will require a huge amount of water and mainly rely on water from East Water. Therefore, East Water should clarify if water will be sufficient for agricultural and industrial sectors in the future. - Will the amount of water from East Water be sufficient? When communicating with local people/communities, water quantity should be referred to in cubic meter unit. Will Dok Krai reservoir be affected? Water availability should be also considered.	➢ Presently, East Water already increased its water availability to be sufficient for water demand in the East as follows. - Collaboration with the Royal Irrigation Department to divert water from Prasae reservoir to store in Nong Pla Lai reservoir at 250,000-300,000 cubic meter per day - Bunds of Prasae reservoir were heightened to increase storage capacity by 40 million cubic meters. - An additional pipeline was built to convey excess water from Prasae reservoir to Bo Win Sub-district. - A diversion tunnel is available to convey water from Dok Krai reservoir to Nong Pla Lai reservoir. - Thap Ma reservoir is used as detention basin to store water of about 40 million cubic meters pumped from Rayong river in the wet season.	- Additional study will be conducted and additional details of this issue will be given in the 2nd public consultation. - The environmental impact prevention and mitigation measures, and environmental impact monitoring measures for water use will be determined.

TABLE 7.7-3

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA SCOPE AND APPROACHES BY RELATED GOVERNMENT AGENCIES DURING THE PUBLIC CONSULTATION (PROVINCIAL LEVEL) (CONT'D)

Inquiries, Comments, and Suggestions	Explanations in the Forum/Additional Explanations	Utilization
- In emergency case, the project will have available water for use for 3 days. Will it be sufficient? Additional water sources should be also considered.	➢ The project will store water for use for 3 days in emergency case. It will be sufficient for electricity generating. At the same time, the project will inform EGAT of water shortage in the power plant so that they will have time to contact other power plants for supply of additional electricity.	- Additional study will be conducted and additional details of this issue will be given in the 2nd public consultation.
- What will the project do to provide knowledge about the project to create understanding with local people?	➢ Gulf PD Company Limited has community relations staff to meet local people and will organize public consultation to provide the project information and to collect opinions from people. Besides, representatives of local communities will be invited to visit the company's existing power plants to build better understanding.	- Additional details of this issue will be given in the 2nd public consultation. - The environmental impact prevention and mitigation measures will be determined for the project as follows: • Socio-economic measures • Public relations and public participation measures
- People are worried about air pollutants and the impact on local people's health. Health checkup/monitoring should be provided to local people.	➢ At present, Gulf Group has a large scale power plant in Kaeng Khoi District, Sara Buri Province. It uses natural gas as fuel for electricity generating and regularly follows the environmental impact prevention and mitigation measures and the environmental impact monitoring measures. No complaint on health issues due to the project operation has been reported. In addition, the company provides financial support to local health stations to arrange health checkup for local people.	- The environmental impact prevention and mitigation measures and the environmental impact monitoring measures will be determined for the project as follows: • Air quality measures • Measures on public health, occupational health and safety

TABLE 7.7-3

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA SCOPE AND APPROACHES BY RELATED GOVERNMENT AGENCIES DURING THE PUBLIC CONSULTATION (PROVINCIAL LEVEL) (CONT'D)

Inquiries, Comments, and Suggestions	Explanations in the Forum/Additional Explanations	Utilization
- Local people's health data should be collected before the start of the project construction. People's health should be followed up after the project operation. The collected data will be used to develop the database for follow up of local people's health.	➢ This suggestion will be taken account of for further study and action.	- The environmental impact prevention and mitigation measures, and environmental impact monitoring measures for public health will be determined.
- Consideration should be given to non-registered population working in the project area in case of emergency or severe events.	➢ This suggestion will be taken account of for further study.	- The environmental impact prevention and mitigation measures will be determined for the project as follows: • Measures on public health, occupational health and safety • Socio-economic measures
- In Pluak Daeng area, no environmental quality measurement station of the government sector is located. It is necessary to use the mobile measurement station of the private entity which is not reliable. The project should also consider the health status of people and environmental quality in Pluak Daeng area.	➢ This suggestion will be taken account of for further study.	- The environmental impact prevention and mitigation measures, and environmental impact monitoring measures will be determined for the project as follows: • Air quality measures • Measures on public health, occupational health and safety
- Did the project have a plan for the construction period? The project should explain the impact on traffic conditions in the project area.	➢ The Consultant will consider the data on transport of construction tools and machines from Gulf PD Company Limited in order to compute the capacity to accommodate traffic volume of the Then, the impact prevention and mitigation measures for transport will be determined for further implementation to cause the minimum impact on the traffic.	- The environmental impact prevention and mitigation measures will be determined for the project as follows: • Transport measures • Public relations and public participation measures

TABLE 7.7-3

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA SCOPE AND APPROACHES BY RELATED GOVERNMENT AGENCIES DURING THE PUBLIC CONSULTATION (PROVINCIAL LEVEL) (CONT'D)

Inquiries, Comments, and Suggestions	Explanations in the Forum/Additional Explanations	Utilization
- The project should ensure no transport of construction materials and tools during rush hours and should coordinate with the Department of Highways, the Department of Rural Roads, or related Highway District. Consideration should be also made on environmental impacts, e.g. dust, pollutants, arising out of the project transport.	➢ This suggestion will be taken account of for further study and implementation.	- The environmental impact prevention and mitigation measures will be determined for the project as follows: • Air quality measures • Transport Measures • Public relations and public participation measures
- Details about the power development fund for sustainable community development should be provided.	➢ The project will make contributions to the power development fund for sustainable community development as follows. • Construction Period: The project will make a contribution in the amount of 150 million baht/year. The construction period is about 4 years. • Operation Period: The project will make a contribution in the amount of 200-250 million baht/year. The operation period is about 25 years. All sub-districts in the radius of 5 km from the project area will benefit from the fund. However, the Energy Regulatory Commission will decide and announce the list of sub-districts which are qualified for receiving assistance from the fund.	- Additional details of this issue will be given in the 2nd public consultation.

TABLE 7.7-3

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA SCOPE AND APPROACHES BY RELATED GOVERNMENT AGENCIES DURING THE PUBLIC CONSULTATION (PROVINCIAL LEVEL) (CONT'D)

Inquiries, Comments, and Suggestions	Explanations in the Forum/Additional Explanations	Utilization
- Apart from the power development fund for sustainable community development, are there other benefits?	➢ Gulf PD Company Limited has the budget for CSR activities and makes donations for the benefit of communities around the power plant. The Thai Energy Foundation was also established to donate money for public charity. The foundation will provide assistance to communities in case of disaster. The company also pays local administration tax.	- Additional details of this issue will be given in the 2nd public consultation.
- Will people around the power plant use electricity free of charge? Will there be any discount for electricity fee?	➢ Gulf PD Company Limited cannot directly sell electricity to people. The Provincial Electricity Authority is in charge of sale of electricity.	- Additional details of this issue will be given in the 2nd public consultation.
- If possible, the water storage and green area in the project area should be developed as the tourist site or the public park for local people.	➢ This suggestion will be taken account of.	-
- The project and related organizations, such as East Water, Pluak Daeng Industrial Park, Department of Highways, and related police stations should have a meeting and result of the meeting should be presented in the next public consultation at provincial level.	➢ This suggestion will be considered for further action.	- The suggestion will be implemented before the 2nd public consultation.

Remark: *The project submitted to the Rayong Provincial Office of Public Works and Town & Country Planning the letter inquiring about the compliance of the project operation with Pluak Daeng comprehensive plan. The examination result revealed that the project is located on the land designated for general industry which does not cause pollution to communities, environment, and warehouses (white color with violet diagonal pattern and frame). Therefore, the project is in compliance with the requirements of the draft comprehensive plan. The letter submitted to the Rayong Provincial Office of Public Works and Town & Country Planning is presented in **Appendix 4J**.

(b) Summary of Opinions from Questionnaires in the 1st Public Consultation (Provincial Level)

Apart from the opportunity to express their opinions in the public consultation forum, the participants also provided collaboration by completing the questionnaires on EIA scope and approaches as well as project development. 21 out of the total 23 participants filled out the questionnaires **(Appendix 7A-4)**. Opinions from the questionnaires are summarized into the following major items.

Perception of Project Information: Nearly all participants (81%) filling out the questionnaires knew before that the Pluak Daeng Power Plant Project of Gulf PD Company Limited is located in Pluak Daeng Industrial Park, Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province and only 19% of participants were not. 71.4% of participants knew before that natural gas is the primary fuel and diesel oil is the backup fuel used in the electrical power generating process of the project. Some did not know before and some did not express opinions (23.8% and 4.8% respectively).

Anxieties about Project Development

Construction Period: Only 9.5% of participants are not worried/ anxious about the impact from project development whereas 90.5% are. They are worried about the impacts on air quality, water sources and aquatic animals, solid waste management, public health, adequacy of public utilities (e.g. water, electricity), transport, sufficiency of public health services for patients, immigration of foreign labor force/ non-registered population, accidents and safety, noises from construction activities, and occupation.

- Operation Period: Only 4.8% of participants are not worried/ anxious about the impact from project development whereas 95.2% are. They are worried about the impacts on air quality, water sources and aquatic animals, public health, accidents and safety, adequacy of public utilities (e.g. water, electricity), sufficiency of public health services for patients, solid waste management, noises from operation activities, occupation, transport, emergency resulting from the project, and social conflict of people around the power plant.

Opinions about Sufficiency of Study Scope and Approaches: 23.8% of participants view that it is sufficient and 76.2% of participants think it is not. Additional details should be included as follows.

Air Quality

- Data on air quality should be collected before the project operation. Measurement frequency and season should be also considered.

- Consideration should be made on the pollutants from the project operation.
- Continual monitoring measures should be determined.

Noise

- Noise level should be measured in the communities around the project area.

Water Sources and Aquatic Animals

- Samples of water and aquatic animals should be collected both before and after the project implementation to compare the change.
- Consideration should be given to the impact on nearby water sources for consumption.
- Sufficiency of water sources for consumption in the project
- Drainage and flood control should be studied.

Solid Waste Management

- Basic data around the project area should be collected before the project implementation.
- Consideration should be made on solid waste management of the project.

Transport

- The impacts from transport of materials and equipment to the project site should be studied.
- The period for transport of materials and equipment should be determined.

Society and Occupation

- Non-registered population should be considered.
- Consideration should be given to crime.
- Attention should be paid on outside workers taking jobs of local people.
- Change in way of living of local people/communities should be considered.

Impact on Health and Public Health Services

- Data on local people's health should be gathered before the project operation.

- Impact on health of local people and project staff should be monitored.
- Public health system should be sufficient to accommodate the increasing number of people.
- Medical specialty experts and services should be provided.
- Support should be provided to local medical establishments.

Dissemination of Project Information: According to the answers from questionnaires, respondents viewed that the top three effective channels for dissemination of the project information are community leaders/government agencies, community radio, and noticeboards/signs. The information that people want to know are safety system and emergency plan, environmental impact prevention and mitigation measure, probable impacts from the project operation, details and knowledge about the power plant.

Additional Suggestions

- Activities of local communities within the radius of 5 km from the project site should be supported since they will be directly affected by the project operation.
- During the initial period, some contributions to the power development fund should be used to support occupational development of local people around the project area.
- Details of the impacts on local people's health should be clearly provided.
- Survey of environmental quality, e.g. air, noise, water sources and aquatic animals, solid waste management, transport, etc., should be conducted before the project construction.

(2) The 1st Public Consultation (Sub-district Level)

It was held during 25th - 27th January 2016. There were 582 participants (excluding staff of Gulf PD Company Limited and the Consultant) as presented in **Tables 7.7-1** and **7.7-2**. Participants included executives of sub-district administrative organizations (Map Yang Phon, Pluak Daeng, Mae Nam Khu, and Phana Nikhom sub-districts), representatives of related government offices, representatives of local schools, sub-district headmen, village headmen, local people, mass media, and general people interested in the project. (List of participants is presented in **Appendix 7A-3**.) The public consultation proceeded in a smooth atmosphere (**Photo 7.7-3**).


Map Yang Phon Sub-district, Pluak Daeng District


Pluak Daeng Sub-district, Pluak Daeng District


Mae Nam Khu Sub-district, Pluak Daeng District


Phana Nikhom Sub-district, Nikhom Phatthana District

PHOTO 7.7-3 : ATMOSPHERE OF THE 1st PUBLIC CONSULTATION (SUB-DISTRICT LEVEL)

After presentation of the EIA scope and approaches, participants had opportunity to express their opinions via two methods: (1) inquiry in the public consultation forum and (2) questionnaire.

(a) Summary of Inquiries, Comments, and Suggestions on EIA Scope and Approaches by People and Related Parties during the Public Consultation (Sub-district Level)

After presentation of the project details, EIA scope and approaches, participants had opportunity to make inquiries and express their comments and suggestions as summarized in **Table 7.7-4**.

(b) Summary of Opinions from Questionnaires in the 1st Public Consultation (Sub-district Level)

Apart from the opportunity to express their opinions in the public consultation forum, the participants also provided collaboration by completing the questionnaires on EIA scope and approaches as well as project development. 491 out of the total 582 participants filled out the questionnaires **(Appendix 7A-4)**. Opinions from the questionnaires are summarized as follows:

Perception of Project Information: 75.8% of participants filling out the questionnaires knew before that the Pluak Daeng Power Plant Project of Gulf PD Company Limited is located in Pluak Daeng Industrial Park, Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province. 20% of participants did not know and 4.2% did not express opinions. 67.6% of participants knew before that natural gas is the primary fuel and diesel oil is the backup fuel used in the electrical power generating process of the project. 28.3% did not know before and 4.1% did not express opinions.

Anxieties about Project Development

- Construction Period: 24.4% of participants are not worried about the impact from project development whereas 75.6% are. They are worried about the impacts on air quality, water sources and aquatic animals, public health, solid waste management, noises from construction activities, accidents and safety, immigration of foreign labor force/non-registered population, transport, adequacy of public utilities (e.g. water, electricity), sufficiency of public health services for patients, occupation, and groundwater quality.

TABLE 7.7-4

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA SCOPE AND APPROACHES BY PEOPLE AND RELATED PARTIES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL)

Inquiries, Comments, and Suggestions	Explanations in the Forum/Additional Explanations	Utilization
A. Project Information		
- What are the differences between the natural gas-fired power plant and the coal-fired power plant?	➢ The pollutants emitted from both types of power plants are the same. However, coal contains more sulfur than natural gas. Thus, sulfur dioxide emissions from a coal-fired power plant is higher than a natural gas-fired power plant. ➢ Pluak Daeng power plant mainly uses natural gas as the primary fuel and diesel as backup fuel. Backup fuel can be used for about 3 days in case of natural gas pipeline problem or as ordered by EGAT only.	- Additional details of this issue will be given in the 2nd public consultation.
- In case of power plant explosion, what will be the impacts on communities?	➢ Explosion can occur in two cases. (1) leaks/breakages in natural gas pipelines which are inspected by the power plant and PTT. Related valves will be closed immediately in case of leakage. (2) In case of boiler explosion, the project will study the size of breakage or leak in order to know the blast radius. For this project, the blast radius will be within the industrial park based on the previous study results. However, the safety system in the power plant is at high level and safety measures are strictly followed. Power plant blast has never occurred in Thailand.	- The environmental impact prevention and mitigation measures, and environmental impact monitoring measures will be determined for the project as follows. - Measures on major hazard - Measures on public health, occupational health and safety
- Since the backup fuel (diesel) is sufficient for 3 days, what fuel will be used next for electricity generating?	➢ Diesel will be used as the backup fuel in case any natural gas pipeline fails to transmit natural gas. The period of electricity generating by diesel is normally short and based on EGAT's order because the cost is high. In case the backup fuel is used up and natural gas cannot be transmitted to the power plant, it is necessary to stop the power plant operation. Other fuel cannot be used.	- Additional details of this issue will be given in the 2nd public consultation.

TABLE 7.7-4

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA SCOPE AND APPROACHES BY PEOPLE AND RELATED PARTIES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries, Comments, and Suggestions	Explanations in the Forum/Additional Explanations	Utilization
- In case of power plant construction, will water conflict occur and will it affect agricultural areas?	➢ In this project, the agricultural area will be surveyed and the required amount of water will be assessed. The project will be supplied with water from East Water which also sells water to the industrial park. Water will be transmitted through separate pipeline from that of local communities. The project will not use water from natural water sources or water sources used by communities.	- The environmental impact prevention and mitigation measures for water use will be determined.
- Will the power plant have water reserve? If the water reserve is used up and water use is about 60,000 cubic meters, how will the project manage to prevent water shortage?	➢ East Water has an extensive water grid and sufficient water reserve. ➢ The project will store water in ponds in the project area which is sufficient for 3 days in emergency case.	- The environmental impact prevention and mitigation measures for water use will be determined.
- Since the project will use water from East Water, will this affect water for agricultural purpose?	➢ The project will use water from East Water which transmits water from Nong Pla Lai reservoir. Before the project start, we studied and consulted East Water about their capacity to supply water throughout the project operation period of 25 years. East Water has planned to install water pipelines from Prasae reservoir to supply water to Pluak Daeng District and will seek new water sources to supply water to Mueang Rayong and Map Ta Phut Districts. Water supplied to Pluak Daeng district will not be used for other purposes to avoid affecting water for agriculture and fishery.	- The environmental impact prevention and mitigation measures for water use will be determined.

TABLE 7.7-4

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA SCOPE AND APPROACHES BY PEOPLE AND RELATED PARTIES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries, Comments, and Suggestions	Explanations in the Forum/Additional Explanations	Utilization
B. Environmental Impacts Resulting from the Project Operation		
- Concern about the impacts (e.g. air quality, traffic, etc.) of the project operation on communities, especially child care centers and children	➢ Air quality will be measured before the start of project. Air pollutant emissions in nearby industrial estates will be assessed by using air quality simulation model. Study will be also conducted on the impact of the project's air pollutant emissions on environmentally sensitive areas, e.g. child care centers. Thus, local communities should feel relieved that the project does not neglect this matter and will present the study result in the next public consultation.	- The environmental impact prevention and mitigation measures will be determined for the project as follows. - Air quality measures - Transport measures
- Concern about the impacts on air quality and groundwater which still used by the surrounding communities. These impacts should be considered in case of project development. Remedial action should be taken if local communities are affected by the project operation, e.g. in aspect of health.	➢ Measurement of air quality and groundwater quality will be measured and the study results will be presented in the next public consultation.	- The environmental impact prevention and mitigation measures will be determined for the project as follows. - Air quality measures - Surface water quality and groundwater quality measures
- During the construction and operation periods, what are the prevention and mitigation measures for air pollution?	➢ The Consultant will study in advance the level of impact on communities and then determine the environmental impact prevention and mitigation measures. For example, if the project will cause particulate matter problem during the construction period, the mesh sheets will be installed and water will be sprayed around the construction area to prevent dust dispersion. The impact will be monitored and the monitoring result will be reported to related government agencies.	- The environmental impact prevention and mitigation measures for air quality will be determined for the project.

TABLE 7.7-4

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA SCOPE AND APPROACHES BY PEOPLE AND RELATED PARTIES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries, Comments, and Suggestions	Explanations in the Forum/Additional Explanations	Utilization
- What will be the pollutants caused by the project operation? How will the project manage the chemicals in the effluents or the air pollutant emissions from the project?	➢ The project operation will have impacts, e.g. air quality, on local communities. However, during EIA, the air pollutant emissions will be assessed by using the air quality simulation model in order to know the quantity of air pollutants that can be emitted and where they will spread to. Then the environmental impact prevention and mitigation measures and the environmental impact monitoring measures will be determined and reported to related government agencies.	- The environmental impact prevention and mitigation measures will be determined for the project as follows. - Air quality measures - Surface water quality and groundwater quality measures - Solid waste management measures
C. Public Participation/Contributions to Communities		
- Over the past period, has the company ever faced problems with local communities in other projects? Did local communities every file complaints and how did the company cope with such complaints?	➢ The company has staff to regularly visit local communities as we do not wait until problems occur/ complaints filed by communities. If problem is found, we will mutually with local communities to find solutions. For example, during the construction period there were dust and noise problems due to pile driving. The project solved the problems by fixing the construction time and prohibiting the construction activities in the night time. In the case of the operation period of the Nong Khae Power Plant, noise from the cooling tower affected the surrounding communities. The sound-proof walls were therefore installed to solve this problem, satisfying local communities.	- The environmental impact prevention and mitigation measures will be determined for the project as follows. - General measures - Socio-economic measures - Public relations and public participation measures

TABLE 7.7-4

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA SCOPE AND APPROACHES BY PEOPLE AND RELATED PARTIES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries, Comments, and Suggestions	Explanations in the Forum/Additional Explanations	Utilization
- Will local people be employed to work in the power plant?	➢ Employment is divided into two periods: - Construction period: The project contractor will normally hire local people to conduct construction activities, e.g. welders, etc. - Operation period: The power plant will employ about 60-70 staff since it mainly uses electronic equipment or computerized system. Local people who are qualified, especially those living within 5 km radius from the project site, will be called for interview step first. As for the candidates who are not local people, their application letters will be screened first and have to pass several recruitment steps.	- The environmental impact prevention and mitigation measures will be determined for the project as follows. - Socio-economic measures - Public relations and public participation measures
- The project should clearly specify the benefits that local communities will have from the power plant development.	➢ The power development fund for sustainable community development will be mutually managed by local communities, the power plant, and local authorities under the supervision of the Energy Regulatory Commission. When civil society forum is held to discuss about use of fund, local people should participate in to ensure fund will be concretely utilized*.	- The environmental impact prevention and mitigation measures will be determined for the project as follows. - Socio-economic measures - Public relations and public participation measures

TABLE 7.7-4

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA SCOPE AND APPROACHES BY PEOPLE AND RELATED PARTIES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries, Comments, and Suggestions	Explanations in the Forum/Additional Explanations	Utilization
- What benefits will local people in the study area/within 5 km radius from the power plant receive from the project operation apart from the negative impacts? How to calculate the fund contributions?	➢ Power plant is the only industry that is required to set up a development fund. Based on the fund development principles, the whole sub-district within the radius of 5 km from the power plant will be funded although only 2 villages in that sub-district are covered in the 5-km radius. The Energy Regulatory Commission will be responsible for supervision of the fund operation/use of funds, and announcement of the areas and villages that are eligible for receiving funds. ➢ The project will make contributions to the power development fund for sustainable community development as follow: - Construction Period: The project will make a contribution in the amount of 150 million baht/year. The construction period is about 4 years. - Operation Period: The project will make a contribution in the amount of 200-250 million baht/year. The operation period is about 25 years.	- Additional details of this issue will be given in the 2nd public consultation.

TABLE 7.7-4

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA SCOPE AND APPROACHES BY PEOPLE AND RELATED PARTIES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries, Comments, and Suggestions	Explanations in the Forum/Additional Explanations	Utilization
- What benefits will people in Phana Nikhom Sub-district receive from the power development fund for sustainable community development?	➢ The project will make contributions to the power development fund for sustainable community development as follows: - Construction Period: The project will make a contribution in the amount of 150 million baht/year. The construction period is about 4 years. - Operation Period: The project will make a contribution in the amount of 200-250 million baht/year. The operation period is about 25 years. - All sub-districts within the 5-km radius will be eligible for the fund. However, the ERC will decide on the list of eligible sub-districts and announce to the public.	- Additional details of this issue will be given in the 2nd public consultation.
- Local communities should be supported by providing scholarships to students living around the power plant.	➢ Based on the corporate policy, the company will participate in all local communities' activities, such as religious ceremonies, traditional activities, and educational assistance, by using the company's own budget which is separate from the fund. Any local community which requires assistance can contact the company.	- The environmental impact prevention and mitigation measures will be determined for the project as follows. - Socio-economic measures - Public relations and public participation measures
- Why does this power plant require a large area of up to 500 rai? We used to visit the power plant in Saraburi Province. It does not require a large area.	➢ The power plant area is divided into several parts. Ponds and transmission system require a large area. The project layout will be presented in the next meeting.	- This point will be considered to prepare the power plant visit in order to build understanding about the project operation.

TABLE 7.7-4

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA SCOPE AND APPROACHES BY PEOPLE AND RELATED PARTIES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries, Comments, and Suggestions	Explanations in the Forum/Additional Explanations	Utilization
- Power plant visit should be arranged for representatives of local communities.	➢ The project plans to invite representatives of local communities to visit other large-scale power plant which has the same nature as the project.	- The environmental impact prevention and mitigation measures for socio-economics will be determined for the project.
- Does the company have other power plants with 2,500 MW capacity and where? The company should invite representatives of local communities to visit the power plant so that they see the real operation process.	➢ The large power plant in the East is Bang Pakong Power Plant. Most of the company's power plants are in the central region, e.g. Saraburi Province, Ayutthaya Province, etc. ➢ The company will invite representatives of local communities to visit our power plant so that they can explain to others and know the operation process.	- This point will be considered to prepare the power plant visit in order to build understanding about the project operation. - The environmental impact prevention and mitigation measures for socio-economics will be determined for the project.
- Although the preliminarily treated effluent from the project will be transmitted to the industrial park for further treatment and discharge into natural water bodies, people are worried about the impact on water in Nong Pla Lai and Nong Krai reservoirs. This point should be explained. Besides, during the power plant visit, the project should show them the wastewater treatment process and the locations where treated effluent is discharged into.	➢ The project is willing to invite local people to visit the power plant, including the locations where treated effluent is discharged into. The treated water is clean enough to discharge into natural water bodies. For example, the Kaeng Khoi 2 Power Plant releases effluent into Pasak River.	- This point will be considered to prepare the power plant visit in order to build understanding about the project operation. - The environmental impact prevention and mitigation measures will be determined for the project as follows: • Surface water quality measures • Socio-economic measures • Public relations and public participation measures

Remark: Details about the power development fund for sustainable community development set up in accordance with the criteria of ERC are presented in **Appendix 7B.**

- Operation Period: 28.7% of participants are not worried about the impact from project development whereas 71.3% are. They are worried about the impacts on air quality, water sources and aquatic animals, public health, solid waste management, accidents and safety, adequacy of public utilities (e.g. water, electricity), noises from operation activities, sufficiency of public health services for patients, transport, occupation, oil smell and air pollutant emissions, and non-registered population.

Opinions about Sufficiency of Study Scope and Approaches: 46.2% of participant view that it is sufficient and 53.8% of participants think it is not. Additional details should be included as follows.

Air Quality

- Pollutant measurement frequency should be increased. Air quality measurement and monitoring methods should be stricter.
- Odor impact
- Trees should be grown around the project area.
- Change in temperature should be considered.
- Air quality should be controlled by considering the quantity of air pollutants emitted into atmosphere and impact on agricultural products.

Noise

- Noise control measures should be implemented to avoid impact on local people living near the power plant, especially during the night time.

Water Sources and Aquatic Animals

- There should be measures to prevent dumping of chemicals into water bodies near the project area.
- The impacts from discharge of wastewater from the project into nearby water bodies should be assessed because the project site is near canals and reservoirs.
- Impact on groundwater quality
- Impact from heat produced during the cooling process
- Pollutant inspection and treatment method, including impact monitoring
- Sampling of water before the project operation

Solid Waste Management

- Consideration of the solid waste dump site of the project
- Consideration/selection of the efficient solid waste management system for the project, including monitoring thereof

Transport

- Consideration of routes for transport of materials to the project by avoiding main roads

- Consideration of traffic congestion problems
- If local roads are affected by the project operation, the roads should be immediately repaired.
- Traffic management method (during construction period)

Social Conditions and Occupation

- Impact from employment of migrant workers to work in the project area
- Management of fund in an accurate and well-organized manner
- Crime, theft, and narcotics problems
- Measure to employ local people to work in the project
- Impact of project development on people's way of life
- Consideration of people's anxieties about the project impact
- Promotion of local communities' occupation to be in accordance with the present situation
- The power plant should have measures to prevent impact on communities.

Impact on People's Health and Public Health Service

- Inspection of toxins in water which may affect people's health
- Gas emissions from the power plant stacks may affect people's health.
- Pollutants from combustion which may affect people's health
- Support should be given to local public health units in providing health care services.
- Sufficiency of public health services upon arrival of migrant workers
- Monitoring of pollutant emissions from the project to prevent impact on people's health
- Consideration of impacts from migrant workers

Dissemination of Project Information: According to the answers from questionnaires, respondents viewed that the top three effective channels for dissemination of the project information are community leaders/government agencies, focus group meetings, and community radio. The information that they want to know are environmental impact prevention and mitigation measures, probable impacts from the project operation, safety system and emergency plan of the project, details and knowledge about the power plant, electricity generating process/sources of fuel used in the project, etc.

Additional Suggestions

- Public relations activities about the project should be clearly and continually conducted, especially in the construction period.
- Public relations channels should be increased. For example, students and community leaders can be mouthpieces of the project.
- The project benefits to people and people and communities, e.g. care of children and the disabled, setup of fund for public health units, etc.
- Impacts on people and communities should be considered.
- The project should follow rules and regulations for living in harmony with local communities.
- All sectors should have opportunity to take part in the project.
- Water supply availability in the project area should be studied as the project area has water shortage problem. Project water storages should be considered to avoid impacts on communities.
- Air pollution should be controlled.
- Environmental impact prevention and mitigation measures should be established for the project.
- Consideration should be given to the accident prevention system in case of leakage/explosion of fuel.
- Three rows of trees should be grown around the project area to reduce noise impact.
- Local workers should be considered to work in the project.
- Contingency plan should be considered in case of accident and emergency.
- Related knowledge should be provided to people, such as project information, fuel for project operation, details of the power development fund for sustainable community development, methods to return benefits to communities, electricity generating process, accident prevention system, etc.

After completion of the 1st public consultation, summary of the results of public consultation (as presented in **Appendix 7A-5**) was posted within 15 days at the noticeboards of related government agencies, offices of sub-district headmen, offices of village headmen in the study area, e.g. Rayong provincial public relations office, Rayong provincial energy office, Pluak Daeng District Office, Nikhom Phatthana District Office, Pluak Daeng Sub-district Office, Mae Nam Khu Sub-district Office, Office of Map Yang Phon Sub-district Headman, Office of Phana Nikhom Sub-district Headman, etc. The 1st public consultation result summary was posted on 9 February 2016 in order to disseminate the project information to people interested in the project. (Examples of notice posting are illustrated in **Photo 7.7-4** and letter of request for assistance in **Appendix 7A-6**.)

Rayong Provincial Public Relations Office

Rayong Provincial Energy Office

Nikhom Phatthana District Public Health Office

Pluak Daeng District Public Health Office

Map Yang Phon Sub-district Administrative Organization

Office of Pluak Daeng Sub-district Headman

PHOTO 7.7-4 : NOTICE OF SUMMARY OF THE 1st PUBLIC CONSULTATION RESULT (EIA SCOPE AND APPROACHES)

7.7.3 The 1st Public Consultation with Dok Krai Fishery Resource Management Group

Since the project emphasizes the importance of dissemination of project information to all sectors, the 1st public consultation was organized with Dok Krai Fishery Resource Management Group which is outside the 5-km radius from the project area in order to provide the accurate and clear information about the project. The public consultation was organized on Tuesday 8th March 2016 during 10.00-12.00 hrs. at the hall of Dok Krai Fishery Resource Management Group. There were 31 participants, such as representatives of related government agencies (Royong Provincial Fishery Office) and members of Dok Krai Fishery Resource Management Group. (List of participants is exhibited in **Appendix 7A-3** and atmosphere of the public consultation in **Photo 7.7-5**). Media for the public consultation are as follows.

- Personal Media: Representatives of Gulf PD Company Limited and TEAM Consulting Engineering and Management Ltd.
- Document Media: PowerPoint presentations, PR documents for the project, questionnaire for the public consultation **(Appendix 7A-2)**.

After presentation of the EIA scope and approaches, participants had opportunity to express their opinions which can be summarized in **Table 7.7-5**.

7.7.4 Survey of Socio-Economic Conditions and Opinions about the Project Development

This activity is another channel for gathering opinions of people living within the radius of 5 km from the project area. The survey was conducted with 605 people during February-March 2016. Survey details and methods are presented in **Item Socio-Economic Conditions in Chapter 4.**

7.7.5 Power Plant Visit

Power plant visit is one of the activities for EIA process of the Pluak Daeng Power Plant Project in Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province. The objective of this activity is to create correct knowledge and understanding about the project development, as well as to collect opinions of people in local communities and reaction of community representatives toward the project during the power plant visit.

PHOTO-7.4 5 : ATMOSPHERE OF THE 1st PUBLIC CONSULTATION WITH DOK KRAI FISHERY RESOURCE MANAGEMENT GROUP

TABLE 7.7-5

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA SCOPE AND APPROACHES DURING THE 1st PUBLIC CONSULTATION WITH DOK KRAI FISHERY RESOURCE MANAGEMENT GROUP

Inquiries, Comments, and Suggestions	Explanations in the Forum/Additional Explanations	Utilization
- What are the differences between NGV and LPG?	➢ NGV is lighter than air and requires high concentration to ignite. LPG or cooking gas used in households is heavier than air. When leaked it will pool on the ground and is easier to be flammable than NGV.	- Additional details of this issue will be given in the 2nd public consultation.
- At present, the area is short of water for agriculture and fishery. If the power plant is located in the area, where will it take water from and will water be sufficient for the power plant?	➢ The project will use water from East Water which will transmit water from Prasae reservoir. ➢ According to the irrigation office, water volume will be sufficient for local people's agriculture and water sale of East Water.	- The environmental impact prevention and mitigation measures for water use will be determined for the project.
- People are worried about wastewater from the project. If wastewater volume is high, how will the project manage it?	➢ In this project, wastewater comes from the cooling water passing the heat transfer and blowdown from the boiler which condenses into liquid. Therefore, the temperature of wastewater from this process is higher than normal and must be stored in the wastewater holding pond before being conveyed to the treatment process of the Pluak Daeng Industrial Park to reach the effluent standards established for industrial factories and industrial estates.	- The environmental impact prevention and mitigation measures for groundwater quality will be determined for the project.
- How will the project treat the wastewater? Will it affect aquatic ecology and how?	➢ Water sampling for water quality analysis will be conducted at 3 locations: (1) upstream of the project area; (2) effluent discharge site; and (3) downstream of the project area. Water samples will be collected to analyze the quality	- The environmental impact prevention and mitigation measures for surface water quality will be determined for the project.

TABLE 7.7-5

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA SCOPE AND APPROACHES DURING THE 1st PUBLIC CONSULTATION WITH DOK KRAI FISHERY RESOURCE MANAGEMENT GROUP (CONT'D)

Inquiries, Comments, and Suggestions	Explanations in the Forum/Additional Explanations	Utilization
	before the start of the project. During the project operation, wastewater will be treated until it passes the established effluent standards for industrial factories before release outside. The treated wastewater will be stored in the holding pond to check it passes the standards before discharge. If not, it will be pumped back for treatment again until it reaches the standards. Therefore, effluent from the project will not affect aquatic ecology.	
- People are worried about particulate matter from the electricity generating process.	➢ The primary fuel for the electricity generating is natural gas which is colorless and odorless. With complete burning, it will cause no soot. However, the air quality measurement system will be installed at the stacks.	- The environmental impact prevention and mitigation measures and environmental impact monitoring measures for air quality will be determined for the project.
- Wastewater treatment may be conducted only during the initial period. Later, the project may discharge wastewater without treatment, affecting people and the ecology system.	➢ The project will continually conduct wastewater treatment as it is required by law.	- The environmental impact prevention and mitigation measures for groundwater quality will be determined for the project.
- Will the project cause odor problem?	➢ There will be no odor problem because the project will use natural gas as the primary fuel. Natural gas is normally colorless and odorless.	- Additional details of this issue will be given in the 2nd public consultation.

Gulf PD Company Limited organized the visit to Kaeng Khoi 2 Power Plant in Saraburi Province which is one of the power plants of Gulf Group in March 2016 (after the 1st public consultation). There were 402 visitors, comprising representatives from Map Yang Phon, Pluak Daeng, and Mae Nam Khu Sub-districts in Pluak Daeng District, and representatives from Phana Nikhom Sub-district, Nikhom Phatthana District, Rayong Province. The power plant visit proceeded in a smooth atmosphere as illustrated in **Photo 7.7-6**. After completion of presentation by the representative of Gulf PD Company Limited and power plant visit, visitors were allowed to inquire and express their opinions about the electricity generating process. They were also asked to fill out the questionnaires. There were 304 respondents. (Results from questionnaires are presented in **Appendix 7C**). Their opinions can be summarized below.

Anxieties about the Impact from the Power Plant Operation before Visit: More than a half of the visitors (62.8%) were not worried about the power plant operation but some (35.2%) were. The top three issues that they were worried about comprised air/other pollution problems, use of water in the project/impact on water sources in communities/natural water bodies, and water pollution/wastewater from the project. 2.0% of respondents did not specify/express opinions.

Understanding about Electricity Generating Process and Environmental Management of the Natural Gas-Fired Power Plant: After listening to the presentation about the power plant project, 89.4% of visitors better understood about the electricity generating process of power plant that used natural gas as a main fuel, 4.3% did not express opinions, and 2.0% did not have better understanding.

Anxieties about the Impact from the Operation of Pluak Daeng Power Plant after Visit: Most visitors were less worried about the operation of the power plant. 71.1% were not worried and 16.4% were still worried. The top three issues that they were worried about comprised impact on water use/insufficient water, air pollution, and impact of higher temperature. The remaining 12.5% did not specify/express opinions.

Benefits from Power Plant Visit: 83.9% of visitors thought that this visit was useful as they had better knowledge and understanding about the electricity generating process and saw the real power plant. 0.3% of visitors thought it was not useful and 15.8% did not express opinions.

Awareness of Project Information: 88.2% of visitors knew before that Gulf PD Company Limited had the plan to develop the Pluak Daeng Power Plant. Most of them knew this from the project staff, community leaders, and government agencies. 6.9% of them did not express opinions and 4.9% did not know before.

PHOTO 7.7-6: PHOTOS OF POWER PLANT VISIT BY REPRESENTATIVES OF LOCAL COMMUNITIES IN THE STUDY AREA (MARCH, 2016)

7.7.6 The 2nd Meeting with Related Government Agencies

The meeting with representatives of related provincial government agencies was scheduled on 3 May 2016 prior to the 2nd public consultation. The objectives of this activity were to inform the study result and draft environmental impact prevention and mitigation measures to related agencies before the public consultation; and to consult them about public consultation. The agencies/representatives that the Consultant had the meetings with were Rayong Provincial Governor, Head of Rayong Provincial Energy Office, and representatives of Rayong provincial office for natural resource and environment. Discussion topics/opinions/concerns about the project development were summarized in **Table 7.7-6** and the meeting atmosphere presented in **Photo 7.7-7**.

7.7.7 The 2nd Public Consultation with People and Related Parties

The objective of this activity is to present the study results and draft environmental impact prevention and mitigation measures and draft environmental impact monitoring measures to all stakeholders in the project. The 2nd public consultation was held at five forums during 25th-27th May 2016 as follows.

(1) The 2nd Public consultation (provincial level) with related government agencies at provincial, district and sub-district levels (1 forum)

(2) The 2nd Public consultation (sub-district level) with related government agencies at sub-district level, sub-district headmen, village headmen, and local people in the study area (4 forums).

Details of this activity and the number of participants are presented in **Table 7.7-7**. The target groups of the public consultation cover 7 groups of stakeholders according to the Guidelines for Public Participation in Social Impact Assessment of the Office of Natural Resources and Environmental Policy and Planning, B.E. 2549 (2006), as shown in **Table 7.7-8**. There were 711 participants, comprising representatives of government officials at different levels (e.g. representatives of provincial government agencies), chief executives of sub-district administrative organizations (SAO), members of SAO councils, sub-district headmen, village headmen, representatives of local people in the study area, people who are interested in the project.

Prior to the 2nd Public Consultation, the Consultant sent the letters of invitation to the target groups and requested for assistance from local government agencies, relevant sub-district headmen and village headmen to post the public consultation schedule notices in conspicuous places at least 15 days in advance from 3 May 2016 as illustrated in **Photo 7.7-8**. (Examples of the letter of invitation and the letter of request for posting the notice of public consultation schedule are presented in **Appendix 7D-1**.)

TABLE 7.7-6

SUMMARY OF INQUIRIES, DISCUSSION TOPICS, COMMENTS, AND ANXIETIES ON PROJECT DEVELOPMENT FROM THE 2nd MEETING WITH PROVINCIAL GOVERNMENT OFFICES

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
➢ What is the progress of the project? Did it start running?	➢ The project is in the process of preparing the draft EIA report and determining the draft environmental impact prevention and mitigation measures to submit to related organizations.	-
➢ During the previous public consultation, how did people react to the project? Did they protest against the project? What are their anxieties? If possible, meeting with local community leaders should be held before the project development to build understanding about the project.	➢ In the previous public consultation, people are worried about environmental impacts from the project development, such as air quality, water quality, noise, and sufficiency of water. ➢ The project had local office and arranged the visit to the Gulf Group's power plant which is currently in operation in order to build understanding about the project.	-
➢ How will the project manage wastewater?	➢ Most of the effluent from the project is water from the cooling system. It has higher temperature than normal. The project will provide holding pond to reduce temperature of water from the cooling system. The total dissolved solids in the effluent will be also controlled not to exceed 1,300 mg/l before transmitting to the holding pond of the industrial park. The online monitoring system will be also installed to continually measure and report the water quality to ensure it will meet the established standards before transmission of water for further treatment of the industrial park.	Environmental impact prevention and mitigation measures have been established. ➢ **Surface Water Quality Measures** Cooling Water Management Measures - Two cooling water holding ponds shall be with the holding capacity of 19,000 cu.m. each for at least one (1) day discharge volume. These two cooling water holding ponds will hold the blowdown from a cooling tower. The ponds shall be pave with HDPE or concrete to prevent leakage.

TABLE 7.7-6

SUMMARY OF INQUIRIES, DISCUSSION TOPICS, COMMENTS, AND ANXIETIES ON PROJECT DEVELOPMENT FROM THE 2nd MEETING WITH PROVINCIAL GOVERNMENT OFFICES (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
		- The online monitoring system shall be installed at the water holding ponds to check the temperature, pH, conductivity and dissolved oxygen. The monitoring results shall be reported to the display in front of the project area and wastewater control center of Pluak Daeng Industrial Park.
➢ How will the project manage wastewater? (Cont'd)	➢ As for the effluent from the electricity generating process, it will be preliminarily treated before transmitted to the wastewater holding pond of the project to check the properties by the online monitoring system. If it meets the established standards of the industrial park, it will be transmitted to the central wastewater system of the industrial park.	Effluent Management Measures - The quality of effluent to be carried to the central wastewater treatment system of Pluak Daeng Industrial Park shall comply with the requirements of Pluak Daeng Industrial Park. - The wastewater holding pond of the project, which can hold the effluent for 24 hours at minimum, shall be provided so that the quality of effluent is checked before being discharged to the central

TABLE 7.7-6

SUMMARY OF INQUIRIES, DISCUSSION TOPICS, COMMENTS, AND ANXIETIES ON PROJECT DEVELOPMENT FROM THE 2nd MEETING WITH PROVINCIAL GOVERNMENT OFFICES (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
		- wastewater treatment system of Pluak Daeng Industrial Park. - The online monitoring system shall be installed at the wastewater holding pond to check the temperature, pH and conductivity. The monitoring results shall be reported to the wastewater control center of Pluak Daeng Industrial Park.
➢ Based on the project study result, what percentage of air quality will be changed if the power plant is constructed?	➢ The main pollutant resulting from burning natural gas is nitrogen dioxide. Upon the project operation, the concentration of nitrogen dioxide in the atmosphere will increase from 21% to 60% of the established standard value. ➢ The project has established the measure to monitor the air pollutants at the stack of the power plant, and also ambient air quality around the project area every 6 months throughout the project operation period.	Environmental impact prevention and mitigation measures have been established. **Air Quality Measures** - The Continuous Emission Monitoring System (CEMS) shall be installed at the stacks emission of the power plant for continuous emission Monitoring. The display of air quality monitoring results shall be installed in front of the project area. Monitoring results shall be reported to Pluak Daeng Industrial Park throughout the project life.

TABLE 7.7-6

SUMMARY OF INQUIRIES, DISCUSSION TOPICS, COMMENTS, AND ANXIETIES ON PROJECT DEVELOPMENT FROM THE 2nd MEETING WITH PROVINCIAL GOVERNMENT OFFICES (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
		- CEMS shall be audited once a year throughout the project life. - Air pollution emissions shall not exceed the values determined in the environmental impact assessment report. - The concentrations of air pollutants emitted from the stack will be continually measured and also randomly measured every 6 months throughout the project operation period. - The concentrations of air pollutants in atmosphere will be measured every 6 months throughout the project operation period.
➢ Did the project plan what fuel will be used to substitute natural gas in case it is used up?	➢ The project selected the technology which can be used with natural gas and diesel. Diesel will be used as the backup fuel in case PTT fails to transmit natural gas for 3 days. If the project has to use other fuels, it is necessary to prepare the report on change of project details. In that case, EIA and public participation activities will be required and submitted for approval from related authorities.	Environmental impact prevention and mitigation measures have been established. - In case Gulf PD Co., Ltd. intends to change the project descriptions and/or environmental impact prevention and mitigation measures or environmental monitoring measures, the Company shall notify the permitting authority as follows: ○

TABLE 7.7-6

SUMMARY OF INQUIRIES, DISCUSSION TOPICS, COMMENTS, AND ANXIETIES ON PROJECT DEVELOPMENT FROM THE 2nd MEETING WITH PROVINCIAL GOVERNMENT OFFICES (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
		o If the permitting authority deems that such changes will have more positive or equivalent impacts on the environment, comparing to the approved measures in the EIA report, the permitting authority shall record such changes according to the criteria and conditions stipulated by relevant laws, and a copy thereof will be submitted to ONEP. o If the permitting authority deems that such changes may affect the essence of the approved EIA report, the permitting authority shall submit the addendum report to ONEP for submission to the relevant Expert Review Committee for comment prior to making changes.
➢ Are there other power plants of the same type located near the project?	➢ The company does not have other power plant within the radius of 5 km from the project area. The nearest one is Nong Lalok Power Plant which is the small-scale natural gas-fuel power plant.	-

TABLE 7.7-6

SUMMARY OF INQUIRIES, DISCUSSION TOPICS, COMMENTS, AND ANXIETIES ON PROJECT DEVELOPMENT FROM THE 2nd MEETING WITH PROVINCIAL GOVERNMENT OFFICES (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
➢ The project should create confidence in the power plant operation among local communities around the project area.	➢ The project arranged the visit to the Gulf Group's power plant which is currently in operation in order to create understanding and confidence about the power plant operation among local communities. ➢ The project has determined the measures for people to participate in monitoring the project operation via the environmental impact monitoring committee which consists of the members who are representatives of local communities. ➢ The project has established the complaint center for the project affected people to file complaints.	Environmental impact prevention and mitigation measures have been established. **Public Relations and Participation Measures** - The environmental impact monitoring committee shall be appointed at least one month before the start of the construction phase. The environmental impact monitoring committee shall perform duties from the pre-construction phase to the operation phase. - Community representatives comprise sub-district representatives and representatives from administrative divisions within 5 km. radius of the power plant as defined in the EIA report. (The number of community representatives shall not be less than half of a total number of the environmental impact monitoring committee).

TABLE 7.7-6

SUMMARY OF INQUIRIES, DISCUSSION TOPICS, COMMENTS, AND ANXIETIES ON PROJECT DEVELOPMENT FROM THE 2nd MEETING WITH PROVINCIAL GOVERNMENT OFFICES (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
		Socio-economic Measures - A "Complaint Center" shall be established to disseminate the project information, hear people's opinion, recommendations and complaints. Affected persons can make complaints or raise problems through any channels, as appropriate, such as verbal communication, telephone, memo, letter, electronic mail, fax, etc.
➢ The project should create confidence in the power plant operation among local communities around the project area. (Cont'd)		- In case of conflicts between the power plant and community people, the project information shall be disseminated urgently through channels or media to show the responsibility and care for people's concerns. - People in nearby communities shall have an opportunity to visit the power plant to ease their concern.

TABLE 7.7-6

SUMMARY OF INQUIRIES, DISCUSSION TOPICS, COMMENTS, AND ANXIETIES ON PROJECT DEVELOPMENT FROM THE 2nd MEETING WITH PROVINCIAL GOVERNMENT OFFICES (CONT'D)

<table>
<tr><th>Inquiries</th><th>Answers/Explanations</th><th>Utilization/Determination of Environmental Impact Prevention and Mitigation Measures</th></tr>
<tr><td>➢ The project should have the green area or allow people to use the green area in the project to create positive attitude toward communities.</td><td>➢ At least 5% of the total project area will be allocated as the green area. However, since the power plant area requires security, it cannot be opened for external people to enter. The project is willing to support local people's activities or tree-planting campaign in local communities around the project.</td><td rowspan="2">Environmental impact prevention and mitigation measures have been established.
Socio-economic Measures
- Measures for benefit return for communities shall be established, such as maintenance of Huai Phu Sai with Pluak Daeng Industrial Park, other factories or involved agencies, support for local educational institutes or public health facilities, promotion of religious maintenance, contribution to public health benefit, etc.</td></tr>
<tr><td>➢ The area around Nong Pla Lai or Dok Krai reservoir should be developed, such as public park with the support of Gulf PD Co., Ltd.</td><td>➢ The project is willing to support local people's activities or tree-planting campaign in local communities around the project.</td></tr>
<tr><td>➢ Who the generated power will be sold to?</td><td>➢ The generated power will be sold to the Electricity Generating Authority of Thailand.</td><td>-</td></tr>
<tr><td>➢ How the electricity is generated?</td><td>The electricity generating process at Pluak Daeng Power Plant is as follows:
➢ Natural gas is injected into the combustion chamber, producing high-pressure hot gas to drive a gas turbine which is connected to a generator to produce energy.</td><td>-</td></tr>
</table>

TABLE 7.7-6

SUMMARY OF INQUIRIES, DISCUSSION TOPICS, COMMENTS, AND ANXIETIES ON PROJECT DEVELOPMENT FROM THE 2nd MEETING WITH PROVINCIAL GOVERNMENT OFFICES (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
	➢ The hot exhaust gases are then fed into a heat recovery steam generator (HRSG) to produce steam. ➢ Steam is then fed to turbine which is connected to the generator to produce additional electricity. ➢ Steam output from the steam turbine is transformed into liquid for reuse in the steam generating process. That is, steam is sent to the condenser to exchange heat with cooling water from the cooling tower, and condenses into the liquid form. The cooling water passing heat transfer has high temperature and is conveyed to the cooling tower to lower its temperature. ➢ Hot water from the condenser is sent to the cooling tower and cooled down by air from the cooling tower fan. The cooled down water is then collected in the holding pond of the cooling tower.	

TABLE 7.7-6

SUMMARY OF INQUIRIES, DISCUSSION TOPICS, COMMENTS, AND ANXIETIES ON PROJECT DEVELOPMENT FROM THE 2nd MEETING WITH PROVINCIAL GOVERNMENT OFFICES (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
➢ The project should present the overall benefits to communities.	➢ According to the Regulations of the Energy Regulatory Commission, a power plant is required to set up a power development fund for development of local communities affected by the power plant operations. The power plant has to send contributions to the fund to organize development activities, e.g. health promotion, occupational development, agricultural development, community economy development, quality of life development, development of education, religion, culture, tradition, etc. ➢ Besides, the project has determined the public participation-related measures by providing support to activities in communities as appropriate in order to build good relationship with them and return benefits to communities and the society.	Environmental impact prevention and mitigation measures have been established. **Socio-economic Measures** - Measures for benefit return for communities shall be established, such as maintenance of Huai Phu Sai with Pluak Daeng Industrial Park, other factories or involved agencies, support for local educational institutes or public health facilities, promotion of religious maintenance, contribution to public health benefit, etc.




PHOTO 7.7-7 : ATMOSPHERE OF THE 2nd MEETING WITH RELATED PROVINCIAL GOVERNMENT AGENCIES

TABLE 7.7-7

DATE, TIME, VENUE AND NUMBER OF PARTICIPANTS IN THE 2nd PUBLIC CONSULTATION

Date/Month/ Year	District	Sub-district	Venue	Number of Participants
25th May 2016	-	-	Uttarakitphichan Conference Room, 3rd floor, Rayong Provincial City Hall	25
	Pluak Daeng	Map Yang Phon	Ban Map Toei School	209
26th May 2016		Pluak Daeng	Meeting room at Pluak Daeng SAO	168
		Mae Nam Khu	Chak Man Thet Temple	172
27th May 2016	Nikhom Phatthana	Phana Nikhom	Office of Phana Nikhom Sub-district Headman	137
Total 5 forums				711

Remark: Excluding staff of Gulf PD Company Limited and the Consultant

TABLE 7.7-8

PARTICIPANTS IN THE 2nd PUBLIC CONSULTATION DIVIDED BY GROUPS OF STAKEHOLDERS ACCORDING TO THE GUIDELINES FOR PUBLIC PARTICIPATION AND SOCIAL IMPACT ASSESSMENT IN ENVIRONMENTAL IMPACT ASSESSMENT PROCESS

Group of Stakeholders	Forum/Number of Participants (Person)				
	Provincial Forum	Sub-district Forum			
		Map Yang Phon Sub-district	Pluak Daeng Sub-district	Mae Nam Khu Sub-district	Phana Nikhom Sub-district
1. Affected People					
- SAO chief executives and SAO council members	-	7	17	15	8
- Community leaders/people in the study area	-	200	50	146	123
2. The entities responsible for EIA report preparation					
- Gulf PD Company Limited (Project Owner)	5	7	7	5	5
- TEAM Consulting Engineering and Management Ltd. (Consultant)	5	5	5	5	5
3. The agencies in charge of considering EIA report					
- ERC	1				
- ONEP	-	-	-	-	-
4. Government agencies at different levels					
- Government agencies at provincial level	10	-	-	-	-
- Government agencies at district level	5	-	-	-	-
- Government agencies at sub-district level	2	2	4	6	4
- Public health offices	4	-	-	-	-

TABLE 7.7-8

PARTICIPANTS IN THE 2nd PUBLIC CONSULTATION DIVIDED BY GROUPS OF STAKEHOLDERS ACCORDING TO THE GUIDELINES FOR PUBLIC PARTICIPATION AND SOCIAL IMPACT ASSESSMENT IN ENVIRONMENTAL IMPACT ASSESSMENT PROCESS (CONT'D)

Group of Stakeholders	Forum/Number of Participants (Person)				
	Provincial Forum	Sub-district Forum			
		Map Yang Phon Sub-district	Pluak Daeng Sub-district	Mae Nam Khu Sub-district	Phana Nikhom Sub-district
5. Environmental non-governmental organizations (ENGO), non-governmental organizations (NGO), local educational institutions, and independent scholars					
- Local educational institutions	-	-	-	2	-
- Dok Krai Fishery Resource Management Group	-	-	-	-	-
6. Mass media					
- Local mass media	-	-	2	-	-
7. People interested in the project	3	-	95	3	2
Total	**35**	**221**	**180**	**181**	**147**

Rayong Provincial Public Health Office

Rayong Provincial Public Relations Office

Rayong Provincial Office for Natural Resource and Environment

Rayong Provincial Energy Office

PHTOTO 7.7-8: POSTING OF NOTICES ON INVITATION TO THE 2nd PUBLIC CONSULTATION (EIA STUDY RESULT AND DRAFT ENVIRONMENTAL IMPACT MITIGATION AND PREVENTION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES)

Media for the Public Consultation

- Personal Media: Representatives of Gulf PD Co., Ltd. and TEAM Consulting Engineering and Management Co., Ltd.

Document Media: PowerPoint presentations, PR documents for the project, questionnaire for each public consultation **(Appendix 7D-2)**

Conclusions of the 2nd public consultation with people and related parties are as follows.

(1) The 2nd Public Consultation (Provincial Level)

It was held on Wednesday 25th May 2016, during 9.30-12.00 hrs. at Uttarakitphichan Conference Room, the 3rd floor, Rayong Provincial City Hall. There were 25 participants (excluding staff of Gulf PD Company Limited and the Consultant). Representatives of provincial, district and sub-district government offices attended the public consultation, for example, representative of the Energy Regulatory Commission Regional Office 8, Chon Buri province, Head of Rayong Provincial Energy Office, representative of Pluak Daeng district, Head of Pluak Daeng District Agricultural Office, representative of Pluak Daeng Public Health Office, etc. (List of participants is presented in **Appendix 7D-3**.) The Deputy Provincial Governor chaired the public consultation which ran smoothly (**Photo 7.7-9**).

PHOTO 7.7-9 : ATMOSPHERE IN THE 2nd PUBLIC CONSULTATION (PROVINCIAL LEVEL) (EIA STUDY RESULT AND DRAFT ENVIRONMENTAL IMPACT MITIGATION AND PREVENTION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES)

After presentation of the EIA result and draft environmental impact prevention and mitigation measures and draft environmental impact monitoring measures, participants had opportunity to express their opinions via two methods: (1) inquiry in the public consultation forum and (2) questionnaire.

(a) Summary of Inquiries, Comments, and Suggestions on EIA Study Result and Draft Environmental Impact Mitigation and Prevention Measures and Draft Environmental Impact Monitoring Measures by Related Government Agencies during the Public Consultation (Provincial Level)

After presentation of the project details, EIA result and draft environmental impact prevention and mitigation measures and draft environmental impact monitoring measures, participants had opportunity to make inquiries and express their comments and suggestions as summarized in **Table 7.7-9**.

(b) Summary of Opinions from Questionnaires in the 2^{nd} Public Consultation (Provincial Level)

Apart from the opportunity to express their opinions in the public consultation forum, the participants also provided collaboration by completing the questionnaires on EIA results and draft environmental impact prevention and mitigation measures and draft environmental impact monitoring measures. 22 out of the total 25 participants filled out the questionnaires **(Appendix 7D-4)**. Opinions from the questionnaires are summarized as follows:

Awareness of Project Information: 81.8% of respondents knew about the development of the Pluak Daeng Power Plant Project from the 1^{st} public consultation with government agencies and from staff of Gulf PD Company Limited. Only 18.2% of respondents did not know before.

Understanding about EIA Results and Draft Environmental Impact Prevention and Mitigation Measures and Draft Environmental Impact Monitoring Measures: 90.9% of respondents understand the EIA results and draft environmental impact prevention and mitigation measures and draft environmental impact monitoring measures and 9.1% do not clearly understand. The issues that they do not clearly understand comprise group of people exposed to toxic substances, local ecology database system, and project impact study result.

TABLE 7.7-9

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES BY RELATED GOVERNMENT AGENCIES DURING THE PUBLIC CONSULTATION (PROVINCIAL LEVEL)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
➢ How does the project design and select the machines for the electricity generating system? Can it use diesel as fuel?	➢ The project selects the latest electricity generating technology which is used in many countries. It has higher efficiency in electricity generating and can control air pollutant emissions better than the systems of the power plants which are currently in operation. ➢ The selected electricity generator can use 2 types of fuel: natural gas as the primary fuel and diesel oil as the backup fuel.	-
➢ The project should invite representatives of local people to visit the power plant which is currently in operation so that they have better understanding and feel relieved from the project impacts. ➢ The project should allow people living around the project area to hear the real noise from the power plant operation so that they know whether the noise will annoy them.	➢ After the 1st public consultation on EIA scope, the project, in March 2016, invited representatives of local people to visit the Kaeng Khoi 2 Power Plant of Gulf Group that is currently in operation. According to the results of the questionnaires filled out by the power plant visitors, most of them have better understanding about the power production process and are not worried about the project development.	Environmental impact prevention and mitigation measures have been established. ➢ Socio-economic Measures - People in nearby communities shall have an opportunity to visit the power plant to ease their concern. - Public relations on the project development should be continually promoted through communication channels during the pre-construction, construction, and operation periods. Public relations campaign shall include the project details and progress during the construction phase, environmental impacts, and environmental impact prevention and mitigation measures, communication channel and complaint receiving channel as well as contact in case of emergency.

TABLE 7.7-9

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES BY RELATED GOVERNMENT AGENCIES DURING THE PUBLIC CONSULTATION (PROVINCIAL LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
➢ The project should invite representatives of local people to visit the power plant which is currently in operation so that they have better understanding and feel relieved from the project impacts. The project should allow people living around the project area to hear the real noise from the power plant operation so that they know whether the noise will annoy them. (Cont'd)		– A "Complaint Center" shall be established to disseminate the project information, hear people's opinion, recommendations and complaints. Affected persons can make complaints or raise problems through any channels, as appropriate, such as verbal communication, telephone, memo, letter, electronic mail, fax, etc – In case of conflicts between the power plant and communities, the project information shall be urgently disseminated to people through channels or media so that people acknowledge facts. This means the project is responsible for communities and aware of people's concerns. ➢ **Public Relations and Public Participation Measures** – The environmental impact monitoring committee shall be appointed at least one month before the start of the construction phase. The environmental impact monitoring committee shall perform duties from the pre-construction phase to the operation phase.

TABLE 7.7-9

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES BY RELATED GOVERNMENT AGENCIES DURING THE PUBLIC CONSULTATION (PROVINCIAL LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
		- Community representatives comprise sub- district representatives and representatives from administrative divisions within 5 km. radius of the power plant as defined in the EIA report. (The number of community representatives shall not be less than half of a total number of the environmental impact monitoring committee.)
➢ Why air pollutant emission standard value in case of using natural gas as fuel is different from that in case of diesel oil?	➢ The air pollutant emissions resulting from burning different fuel types are different. Natural gas is clean energy and therefore will cause less air pollutant emissions than diesel oil. ➢ However, to assess the air quality impacts, consideration will be made on air pollutant emissions from the power plant which uses two types of fuel. How the air pollutant emissions will affect the concentrations of air pollutants in the atmosphere will be also considered by comparing to the ambient air quality standard. The assessment results revealed that the ambient air quality after the project development will not exceed the established standards.	Environmental impact prevention and mitigation measures have been established. ➢ **Air Quality Measures** - Air pollution emissions shall not exceed the values determined in the environmental impact assessment report. - The Continuous Emission Monitoring System (CEMS) shall be installed at the stacks emission of the power plant for continuous emission Monitoring. The display of air quality monitoring results shall be installed in front of the project area. Monitoring results shall be reported to Pluak Daeng Industrial Park throughout the project life. - CEMS shall be audited once a year throughout the project life.

TABLE 7.7-9

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES BY RELATED GOVERNMENT AGENCIES DURING THE PUBLIC CONSULTATION (PROVINCIAL LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
➢ How can the project forecast the environmental impacts while the specifications of the machines for the power generating system are not clear?	➢ The project has already selected the preliminary technology for power production. It forecasted the air quality impacts from the project development and conducted measurement of the existing air quality in order to determine the environmental impact prevention and mitigation measures. The concentrations of air pollutants emitted from the stack will be specified as the measure and used as the requirement for selecting a contractor.	Environmental impact monitoring measures have been established. ➢ **Air Quality Measures** - The concentrations of air pollutants emitted from the stack will be continually measured and also randomly measured every 6 months throughout the project operation period. - The concentrations of air pollutants in atmosphere will be measured every 6 months throughout the project operation period.
➢ The Company should present the environmental measurement results of the existing power plants under Gulf Group that are currently in operation to the public consultation forum. By this way, people will see the overview of the power plant operation and feel more confident about the project. ➢ There are various air pollutant emission standards and many technical information. The explanations and presentation method should be simple and easy to understand.	➢ The project will take these suggestions into consideration.	Environmental impact prevention and mitigation measures have been established. ➢ **Public Relations and Public Participation Measures** - The environmental impact monitoring committee shall be appointed at least one month before the start of the construction phase. The environmental impact monitoring committee shall perform duties from the pre-construction phase to the operation phase. - The committee shall hold a position for 4 years each term from the appointment date and can take a position consecutively for not more than 2 terms.

TABLE 7.7-9

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES BY RELATED GOVERNMENT AGENCIES DURING THE PUBLIC CONSULTATION (PROVINCIAL LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
		– Public relations campaign about the project information shall be made for communities through leaflet, media or other activities, which are in line with the objectives of established measures. Moreover, local people shall have an opportunity to monitor the project throughout the project life.
➢ Transport of construction material and equipment during the construction period will cause motor vehicular emissions. Dust dispersion from soil stripping will occur. The prevention and mitigation measures include spraying of water on roads and washing of truck wheels. In practice, will the project follow the measures?	➢ Environmental impact prevention and mitigation measures and environmental impact monitoring measures specified in the EIA report will be included in the contractor agreement. Therefore, the contractor will follow the measures. Compliance with the measures will be monitored and reported to related agencies every 6 months. ➢ In addition, the project has set the policy regarding setup of the environmental impact monitoring committee before the start of the project construction. Representatives of people in the study area will be members of the committee. The committee has duties to monitor the project's compliance with the established standards and to be the center for accepting complaints about the impacts from the project activities for further investigation and correction.	Environmental impact prevention and mitigation measures have been established. ➢ Air Quality Measures – Trucks transporting construction materials shall be covered and/or fastened to prevent the falling of materials and reduce the diffusion of dust. – While being transported, construction materials will be covered with tarpaulin sheets to prevent accidents and dust. – Water shall be sprayed at the construction site, earth piles or the areas where construction activities cause diffusion of dust, such as roads, land leveling, etc., to reduce dust diffusion at least twice a day (morning-afternoon). However, when it is dry or windy and it is considered that the sprayed areas are getting dry and dust dispersion is likely to occur, water spraying will be additionally done.

TABLE 7.7-9

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES BY RELATED GOVERNMENT AGENCIES DURING THE PUBLIC CONSULTATION (PROVINCIAL LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
		- Truck wheels shall be washed before the trucks leave the construction site or construction-related areas to prevent dirt and sand from falling onto the roads, both inside and outside the project area. ➢ **Public Relations and Public Participation Measures** - The environmental impact monitoring committee shall be appointed at least one month before the start of the construction phase. The environmental impact monitoring committee shall perform duties from the pre-construction phase to the operation phase. - The committee shall hold a position for 4 years each term from the appointment date and can take a position consecutively for not more than 2 terms. - The information of Pluak Daeng Power Plant Project shall be continuously publicized throughout the construction phase. The information to be provided include: construction schedule, environmental monitoring action plan, etc., through media. Optionally, any of the following methods may be adopted: local radio, installation of signboards at important places, e.g. office of community leaders, in front of the the Sub-district Administrative Organization (SAO) or other methods which are consistent with the objectives of the measures, one month in advance before the construction begins.

TABLE 7.7-9

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES BY RELATED GOVERNMENT AGENCIES DURING THE PUBLIC CONSULTATION (PROVINCIAL LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
➢ The project should set conditions or make an agreement with contractors on implementing the measures for construction activities which may have impacts on communities to ensure the contractor will strictly follow.	➢ The project will include the measures in the EIA report as the conditions to the contract/ contractor agreement to ensure the contractor will strictly follow the measures during the construction.	Environmental impact prevention and mitigation measures have been established. ➢ **General Measures** - Gulf PD Co., Ltd. shall incorporate measures in the environmental action plans into the conditions of contractor contract. These shall be strictly adhered to for effective implementation. ➢ **Socio-economic Measures** - Environmental impact prevention and mitigation measures shall be strictly adhered to.
➢ Where the power transmission lines between the project and the sub-station of EGAT will pass? This is a consequent problem to local people because they cannot grow perennial trees along the transmission lines.	➢ EGAT will be responsible for installation of high-voltage power transmission lines between the project and the sub-station. Presently, the project knows only that the Pluak Daeng sub-station will be an inter connecting point of this project	-
➢ Will the project set up a power development fund for sustainable community development? Have other funds already existed in this area? Will there be any overlapping/ problem in terms of fund management?	➢ The project will set up the power development fund for sustainable community development before the other construction period. However, at present, there are already power development funds of other power plants, the project may join with these funds to reduce overlapping problem. However, this will depend on the consideration of the Energy Regulatory Commission (ERC)*.	-

TABLE 7.7-9

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES BY RELATED GOVERNMENT AGENCIES DURING THE PUBLIC CONSULTATION (PROVINCIAL LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
➢ The project should have the measures to prevent health problems, etc. in order to relieve local people's anxiety and protest against the project. The situation in local communities should be assessed. In case of protest by local people, the project should be ready to create understanding.	➢ The project will take this suggestion into consideration.	Environmental impact prevention and mitigation measures have been established. ➢ **Public Health, Occupational Health and Safety Measures** - The list of construction workers shall be created. The number of construction workers and the congenital disease of the construction workers shall be notified to the responsible public facilities before starting operations. - Communicable disease surveillance shall be provided by local public health agencies and the project. - Pre-placement examination and the annual health check-up shall be provided for staff at lease once a year. - Health promotion activities shall be organized. Public relations campaign about environmental aspect and health issues for communities shall be done. - Local public health facilities shall be supported in terms of health promotion, rehabilitation, disease prevention and healthcare for communities. - Morbidity survey on people living within 5 km. radius of the project location shall be conducted.

TABLE 7.7-9

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES BY RELATED GOVERNMENT AGENCIES DURING THE PUBLIC CONSULTATION (PROVINCIAL LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
➢ The Company's management should visit local people to build good relationship with them.	➢ At present, the project has community relations unit to coordinate with local communities and build good relationship with them.	Environmental impact prevention and mitigation measures have been established. ➢ **Public Relations and Public Participation Measures** - The project staff shall build good relationship with local officials and people through regular visits and shall be ready to solve any problem that may arise due to the project
➢ Water from East Water should be recycled for maximum use. ➢ Are chemicals added to water used in the project? How will the project treat the effluent before discharge outside the project? Is it contaminated by chemicals?	➢ The project will recycle water as much as possible. The quality of effluent from the cooling system will be controlled to meet the effluent standards before discharge into water sources for irrigation. The total dissolved solid must not exceed 1,300 mg/l. The effluent quality will be continually monitored before conveyance to the industrial park for further treatment. ➢ Quality of water from East Water will be preliminarily improved by adding chemicals in the same way as production of tap water.	Environmental impact prevention and mitigation measures have been established. ➢ **Water Use Measures** - Efficient water use shall be considered, such as reduction in water drainage from the cooling system or recirculation of water within the project, etc. - Water pipes shall be checked. Leaking pipes shall be fixed immediately to prevent water loss. - In the event of water shortage and Eastern Water Resources Development and Management PLC. is unable to convey water to the project, the project shall reduce power generation capacity or stop the operation.

TABLE 7.7-9

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES BY RELATED GOVERNMENT AGENCIES DURING THE PUBLIC CONSULTATION (PROVINCIAL LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
		➢ **Surface Water Quality Measures** <u>Cooling Water Management Measures</u> - Two cooling water holding ponds shall be provided with the holding capacity of 19,000 cu.m. each for at least one (1) day discharge volume. These two cooling water holding ponds will hold the blowdown from a cooling tower. The ponds shall be paved with (HDPE) or concrete to prevent leakage. - The online monitoring system shall be installed at the water holding ponds to check the temperature, pH, conductivity and dissolved oxygen. The monitoring results shall be reported to the display in front of the project area and wastewater control center of Pluak Daeng Industrial Park. - The Project shall control the quality of effluent discharged from a cooling tower to be in compliance with the measures of Pluak Daeng Industrial Park. The Industrial Park requires that the quality of cooling water shall meet the Notification of Ministry of Industry and temperature shall not exceed 34 °C.

TABLE 7.7-9

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES BY RELATED GOVERNMENT AGENCIES DURING THE PUBLIC CONSULTATION (PROVINCIAL LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
		- One emergency pond with the capacity of 19,000 cu.m. shall be provided with the holding capacity of at least one (1) day discharge volume. The emergency pond will hold the blowdown from a cooling tower. In case the monitoring results show that the quality of effluent from a cooling water does not comply with the measures of Pluak Daeng Industrial Park. Effluent Management Measures - The quality of effluent to be carried to the central wastewater treatment system of Pluak Daeng Industrial Park shall comply with the requirements of Pluak Daeng Industrial Park. - An oil separator shall be provided to separate oil from oil contaminated effluent. Then the contaminated effluent shall be carried to a wastewater holding pond for quality check prior to being discharged to the central wastewater treatment system of Pluak Daeng Industrial Park. - The wastewater holding pond of the project, which can hold the effluent for 24 hours at minimum, shall be provided so that the quality of effluent is checked before being discharged to the central wastewater treatment system of Pluak Daeng Industrial Park.

TABLE 7.7-9

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES BY RELATED GOVERNMENT AGENCIES DURING THE PUBLIC CONSULTATION (PROVINCIAL LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
		- The online monitoring system shall be installed at the wastewater holding pond to check the temperature, pH and conductivity. The monitoring results shall be reported to the wastewater control center of Pluak Daeng Industrial Park. - The effluent that passes quality check from the wastewater holding pond shall be carried through the drain pipe for treatment at the central wastewater treatment system of Pluak Daeng Industrial Park.
➢ Does cooling water still contain heat?	➢ The cooling system of the project will reduce the temperature of cooling water released from the condenser. ➢ However, the project will provide the cooling water holding pond to reduce the temperature of water from the cooling tower to be closest to the natural temperature.	Environmental impact prevention and mitigation measures have been established. ➢ **Surface Water Quality Measures** Cooling Water Management Measures - Two cooling water holding ponds shall be provided with the holding capacity of 19,000 cu.m. each for at least one (1) day discharge volume. These two cooling water holding ponds will hold the blowdown from a cooling tower. The ponds shall be paved with (HDPE) or concrete to prevent leakage. - The online monitoring system shall be installed at the water holding ponds to check the temperature, pH, conductivity and dissolved oxygen. The monitoring results shall be reported to the display

TABLE 7.7-9

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES BY RELATED GOVERNMENT AGENCIES DURING THE PUBLIC CONSULTATION (PROVINCIAL LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
		in front of the project area and wastewater control center of Pluak Daeng Industrial Park. - The Project shall control the quality of effluent discharged from a cooling tower to be in compliance with the measures of Pluak Daeng Industrial Park. The Industrial Park requires that the quality of cooling water shall meet the Notification of Ministry of Industry and temperature shall not exceed 34 °C. - One emergency pond with the capacity of 19,000 cu.m. shall be provided with the holding capacity of at least one (1) day discharge volume. The emergency pond will hold the blowdown from a cooling tower. In case the monitoring results show that the quality of effluent from a cooling water does not comply with the measures of Pluak Daeng Industrial Park.
➢ During the project operation, will smoke/flame be emitted from the stacks of the power plant?	➢ The project's power plant will not generate ash like a coal-fired power plant or a biomass power plant. Thus, there will be no ash or smoke emitted from the stacks of the power plant. ➢ The air pollutants emitted from the fuel combustion will be continually measured at the stacks of the power plant to ensure the air quality does not exceed the established	Environmental impact prevention and mitigation measures have been established. ➢ **Air Quality Measures** - Air pollution emissions shall not exceed the values determined in the environmental impact assessment report.

TABLE 7.7-9

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES BY RELATED GOVERNMENT AGENCIES DURING THE PUBLIC CONSULTATION (PROVINCIAL LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures
	standards. The measurement results will be displayed on the monitor installed in front of the power plant so that people can check.	– The Continuous Emission Monitoring System (CEMS) shall be installed at the stacks emission of the power plant for continuous emission Monitoring. The display of air quality monitoring results shall be installed in front of the project area. Monitoring results shall be reported to Pluak Daeng Industrial Park throughout the project life.
➢ Since the project will cause air pollutant emissions, the project should create confidence to local people by providing air pollution measurement tools and training to educate local people to understand and check the measurement results. The measurement tools should be installed before construction of the power plant.	➢ The project will take this suggestion into consideration.	Environmental impact prevention and mitigation measures have been established. ➢ **Air Quality Measures** – CEMS shall be audited once a year throughout the project life. – Air pollution emissions shall not exceed the values determined in the environmental impact assessment report. Environmental impact monitoring measures have been established. ➢ **Air Quality Measures** – The concentrations of air pollutants emitted from the stack will be continually measured and also randomly measured every 6 months throughout the project operation period. – The concentrations of air pollutants in atmosphere will be measured every 6 months throughout the project operation period.

Remark: *Details about the power development fund for sustainable community development set up in accordance with the criteria of ERC are presented in **Appendix 7B.**

Suitability/Sufficiency of Draft Environmental Impact Prevention and Mitigation Measures in the Pluak Daeng Power Plant Project: 40.9% of respondents view that the draft environmental impact prevention and mitigation measures are suitable/sufficient for project development. 31.8% of respondents think the measures are not suitable/sufficient as the implementation should be more concrete. Solutions to the impact problems, monitoring of public health, and assessment of all risks should be clearer. 27.3% are not certain as they are not updated on the present status of the project implementation and the project may not implement the measures as they were presented in the meeting. They are also concerned about exposure to disease and impact on air pollution.

Suitability/Sufficiency of Draft Environmental Impact Monitoring Measures in the Pluak Daeng Power Plant Project: 50% of respondents consider that the draft environmental impact monitoring measures are suitable/sufficient. 27.3% are not certain as they are not updated on the present status of the project implementation and the impacts have not occurred yet. They are not confident about the monitoring system (sensor system) and continuity of the environmental impact monitoring system. 13.6% think the draft measures are not suitable/sufficient in aspects of risk assessment, compliant with the measures. 9.1% did not express opinion.

Anxieties about Project Development

63.6% of respondents are still worried about the impact from project development. They are worried about the impacts on transport, effluent management, impact from toxic residue in soil, compliance with the established measures, environmental impacts, health impact, long-term impact on heat/pollution, air pollution, and noise. 31.8% of respondents are not worried about the project development whereas 4.6% did not express opinion.

Comments and Suggestions about the Project Development

Comments and suggestions on the project development collected from respondents are as follows:

- Impact on local people's health should be considered.
- Rehearsal of emergency response plan should be regularly undertaken.
- Impact mitigation guidelines should be thoroughly informed to people.
- Importance should be placed on people's health on a continual basis.
- Air quality measurement tools should be installed in communities and people should be able to measure the air quality by themselves.
- Impact on food chain should be considered.

- The impacts in emergency case should be informed to people.
- Consideration should be given to the probable impacts on people's health although the measure results do not exceed the established standards.
- Site visit should be arranged.
- People in local communities should have opportunity to take part in the project.
- More attention should be paid to impacts on people in the project area during the operation period.
- Regular meetings with local government offices should be organized.
- Annual health checkup should be provided to people around the power plant.
- At least 1-2 meetings with local people should be held to update them on the project progress.
- Attention should be paid to local people on a regular basis.

(2) The 2nd Public Consultation (Sub-district Level)

It was held during 25-27 May 2016. There were 686 participants (excluding staff of Gulf PD Company Limited and the Consultant) as presented in **Tables 7.7-7** and **Table 7.7-8**. Participants included executives of sub-district administrative organizations (Map Yang Phon, Pluak Daeng, Mae Nam Khu, Phana Nikhom sub-districts), representatives of related government offices, representatives of local schools, mass media, sub-district headmen, village headmen, local people, and general people interested in the project. (List of participants is presented in **Appendix 7D-3**.) The public consultation proceeded in a smooth atmosphere (**Photo 7.7-10).**

After presentation of the EIA results and draft environmental impact prevention and mitigation measures and draft environmental impact monitoring measures, participants had opportunity to express their opinions via two methods: (1) inquiry in the public consultation forum and (2) questionnaire.

(a) Summary of Inquiries, Comments, and Suggestions on EIA Results and Draft Environmental Impact Prevention and Mitigation Measures and Draft Environmental Impact Monitoring Measures during the Public Consultation (Sub-district Level)

After presentation of the EIA results and draft environmental impact prevention and mitigation measures and draft environmental impact monitoring measures, participants had opportunity to make inquiries and express their comments and suggestions as summarized in **Table 7.7-10**.


Map Yang Phon Sub-district, Pluak Daeng District


Pluak Daeng Sub-district, Pluak Daeng District


Mae Nam Khu Sub-district, Pluak Daeng District


Phana Nikhom Sub-district, Nikhom Phatthana District

PHOTO 7.7-10: ATMOSPHERE OF THE 2nd PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (EIA RESULTS AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES)

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
Map Yang Phon Sub-district (25th May 2016 at Ban Map Toei School, Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province)		
➢ At present, it does not have sufficient water in this area due to drought problem. How will the project manage water? If possible, the project should support local people by providing them with water in case of drought.	➢ The project will recycle water as much as possible. The quality of effluent from the cooling system will be controlled to meet the effluent standards before discharge into water sources for irrigation. The total dissolved solid must not exceed 1,300 mg/l. The effluent quality will be continually monitored before conveyance to the industrial park for further treatment. ➢ The project will take into consideration the suggestion to provide water to local people in case of drought.	Environmental impact prevention and mitigation measures have been established. ➢ Water Use Measures - Efficient water use shall be considered, such as reduction in water drainage from the cooling system or recirculation of water within the project, etc. - Water pipes shall be checked. Leaking pipes shall be fixed immediately to prevent water loss. - In the event of water shortage and Eastern Water Resources Development and Management PLC. is unable to convey water to the project, the project shall reduce power generation capacity or stop the operation.

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
➢ Safety of local communities in case of power plant operation	➢ The project has designed the machine, safety system, and fire extinguishing system in accordance with international standards and the ministerial regulations No. 33 (B.E. 2535) issued under the Building Control Act B.E. 2522. ➢ In addition, the maintenance plan will be prepared to ensure all machines and equipment will be always efficient throughout the project period. The emergency response plan will be available in case of accident. Rehearsal of emergency response plan will be undertaken annually.	Environmental impact prevention and mitigation measures have been established. ➢ **Public Health, Occupational Health and Safety Measures** - A fire protection system and fire fighting system shall be provided by the power plant according to National Fire Protection Association (NFPA) and related requirements and standards. - Adequate personal protective equipment, which is suitable for working conditions shall be provided for all staff. - An emergency shall be established for operations in emergency cases. - The annual emergency drill shall be performed for the power plant itself and together with Pluak Daeng Industrial Park. Moreover, training on emergency preparedness and response shall be provided for personnel at least once a year. - Diesel transport measures will include emergency response training, prevention of

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		oil leakage, preparation/inspection of emergency equipment, action to be taken in case of oil leakage, etc. - Safety measures for transport of chemicals - Safety measures for chemical storage - Measures for safe use of chemical substances
➢ In the long run, will the power plant affect local communities? Will the air that people breathe in affect their health?	➢ According to the air quality assessment results, the average air pollutant concentrations for 1 year and the air quality measurement results do not exceed the established standards. Therefore, it will not affect people's health. Besides, the environmental quality monitoring measures will be also established throughout the project period.	Environmental impact prevention and mitigation measures have been established. ➢ **Air Quality Measures** - Air pollution emissions shall not exceed the values determined in the environmental impact assessment report. - The Continuous Emission Monitoring System (CEMS) shall be installed at the stacks emission of the power plant for continuous emission Monitoring. The display of air quality monitoring results shall be installed in front of the project area. Monitoring results shall be reported to Pluak Daeng Industrial Park throughout the project life. - CEMS shall be audited once a year throughout the project life.

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		Environmental impact monitoring measures have been established. ➢ **Air Quality Measures** - The concentrations of air pollutants emitted from the stack will be continually measured and also randomly measured every 6 months throughout the project operation period. - The concentrations of air pollutants in atmosphere will be measured every 6 months throughout the project operation period.
➢ What will communities benefit from power plant operation?	➢ Benefits from power plant operation to local communities: - Representatives from local people will be members of the committee to manage the power development fund for sustainable community development. - The project will establish the measures to return benefits to local communities, for example, support to local educational institutions or public health offices, support of activities for public benefits, etc.	Environmental impact prevention and mitigation measures have been established. ➢ **Socio-economic Measures** - Qualified local people shall have the priority to be hired for any vacancy in order to mitigate the impact of relationship between the Project and people and communities. Local people should be always notified for any vacancy every time.

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		- Measures for benefit return for communities shall be established, such as maintenance of Huai Phu Sai with Pluak Daeng Industrial Park, other factories or involved agencies, support for local educational institutes or public health facilities, promotion of religious maintenance, contribution to public health benefit, etc. - The quality of life improvement policy shall be set up. Community businesses shall be supported and promoted for sustainable economic and social development.
Pluak Daeng Sub-district (26th May 2016 at Meeting Room at Pluak Daeng SAO, Pluak Daeng Sub-district, Pluak Daeng District, Rayong Province)		
➢ Will water supplied from East Water to the project affect local communities?	➢ The project will be supplied with raw water from East Water. The water management plan will be also prepared to support long- term water demand, for example, purchase of water from private pond owners in Chon Buri province, allocation of water from Bang Phra reservoir of RID, construction of Thap Ma raw water pond, and construction of Prasae-Nong Pla Lai transmission pipeline.	Environmental impact prevention and mitigation measures have been established. ➢ Water Use Measures - Efficient water use shall be considered, such as reduction in water drainage from the cooling system or recirculation of water within the project, etc.

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		- Water pipes shall be checked. Leaking pipes shall be fixed immediately to prevent water loss. - In the event of water shortage and Eastern Water Resources Development and Management PLC. is unable to convey water to the project, the project shall reduce power generation capacity or stop the operation.
➢ East Water and RID should be invited to attend every meeting.	➢ The project will take this suggestion into account.	-
➢ Is it possible for people to participate in EIA process? Presently, there are many factories in Pluak Daeng area. If people participate in the process, they will know that the environmental study is really conducted.	➢ During the EIA process, the project will disseminate the information and progress to local people from the start until completion. The project will establish the measures on project information dissemination to people in the pre- construction, construction, and operation periods. The environmental impact monitoring committee will be set up before the start of the project construction. Representatives of local people will be the members of the committee responsible for monitoring the project's compliance with the established standards.	Environmental impact prevention and mitigation measures have been established. ➢ **Public Relations and Participation Measures** - The information of Pluak Daeng Power Plant Project shall be continuously publicized throughout the construction phase. The information to be provided include: construction schedule, environmental monitoring action plan, etc., through media. Optionally, any of the following methods may be adopted: local radio, installation of signboards at

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		important places, e.g. office of community leaders, in front of the the Sub-district Administrative Organization (SAO) or other methods which are consistent with the objectives of the measures, one month in advance before the construction begins. - The environmental impact monitoring committee shall be appointed at least one month before the start of the construction phase. The environmental impact monitoring committee shall perform duties from the pre-construction phase to the operation phase. - The committee shall hold a position for 4 years each term from the appointment date and can take a position consecutively for not more than 2 terms.
➢ The project construction is not started yet. How will we know whether the project construction will cause air quality/particulate matter problems from transport of construction materials and whether it will affect local communities?	➢ The Consultant considered to use the mathematical simulation model which is generally accepted to assess the impacts from construction activities. In addition, the Consultant established the measures to mitigate the impacts, for example, spraying of water on roads and washing of truck wheels. Environmental quality	Environmental impact prevention and mitigation measures have been established. ➢ **Air Quality Measures** - Trucks transporting construction materials shall be covered and/or fastened to

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
	monitoring will be also performed every 6 months throughout the construction period to ensure the project development will not cause impact on local communities.	prevent the falling of materials and reduce the diffusion of dust. - While being transported, construction materials will be covered with tarpaulin sheets to prevent accidents and dust. - Water shall be sprayed at the construction site, earth piles or the areas where construction activities cause diffusion of dust, such as roads, land leveling, etc., to reduce dust diffusion at least twice a day (morning-afternoon). However, when it is dry or windy and it is considered that the sprayed areas are getting dry and dust dispersion is likely to occur, water spraying will be additionally done. - Truck wheels shall be washed before the trucks leave the construction site or construction-related areas to prevent dirt and sand from falling onto the roads, both inside and outside the project area.

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		Environmental impact monitoring measures have been established. ➢ **Air Quality Measures** - The concentrations of air pollutants in atmosphere will be measured every 6 months throughout the project construction period.
➢ The project should invite various participants to attend the meetings. People who have never attended the meetings should be invited so that they know the project information. Those who already attended the meetings knew the project information.	The project determined 7 target groups or stakeholders according to the Guidelines for Public Participation in Social Impact Assessment of the Office of Natural Resources and Environmental Policy and Planning, B. E. 2557: affected people, the entities responsible for EIA report preparation, the agencies in charge of considering EIA report, relevant government agencies, local educational institutions, mass media, and general public. The project will invite affected people via local community leaders in the study area and will post the public consultation schedule notices in conspicuous places, e.g. government offices and community offices.	Environmental impact prevention and mitigation measures have been established. ➢ **Public Relations and Participation Measures** - The information of Pluak Daeng Power Plant Project shall be continuously publicized throughout the construction phase. The information to be provided include: construction schedule, environmental monitoring action plan, etc., through media. Optionally, any of the following methods may be adopted: local radio, installation of signboards at important places, e.g. office of community leaders, in front of the the Sub-district Administrative Organization (SAO) or other methods which are consistent with the objectives of the measures, one month in advance before the construction begins.

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
➢		- The environmental impact monitoring committee shall be appointed at least one month before the start of the construction phase. The environmental impact monitoring committee shall perform duties from the pre-construction phase to the operation phase. - The committee shall hold a position for 4 years each term from the appointment date and can take a position consecutively for not more than 2 terms.
➢ The power plant should regularly pay attention to both community leaders and members. In case of emergency, the power plant should immediately inform community leaders. The project should be also responsible for the impact on communities.	➢ The project will prepare an emergency response plan which contains two levels of emergencies. - In case of fire in the power plant area, preliminary fire extinguishing will be conducted. If fire cannot be controlled, the power plant director will be informed of the incident (Level One Emergency Plan). - If fire cannot be controlled, it will be informed to the industrial park for assistance (Level Two Emergency Plan). Then the emergency plan of the industrial park will be used. If the incident is worse and reach Level Two Emergency, the industrial park will inform people and external units and will also disseminate	Environmental impact prevention and mitigation measures have been established. ➢ **Public Health, Occupational Health and Safety Measures** - An emergency shall be established for operations in emergency cases. - The annual emergency drill shall be performed for the power plant itself and together with Pluak Daeng Industrial Park. Moreover, training on emergency preparedness and response shall be provided for personnel at least once a year.

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
	information about the incident to people via various channels.	➢ **Public Relations and Participation Measures** - The environmental impact monitoring committee shall be appointed at least one month before the start of the construction phase. The environmental impact monitoring committee shall perform duties from the pre-construction phase to the operation phase. - The committee shall hold a position for 4 years each term from the appointment date and can take a position consecutively for not more than 2 terms. - Public relations campaign about the project information shall be made for communities through leaflet, media or other activities, which are in line with the objectives of established measures. Moreover, local people shall have an opportunity to monitor the project throughout the project life.

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
➢ Will the project development affect agriculture in the study area?	➢ Based on the forecast of air quality impacts resulting from the project development and the measurement of the existing air quality, the concentrations of air pollutants in the atmosphere will not affect agriculture. The operations of the power plants under Gulf Group have not affected local agriculture.	Environmental impact prevention and mitigation measures have been established. ➢ **Air Quality Measures** - Air pollution emissions shall not exceed the values determined in the environmental impact assessment report. - The Continuous Emission Monitoring System (CEMS) shall be installed at the stacks emission of the power plant for continuous emission Monitoring. The display of air quality monitoring results shall be installed in front of the project area. Monitoring results shall be reported to Pluak Daeng Industrial Park throughout the project life. - CEMS shall be audited once a year throughout the project life.

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		Environmental impact monitoring measures have been established. ➢ **Air Quality Measures** - The concentrations of air pollutants emitted from the stack will be continually measured and also randomly measured every 6 months throughout the project operation period. - The concentrations of air pollutants in atmosphere will be measured every 6 months throughout the project operation period. ➢ **Surface Water Quality Measures** <u>Cooling Water Management Measures</u> - Two cooling water holding ponds shall be provided with the holding capacity of 19,000 cu.m. each for at least one (1) day discharge volume. These two cooling water holding ponds will hold the blowdown from a cooling tower. The ponds shall be paved with (HDPE) or concrete to prevent leakage.

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		- The online monitoring system shall be installed at the water holding ponds to check the temperature, pH, conductivity and dissolved oxygen. The monitoring results shall be reported to the display in front of the project area and wastewater control center of Pluak Daeng Industrial Park. - The Project shall control the quality of effluent discharged from a cooling tower to be in compliance with the measures of Pluak Daeng Industrial Park. The Industrial Park requires that the quality of cooling water shall meet the Notification of Ministry of Industry and temperature shall not exceed 34 °C. - One emergency pond with the capacity of 19,000 cu.m. shall be provided with the holding capacity of at least one (1) day discharge volume. The emergency pond will hold the blowdown from a cooling tower. In case the monitoring results show that the quality of effluent from a cooling water does not comply with the measures of Pluak Daeng Industrial Park.

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		Effluent Management Measures - The quality of effluent to be carried to the central wastewater treatment system of Pluak Daeng Industrial Park shall comply with the requirements of Pluak Daeng Industrial Park. - An oil separator shall be provided to separate oil from oil contaminated effluent. Then the contaminated effluent shall be carried to a wastewater holding pond for quality check prior to being discharged to the central wastewater treatment system of Pluak Daeng Industrial Park. - The wastewater holding pond of the project, which can hold the effluent for 24 hours at minimum, shall be provided so that the quality of effluent is checked before being discharged to the central wastewater treatment system of Pluak Daeng Industrial Park.

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		- The online monitoring system shall be installed at the wastewater holding pond to check the temperature, pH and conductivity. The monitoring results shall be reported to the wastewater control center of Pluak Daeng Industrial Park. The effluent that passes quality check from the wastewater holding pond shall be carried through the drain pipe for treatment at the central wastewater treatment system of Pluak Daeng Industrial Park.
➢ EIA were conducted for many projects. Will environmental impact monitoring be conducted after EIA and start of the project operation?	➢ After approval of EIA report, the project will perform the measures stated in the EIA report. Also the project will be required to submit the report on compliance with the environmental impact prevention and mitigation measures and the environmental impact monitoring measures to relevant organizations and representatives of people sector (e.g. the environmental impact monitoring committee) every 6 months throughout the construction and operation periods.	Environmental impact prevention and mitigation measures have been established. ➢ **Public Relations and Public Participation Measures** - The environmental impact monitoring committee shall be appointed at least one month before the start of the construction phase. The environmental impact monitoring committee shall perform duties from the pre-construction phase to the operation phase.

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		- The committee shall hold a position for 4 years each term from the appointment date and can take a position consecutively for not more than 2 terms. - Public relations campaign about the project information shall be made for communities through leaflet, media or other activities, which are in line with the objectives of established measures. Moreover, local people shall have an opportunity to monitor the project throughout the project life.
➢ Before the start of the project, health checkup should be provided to people around the project area.	➢ The project will take this suggestion into consideration.	Environmental impact prevention and mitigation measures have been established. ➢ **Public Health, Occupational Health and Safety Measures** - Health promotion activities shall be organized. Public relations campaign about environmental aspect and health issues for communities shall be done. - Local public health facilities shall be supported in terms of health promotion, rehabilitation, disease prevention and healthcare for communities.

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		- Morbidity survey on people living within 5 km. radius of the project location shall be conducted.
➢ The project should provide opportunities for local people to work with the Company/to participate in the project. ➢ What vacancies are available at the project? ➢ The project should perform as it has promised to communities.	➢ The project has the measure to employ local people first. ➢ During the operation period, the power plant will not require many employees as the operation is mainly based on electrical system. Therefore, the power plant will require the employees who obtained electrical engineering degree.	Environmental impact prevention and mitigation measures have been established. ➢ **Socio-economic Measures** - Qualified local people shall have the priority to be hired for any vacancy in order to mitigate the impact of relationship between the Project and people and communities. Local people should be always notified for any vacancy every time. - Measures for benefit return for communities shall be established, such as maintenance of Huai Phu Sai with Pluak Daeng Industrial Park, other factories or involved agencies, support for local educational institutes or public health facilities, promotion of religious maintenance, contribution to public health benefit, etc.

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		- The quality of life improvement policy shall be set up. Community businesses shall be supported and promoted for sustainable economic and social development.
➢ After completion of EIA, will the same group of community relations officers still work?	➢ After approval of EIA report, the project will establish the measures to return benefits to local communities, for example, support to local educational institutions or public health offices, promotion and enhancement of religion, support of activities for public benefits, etc. The community relations officers will still work in the project like the present time.	Environmental impact prevention and mitigation measures have been established. ➢ **Socio-economic Measures** - Measures for benefit return for communities shall be established, such as maintenance of Huai Phu Sai with Pluak Daeng Industrial Park, other factories or involved agencies, support for local educational institutes or public health facilities, promotion of religious maintenance, contribution to public health benefit, etc. - The quality of life improvement policy shall be set up. Community businesses shall be supported and promoted for sustainable economic and social development.

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		➢ **Public Relations and Public Participation Measures** - The focus group meeting/discussion shall be organized once in the first five years of the project operation. The focus group meeting/discussion then shall be organized once per three years throughout the project life of Pluak Daeng Power Plant. - A good relationship with local government officers and local people shall be made through regular visit and prompt solutions to problems that may arise due to the project development. - Receive information from communities regularly and continuously.
➢ What are the causes of frequent blackouts?	➢ Causes of frequent blackouts are as follows: - Blackout/ brownout during thunderstorm: There are problems with power transmission lines. - Blackout/ brownout in the morning/ afternoon: Power demand is higher than power supply capacity.	-

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
➢ Why is it difficult to expand the power supply service area?	➢ Expansion of the power supply service area is under the responsibility of the Power Electricity Authority. There may be several reasons that make it difficult to expand the service area, e.g. low power demand, no budget for development, etc.	-
Mae Nam Khu Sub-district (26th May 2016, at Chak Man Thet Temple, Mae Nam Khu Sub-district, Pluak Daeng District, Rayong Province)		
➢ The effluent should be recycled within the project area without discharge outside the project area.	➢ The power plant will recycle the effluent in the project area. However, the effluent which is recycled for several times must be discharged outside due to higher concentration of total dissolved solids which may cause scale problem to the machines. Therefore, it is necessary for the project to discharge effluent from the cooling system. The quality of effluent from the cooling system will be controlled to meet the effluent standards before discharge into water sources for irrigation. The total dissolved solid must not exceed 1,300 mg/l. The effluent quality will be continually monitored before conveyance to the industrial park for further treatment.	Environmental impact prevention and mitigation measures have been established. ➢ **Water Use Measures** - Efficient water use shall be considered, such as reduction in water drainage from the cooling system or recirculation of water within the project, etc. - Water pipes shall be checked. Leaking pipes shall be fixed immediately to prevent water loss. - In the event of water shortage and Eastern Water Resources Development and Management PLC. is unable to convey water to the project, the project shall reduce power generation capacity or stop the operation.

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
➢ In case of pollution and environmental impacts, what measures will the project use to prevent and mitigate the environmental impact and compensate affected people?	➢ If local people are affected, the project is willing to remedy or responsible for the impacts. However, in the operations of other power plants, the Gulf Group has never received complaints on health impact from local people.	Environmental impact prevention and mitigation measures have been established. ➢ Socio-economic Measures - In case of conflicts between the power plant and community people, the project information shall be disseminated urgently through channels or media to show the responsibility and care for people's concerns. - If it is proven that the power plant is the cause of any impact, the problem shall be solved urgently. The database of an affected person or affected group shall be created. The impact prevention measures shall be established. - A resgister of affected persons shall be established. Complaints or incidence shall be registered. Facts, remedial action and negitiations shall be compliled and registered to be used as evidence of the power plant operation.

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
➢ What are the benefits people will receive from the project operation? Where will people contact the project in case of problem occurring from the project operation?	➢ Benefits from power plant operation to local communities: - Representatives from local people will be members of the committee to manage the power development fund for sustainable community development. - The project will establish the measures to return benefits to local communities, for example, support to local educational institutions or public health offices, support of activities for public benefits, etc. ➢ In case of encountering the problems from the project operation, people can inform the environmental impact monitoring committee which consists of members who are representatives of local people or the project's complaint center set up since the construction period.	Environmental impact prevention and mitigation measures have been established. ➢ **Socio-economic Measures** - A "Complaint Center" shall be established to disseminate the project information, hear people's opinion, recommendations and complaints. Affected persons can make complaints or raise problems through any channels, as appropriate, such as verbal communication, telephone, memo, letter, electronic mail, fax, etc. - Complaints and sufferings of people in communities due to construction activities shall be received and solved urgently. - Qualified local people shall have the priority to be hired for any vacancy in order to mitigate the impact of relationship between the Project and people and communities. Local people should be always notified for any vacancy every time. - Measures for benefit return for communities shall be established, such as maintenance

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SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		of Huai Phu Sai with Pluak Daeng Industrial Park, other factories or involved agencies, support for local educational institutes or public health facilities, promotion of religious maintenance, contribution to public health benefit, etc. - The quality of life improvement policy shall be set up. Community businesses shall be supported and promoted for sustainable economic and social development.
➢ Will the results of noise, air and water quality measurement every 6 months be reported to communities?	➢ The project measure implementation results which cover noise, air and water quality will be reported every 6 months to related organizations and the monitoring committee which consists of the members who are representatives of local people.	Environmental impact prevention and mitigation measures have been established. ➢ **Public Relations and Public Participation Measures** - The environmental impact monitoring committee shall be appointed at least one month before the start of the construction phase. The environmental impact monitoring committee shall perform duties from the pre-construction phase to the operation phase.

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SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		- The committee shall hold a position for 4 years each term from the appointment date and can take a position consecutively for not more than 2 terms. - The information of Pluak Daeng Power Plant Project shall be continuously publicized throughout the construction phase. The information to be provided include: project name, construction schedule, contractor company, project owner, project coordinator, contact telephone number, environmental monitoring action plan, etc., through media. Optionally, any of the following methods may be adopted: local radio, installation of signboards at important places, e.g. office of community leaders, in front of the project location or other methods which are consistent with the objectives of the measures, throughout the construction phase.

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SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		- The focus group meeting/discussion shall be organized once in the first five years of the project operation. The focus group meeting/discussion then shall be organized once per three years throughout the project life of Pluak Daeng Power Plant.
➢ Will the power plant make the weather hotter?	➢ Hot air from the combustion process of the power plant will be released through the stacks which are 60 m high from the ground. Hot air will expand and rise to exchange heat with atmospheric temperature. When cool, it will drop to the ground. Therefore, discharge of hot air via stacks will not cause higher temperature around the power plant.	Environmental impact monitoring measures have been established. ➢ **Measures for Monitoring heat radiation from Power Plant during the Pre-construction and Construction Periods** - Satellite image showing temperature data around the project construction area and air quality measurement stations will be compared and air quality will be measured 3 times (covering all seasons) before commissioning. Monthly reports will be prepared and the results will be reported to the ERC, the Department of Industrial Works, Rayong Province, Office of Natural Resources and Environmental Policy and Planning, and Rayong Provincial Office of Natural Resources and Environment every 6 months.

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SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		➢ **Measures during Operation Period** - Satellite image showing temperature data around the project construction area and air quality measurement stations will be compared. Air quality will be measured during the first year of the operation period, then every 3 years covering all seasons throughout the project period. The results will be reported to the ERC, the Department of Industrial Works, Rayong Province, Office of Natural Resources and Environmental Policy and Planning, and Rayong Provincial Office of Natural Resources and Environment every 6 months.
➢ Upon the existence of the power plant, will the natural gas price be higher and will the electricity fee be cheaper? ➢ Will electricity generated from the project be sold to people or only industrial factories?	➢ The natural gas prices will be controlled by the government sector. Therefore, the project's power plant will not affect the natural gas price. ➢ According to relevant laws, electricity generated from the power plant will be sold to EGAT only. People will indirectly use electricity via PEA which purchases electricity from EGAT.	-

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
➢ In case of problems with Pluak Daeng Power Plant, who will be the contact person of the power plant?	➢ In case of problem with the project operation, people can inform the environmental impact monitoring committee which consists of members who are representatives of local people or the project's complaint center set up since the construction period.	Environmental impact prevention and mitigation measures have been established. ➢ **Socio-economic Measures** - A "Complaint Center" shall be established to disseminate the project information, hear people's opinion, recommendations and complaints. Affected persons can make complaints or raise problems through any channels, as appropriate, such as verbal communication, telephone, memo, letter, electronic mail, fax, etc. - In case of conflicts between the power plant and community people, the project information shall be disseminated urgently through channels or media to show the responsibility and care for people's concerns. ➢ **Public Relations and Public Participation Measures** - The environmental impact monitoring committee shall be appointed at least one month before the start of the construction phase. The environmental impact monitoring committee shall perform duties from the pre-construction phase to the operation phase.

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SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		- The committee shall hold a position for 4 years each term from the appointment date and can take a position consecutively for not more than 2 terms.
➢ In case of explosion, how far is the blast radius? What should people in the blast radius do?	➢ The project has designed the machine, safety system, and fire extinguishing system in accordance with international standards and the ministerial regulations No. 33 (B.E. 2535) issued under the Building Control Act B.E. 2522.	Environmental impact prevention and mitigation measures have been established. ➢ **Public Health, Occupational Health and Safety Measures** - A fire protection system and fire fighting system shall be provided by the power plant according to National Fire Protection Association (NFPA) and related requirements and standards. - Adequate personal protective equipment, which is suitable for working conditions shall be provided for all staff. - An emergency shall be established for operations in emergency cases. - The annual emergency drill shall be performed for the power plant itself and together with Pluak Daeng Industrial Park. Moreover, training on emergency preparedness and response shall be provided for personnel at least once a year.

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SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
➢ The power plant will release hot air via the stacks. Will it cause lack of rain?	➢ Discharge of hot air via stacks does not relate to raining. The power plant's operation that relates to raining is that the cooling system will generate higher steam volume in atmosphere.	Environmental impact monitoring measures have been established. ➢ **Measures for Monitoring heat radiation from Power Plant during the Pre-construction and Construction Periods** - Satellite image showing temperature data around the project construction area and air quality measurement stations will be compared and air quality will be measured 3 times (covering all seasons) before commissioning. Monthly reports will be prepared and the results will be reported to the ERC, the Department of Industrial Works, Rayong Province, Office of Natural Resources and Environmental Policy and Planning, and Rayong Provincial Office of Natural Resources and Environment every 6 months. ➢ **Measures during Operation Period** - Satellite image showing temperature data around the project construction area and air quality measurement stations will be compared. Air quality will be measured

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		during the first year of the operation period, then every 3 years covering all seasons throughout the project period. The results will be reported to the ERC, the Department of Industrial Works, Rayong Province, Office of Natural Resources and Environmental Policy and Planning, and Rayong Provincial Office of Natural Resources and Environment every 6 months.
➢ Why was the environmental quality measurement not conducted in Mae Nam Khu Sub-district?	➢ As for the criteria for determining the locations of the air quality measurement stations of the project, consideration is made on the wind direction in the 30-year period of the Meteorological Department's air quality measurement station which is closest to the project area. Mae Name Khu Sub-district is in the location which will not be affected by wind direction. However, the project will assess air quality impacts in Mae Nam Khu sub-district.	Environmental impact prevention and mitigation measures have been established. ➢ **Air Quality Measures** - Air pollution emissions shall not exceed the values determined in the environmental impact assessment report. - The Continuous Emission Monitoring System (CEMS) shall be installed at the stacks emission of the power plant for continuous emission Monitoring. The display of air quality monitoring results shall be installed in front of the project area. Monitoring results shall be reported to

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		Pluak Daeng Industrial Park throughout the project life. - CEMS shall be audited once a year throughout the project life. Environmental impact monitoring measures have been established. ➢ **Air Quality Measures** - The concentrations of air pollutants emitted from the stack will be continually measured and also randomly measured every 6 months throughout the project operation period. - The concentrations of air pollutants in atmosphere will be measured every 6 months throughout the project operation period.
➢ The project should measure the surface water quality in Dok Krai reservoir and Huai Phu Sai.	➢ The project has determined the measure to monitor the surface water quality in Dok Krai reservoir and Huai Phu Sai.	Environmental impact monitoring measures have been established. ➢ **Surface Water Quality Measures** - Measurement of surface water quality should be conducted in Huai Phu Sai and Dok Krai reservoir twice a year during the construction and operation periods.

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SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
➢ If the project construction causes impact on air quality, what will the project do to prevent the impacts?	➢ The project has determined the environmental impact prevention and mitigation measures for air quality during the construction period, e.g. spraying of water on roads at least twice a day, control of the construction site to be used as necessary, washing of truck wheels each time the trucks leave the construction site, etc. ➢ The project also has the air quality monitoring measures during the construction period.	Environmental impact prevention and mitigation measures have been established. ➢ **Air Quality Measures** - Trucks transporting construction materials shall be covered and/or fastened to prevent the falling of materials and reduce the diffusion of dust. - While being transported, construction materials will be covered with tarpaulin sheets to prevent accidents and dust. - Water shall be sprayed at the construction site, earth piles or the areas where construction activities cause diffusion of dust, such as roads, land leveling, etc., to reduce dust diffusion at least twice a day (morning-afternoon). However, when it is dry or windy and it is considered that the sprayed areas are getting dry and dust dispersion is likely to occur, water spraying will be additionally done. - Truck wheels shall be washed before the trucks leave the construction site or

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SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		construction-related areas to prevent dirt and sand from falling onto the roads, both inside and outside the project area. Environmental impact monitoring measures have been established. ➢ **Air Quality Measure** - The concentrations of air pollutants will be measured every 6 months throughout the construction period.
➢ Will the power plant cause odor that annoys local people?	➢ The power plant uses two types of fuel: natural gas and diesel oil. - PTT adds chemicals to give natural gas a distinctive oder and make it easy to detect when natural gas leaks. At present, the company is coordinating with PTT to consider whether chemicals should be added to make natural gas smell. The project also has the leak detecting system which meets PTT standard. - Diesel stored near the oil storage tank may have the slight smell of oil vapor. ➢ During the operation of the power plant, smell may occur for a short period within the power plant area when it changes from using natural gas to diesel oil.	➢ **Socio-economic Measures** - A "Complaint Center" shall be established to disseminate the project information, hear people's opinion, recommendations and complaints. Affected persons can make complaints or raise problems through any channels, as appropriate, such as verbal communication, telephone, memo, letter, electronic mail, fax, etc. - In case of conflicts between the power plant and community people, the project information shall be disseminated urgently

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SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		through channels or media to show the responsibility and care for people's concerns. - People in nearby communities shall have an opportunity to visit the power plant to ease their concern.
➢ Since the project operation is not started, how can the project know that the effluent from the power plant will not affect communities?	➢ The Consultant will assess the properties of the effluent that the project has to control not to exceed the established standards. The study result revealed that the properties of water in Huai Phu Sai and Dok Krai reservoir will be within the established standards when effluent is discharged from the power plant and Pluak Daeng Industrial Park.	Environmental impact prevention and mitigation measures have been established. ➢ **Surface Water Quality Measures** <u>Cooling Water Management Measures</u> - Two cooling water holding ponds shall be provided with the holding capacity of 19,000 cu.m. each for at least one (1) day discharge volume. These two cooling water holding ponds will hold the blowdown from a cooling tower. The ponds shall be paved with HDPE or concrete to prevent leakage. - The online monitoring system shall be installed at the water holding ponds to check the temperature, pH, conductivity and dissolved oxygen. The monitoring results shall be reported to the display in front of

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		the project area and wastewater control center of Pluak Daeng Industrial Park. - The Project shall control the quality of effluent discharged from a cooling tower to be in compliance with the measures of Pluak Daeng Industrial Park. The Industrial Park requires that the quality of cooling water shall meet the Notification of Ministry of Industry and temperature shall not exceed 34 °C. - One emergency pond with the capacity of 19,000 cu.m. shall be provided with the holding capacity of at least one (1) day discharge volume. The emergency pond will hold the blowdown from a cooling tower. In case the monitoring results show that the quality of effluent from a cooling water does not comply with the measures of Pluak Daeng Industrial Park. <u>Effluent Management Measures</u> - The quality of effluent to be carried to the central wastewater treatment system of Pluak

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SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		Daeng Industrial Park shall comply with the requirements of Pluak Daeng Industrial Park. - An oil separator shall be provided to separate oil from oil contaminated effluent. Then the contaminated effluent shall be carried to a wastewater holding pond for quality check prior to being discharged to the central wastewater treatment system of Pluak Daeng Industrial Park. - The wastewater holding pond of the project, which can hold the effluent for 24 hours at minimum, shall be provided so that the quality of effluent is checked before being discharged to the central wastewater treatment system of Pluak Daeng Industrial Park. - The online monitoring system shall be installed at the wastewater holding pond to check the temperature, pH and conductivity. The monitoring results shall be reported to the wastewater control center of Pluak Daeng Industrial Park.

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SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		- The effluent that passes quality check from the wastewater holding pond shall be carried through the drain pipe for treatment at the central wastewater treatment system of Pluak Daeng Industrial Park.Environmental impact monitoring measures have been established. ➢ **Surface Water Quality Measures** - Measurement of surface water quality should be conducted in Huai Phu Sai and Dok Krai reservoir twice a year during the construction and operation periods.
Phana Nikhom Sub-district (27th May 2016 at Office of Phana Nikhom Sub-district Headman, Phana Nikhom Sub-district, Nikhom Phatthana District, Rayong Province)		
➢ Will the project inform communities of air quality measurement plan?	➢ The Consultant will inform the overview study plan in the public consultation to collect opinions on the study scope. Owners of the areas where measurement tools will be installed will be informed before air quality measurement will be performed. The project will also	Environmental impact prevention and mitigation measures have been established. ➢ **Socio-economic Measures** - Public relations on the project development should be continually promoted through

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
	inform the work plan to the environmental impact monitoring committee in both the construction and operation periods.	communication channels during the pre-construction, construction, and operation periods. The details that should be disseminated are the project features, progress, environmental impact prevention and mitigation measures, channels for communication with the project, channels for filing complaints on the project development, and channels for contact in emergency cases. ➢ **Public Relations and Participation Measures** - Information of the Pluak Daeng Power Plant Project, including construction plan, and environmental quality measurement plan, should be disseminated via media or one of the following means: local authorities, local radio, noticeboards installed at important places, e. g. offices of local community leaders, SAO offices, or others which are in compliance with the objectives of the measures.

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SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		- Setup of the environmental impact monitoring committee must be completed at least 1 month before the start of the construction. - The environmental impact monitoring committee will start working since the pre-construction period until the operation period. Each term of the committee member is 4 years and each member cannot serve for more than 2 consecutive terms.
➢ After measurement of environment quality, if change in air quality is found, the project should inform local people.	➢ When performing measurement of environmental quality in accordance with the measures stated in the EIA report, EIA monitoring report will be submitted to related authorities and the environmental impact monitoring committee every 6 months throughout the construction and the operation periods.	Environmental impact prevention and mitigation measures have been established. ➢ **Socio-economic Measures** - Public relations campaign shall include the project details and progress during the operation phase, environmental impact prevention and mitigation measures, communication channel and complaint receiving channel as well as contact in case of emergency. ➢ **Public Relations and Participation Measures** - The information of Pluak Daeng Power Plant Project shall be continuously publicized throughout the construction phase. The

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		information to be provided include: project name, construction schedule, contractor company, project owner, project coordinator, contact telephone number, environmental monitoring action plan, etc., through media. Optionally, any of the following methods may be adopted: local radio, installation of signboards at important places, e.g. office of community leaders, in front of the project location or other methods which are consistent with the objectives of the measures, throughout the construction phase. - The environmental impact monitoring committee shall be appointed at least one month before the start of the construction phase. The environmental impact monitoring committee shall perform duties from the pre-construction phase to the operation phase. - The committee shall hold a position for 4 years each term from the appointment date and can take a position consecutively for not more than 2 terms.

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SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
➢ People in the project area are quite worried about air quality.	➢ According to the assessment of air quality impact resulting from air pollutant emissions by using the mathematical model, the impact will not exceed the established standards when considering together with the existing air quality measurement result.	Environmental impact prevention and mitigation measures have been established. ➢ **Air Quality Measures** - Air pollution emissions shall not exceed the values determined in the environmental impact assessment report. - The Continuous Emission Monitoring System (CEMS) shall be installed at the stacks emission of the power plant for continuous emission Monitoring. The display of air quality monitoring results shall be installed in front of the project area. Monitoring results shall be reported to Pluak Daeng Industrial Park throughout the project life. - CEMS shall be audited once a year throughout the project life.

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SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		Environmental impact monitoring measures have been established. ➢ **Air Quality Measures** - The concentrations of air pollutants emitted from the stacks will be continually measured and also randomly measured every 6 months throughout the project operation period. - The concentrations of air pollutants in atmosphere will be measured every 6 months throughout the project operation period.
➢ People are worried about dust problem from transport of construction materials and equipment.	➢ As for the impact of particulate matter from transport of construction materials and equipment, the project has established the environmental impact prevention measures for the contractors to follow, e.g. washing of truck wheels before leaving the construction site, covering of construction materials on trucks, vehicular speed control, etc.	Environmental impact prevention and mitigation measures have been established. ➢ **Air Quality Measures** - Trucks transporting construction materials shall be covered and/or fastened to prevent the falling of materials and reduce the diffusion of dust. - While being transported, construction materials will be covered with tarpaulin sheets to prevent accidents and dust.

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		- Water shall be sprayed at the construction site, earth piles or the areas where construction activities cause diffusion of dust, such as roads, land leveling, etc., to reduce dust diffusion at least twice a day (morning-afternoon). However, when it is dry or windy and it is considered that the sprayed areas are getting dry and dust dispersion is likely to occur, water spraying will be additionally done. - Truck wheels shall be washed before the trucks leave the construction site or construction-related areas to prevent dirt and sand from falling onto the roads, both inside and outside the project area. Environmental impact monitoring measures have been established. ➢ **Air Quality Measures** - The concentrations of air pollutants in atmosphere will be measured every 6 months throughout the project construction period.

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
➢ Public health officers or officers who have knowledge about environmental impact should be invited to participate in monitoring the project's operation.	➢ The project has the measure to set up the environmental impact monitoring committee consisting of representatives of local people. The committee is responsible for monitoring the project operations in compliance with the established standards. The committee can invite experts to participate in monitoring the project's operations.	➢ **Public Relations and Participation Measures** - The information of Pluak Daeng Power Plant Project shall be continuously publicized throughout the construction phase. The information to be provided include: project name, construction schedule, contractor company, project owner, project coordinator, contact telephone number, environmental monitoring action plan, etc., through media. Optionally, any of the following methods may be adopted: local radio, installation of signboards at important places, e.g. office of community leaders, in front of the project location or other methods which are consistent with the objectives of the measures, throughout the construction phase. - The environmental impact monitoring committee shall be appointed at least one month before the start of the construction phase. The environmental impact monitoring committee shall perform duties from the pre-construction phase to the operation phase.

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		- The committee shall hold a position for 4 years each term from the appointment date and can take a position consecutively for not more than 2 terms. - Community representatives comprise sub-district representatives and representatives from administrative divisions within 5 km. radius of the power plant as defined in the EIA report. (The number of community representatives shall not be less than half of a total number of the environmental impact monitoring committee.)
➢ The locations of environmental quality measurement stations should not be fixed. What are the criteria for identifying the station locations?	➢ Environmental quality measurement must be performed at the same place so that the results can be compared to see the change.	-
➢ Since the wind direction is different in each season, how will the project identify the locations for environmental quality measurement?	➢ The project determined 4 environmental quality measurement stations around the project area to cover all wind directions in the project area.	Environmental impact monitoring measures have been established. ➢ **Air Quality Measures** - The concentrations of air pollutants emitted from the stacks will be continually measured

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		and also randomly measured every 6 months throughout the project operation period. - The concentrations of air pollutants in atmosphere will be measured every 6 months throughout the project operation period. - Samples of air quality will be collected from 4 stations near the project area: • Station 1: Ban Noen Sawan, Village no. 2, Map Yang Phon Sub-district • Station 2: Prasit Tharam Temple or nearby area • Station 3: Ban Map Toei School or nearby area • Station 4: Ban Wang Tan, Village no. 5, Map Yang Phon Sub-district
➢ The route for transporting construction materials and equipment should be identified, using the same name as local people call.	➢ The project will take this suggestion into consideration.	-

TABLE 7.7-10

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE PUBLIC CONSULTATION (SUB-DISTRICT LEVEL) (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
➢ The project should clearly present the required qualifications of application for the power plant to avoid the problem on employment of local people.	➢ During the operation period, the power plant will not require many employees as the operation is mainly based on electrical system. Therefore, the power plant will require the employees who obtained electrical engineering degree and mechanical engineering degree. If local people are qualified, they will be considered first.	Environmental impact prevention and mitigation measures have been established. ➢ **Socio-economic Measures** - Qualified local people shall have the priority to be hired for any vacancy in order to mitigate the impact of relationship between the Project and people and communities. Local people should be always notified for any vacancy every time. - The quality of life improvement policy shall be set up. Community businesses shall be supported and promoted for sustainable economic and social development.

(b) Summary of Opinions from Questionnaires in the 2nd Public Consultation (Sub-district Level)

The participants also provided collaboration by completing the questionnaires on EIA scope and approaches as well as project development. 570 out of the total 686 participants filled out the questionnaires **(Appendix 7D-4)**. Opinions from the questionnaires are summarized as follows:

Awareness of Project Information: 86.3% of respondents knew about the development of the Pluak Daeng Power Plant Project from meeting with local community leaders, government agencies and staff of Gulf PD Company Limited. Only 13.3% of respondents did not know before, and 0.4% did not specify/express opinions.

Understanding about EIA Results and Draft Environmental Impact Prevention and Mitigation Measures and Draft Environmental Impact Monitoring Measures: 86% of respondents understand the EIA results and draft environmental impact prevention and mitigation measures and draft environmental impact monitoring measures and 8.1% do not clearly understand. The issues that they do not clearly understand comprise impact on air quality, impact on agricultural produces, measures to prevent impacts on water, environmental impact, etc. 5.9% did not express opinion.

Suitability/Sufficiency of Draft Environmental Impact Prevention and Mitigation Measures in the Pluak Daeng Power Plant Project: 76.8% of respondents view that the draft environmental impact prevention and mitigation measures are suitable/sufficient for project development. 7.9% of respondents consider the measures are not suitable/sufficient. Additional issues that should be considered are air pollution, water pollution, impact on water sources, measures on public utilities, e.g. road damage, health impact, contamination of chemicals in water sources, sources of water for consumption, etc. 6.5% are not certain as the project has not started yet and do not understand the prevention and mitigation measures, compliance with measures, more pollution, etc. 4.9% and 3.9% of respondents did not specify and express opinion respectively.

Suitability/Sufficiency of Draft Environmental Impact Monitoring Measures in the Pluak Daeng Power Plant Project: 74.4% of respondents view that the draft environmental impact monitoring measures are suitable/sufficient. 8.8% did not express opinion and 7.5% are not certain as the project has not started yet. They are not sure about impact monitoring period, compliance with measures, etc. 6.1% view that the measures are not suitable/sufficient in regard to shortage of water for consumption, direct inquiry about impact from affected people, impact from water shortage, people's safety, and opportunity for people to participate in the project.

Anxieties about Project Development

72.1% of respondents are not worried about the impact from the project development whereas 20.2% are. They are worried about odor problem, transport, effluent management, management of water for power production, dissemination of project information, combustion, leak of natural gas, study of impact from toxic residue, lack of safety, impact on soil quality, health impact, etc. 7.7% did not express opinion.

Comments and Suggestions about the Project Development

Comments and suggestions on the project development collected from respondents are as follows.

<u>Project Operation and Environmental Impact</u>

- The project operation should be transparent and can be inspected by local communities.
- Water shortage/insufficiency should be considered.
- Consideration should be made on water quality/water source impact prevention and mitigation measures.
- Probable environmental impacts on communities should be considered.
- Installation of environmental quality measurement tools at natural water bodies should be considered.
- The project operation should cause the minimum impact on air quality.
- The project operation should not affect local communities.
- The project should strictly follow what they proposed to do.
- Environmental quality should be measured regularly.
- Environmental quality, especially air quality, should be safeguarded.
- A concrete air quality measurement plan should be prepared.
- During the construction period, water should be sprayed to reduce dust dispersion.
- Additional study and assessment should be conducted during the operation period.
- Machines and system should be controlled and inspected to ensure they meets the standards. This will prevent natural gas leakage and accidents.
- Trees should be grown around the power plant area.

Public Relations and Public Participation

- Local people should have opportunity to work with the project.
- A committee consisting of the members who are local people should be set up to participate in the project operation.
- Local people should be informed in advance of the project development.
- Remedial action should be immediately taken in case of problem.
- The project staff should monitor the environmental impacts and regularly report the monitoring results, e.g. water quality and air quality, to communities.
- The project progress or events should be regularly informed to local people, e.g. meeting or site visit.
- The project information should be disclosed to people.
- Local people and authorities should be provided with knowledge about the power plant.
- A good relationship with communities should be built. The project should also support activities of communities, temples, schools, and medical establishments.
- Local people should have opportunity to participate in monitoring all steps of the project operations.
- A fund should be set up to support activities of communities.
- In case of problem, the project should provide assistance to communities.
- Survey of opinions should be conducted regularly.
- Representatives of East Water or RID should participate in every meeting.

Public Health

- The project should provide support to setup of a community clinic.
- Health checkup should be provided to local people annually.
- Medical equipment should be provided to local communities.

After completion of the 2nd public consultation, summary of the results of public consultation (as presented in **Appendix 7D-5**) was posted within 15 days at the noticeboards of related government agencies, offices of sub-district headmen, offices of village headmen in the study area, e.g. Rayong provincial public relations office, Rayong provincial energy office, Pluak Daeng District Office, Nikhom Phatthana District Office, Pluak Daeng Sub-district Office, Mae Nam Khu Sub-district Office, Office of Map Yang Phon Sub-district Headman, Office of Phana Nikhom Sub-district Headman, etc. The 2nd public consultation result summary was posted on 9th June 2016 in order to disseminate to the public the project progress, people's anxieties and clarifications of the project. (Examples of notice posting are illustrated in **Photo 7.7-11** and letter of request for assistance in **Appendix 7D-6**.)

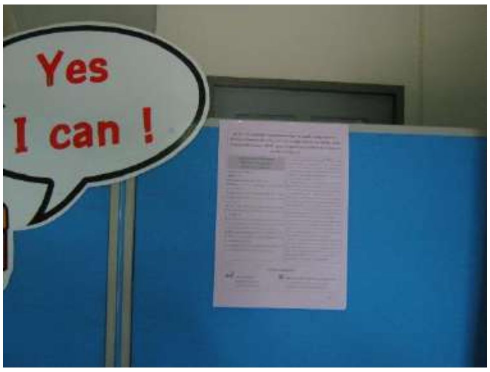
4.7.8 2nd Public Consultation with Dok Krai Fishery Resource Management Group

The 2nd public consultation was organized with Dok Krai Fishery Resource Management Group which is outside the 5-km radius from the project area in order to cover all related sectors. The public consultation was organized on Monday 13th June 2016 during 10.00-12.00 hrs. at the hall of Dok Krai Fishery Resource Management Group. There were 34 participants, such as representatives of related government agencies (Royong Provincial Fishery Office) and members of Dok Krai Fishery Resource Management Group. (List of participants is exhibited in **Appendix 7D-3** and atmosphere of the public consultation in **Photo 7.7-12**). Media for the public consultation are as follows:

- Personal Media: Representatives of Gulf PD Company Limited and TEAM Consulting Engineering and Management Co., Ltd.
- Document Media: PowerPoint presentations, PR documents for the project, questionnaire for the public consultation **(Appendix 7D-2).**

After presentation of the EIA result and draft environmental impact prevention and mitigation measures and draft environmental impact monitoring measures, participants had opportunity to express their opinions via two methods: (1) inquiry in the public consultation forum and (2) questionnaire.

Rayong Provincial Industrial Office



Rayong Provincial Energy Office

Rayong Provincial Office for Natural Resources and Environment

Rayong Provincial Public Relations Office

Office of Pluak Daeng Sub-district Headman

Office of Village Headman (Moo 6)

PHOTO 7.7-11: NOTICE OF SUMMARY OF THE 2nd PUBLIC CONSULTATION RESULT (EIA RESULTS AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURE)

PHOTO 7.7-12: ATMOSPHERE OF PUBLIC CONSULTATION WITH DOK KRAI FISHERY RESOURCE MANAGEMENT GROUP ON RESULTS AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES

(1) Summary of Inquiries, Comments, and Suggestions on EIA Study Result and Draft Environmental Impact Mitigation and Prevention Measures and Draft Environmental Impact Monitoring Measures during the 2nd Public Consultation with Dok Krai Fishery Resource Management Group

After presentation of the project details, EIA result and draft environmental impact prevention and mitigation measures and draft environmental impact monitoring measures, participants had opportunity to make inquiries and express their comments and suggestions as summarized in **Table 7.7-11**.

(2) Summary of Opinions from Questionnaires in the 2nd Public Consultation with Dok Krai Fishery Resource Management Group

The participants also provided collaboration by completing the questionnaires on EIA results and draft environmental impact prevention and mitigation measures and draft environmental impact monitoring measures. 33 participants filled out the questionnaires **(Appendix 7D-4)**. Opinions from the questionnaires are summarized as follows:

Awareness of Project Information: 72.7% of respondents knew about the development of the Pluak Daeng Power Plant Project from the meeting with local leaders and from staff of Gulf PD Company Limited. Only 27.3% of respondents did not know before.

Understanding about EIA Results and Draft Environmental Impact Prevention and Mitigation Measures and Draft Environmental Impact Monitoring Measures: 93.9% of respondents understand the EIA results and draft environmental impact prevention and mitigation measures and draft environmental impact monitoring measures and 6.1% do not clearly understand and did not specify the issues they do not understand.

Suitability/Sufficiency of Draft Environmental Impact Prevention and Mitigation Measures in the Pluak Daeng Power Plant Project: 84.8% of respondents view that the draft environmental impact prevention and mitigation measures are suitable/sufficient for project development. 9.2% of respondents think the measures are not suitable/sufficient and should include effluent-related measures. 3.0% are not certain as they are worried about sediments in water sources. The remaining 3.0% did not express opinion as the company should provide a good prevention system.

Suitability/ Sufficiency of Draft Environmental Impact Monitoring Measures in the Pluak Daeng Power Plant Project: 87.9% of respondents consider that the draft environmental impact monitoring measures are suitable/sufficient. 6.1% did not express opinion as the company should provide a good prevention system and environmental monitoring measures. 3.0% think the draft measures are not suitable/ sufficient and 3% are not certain.

TABLE 7.7-11

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE 2nd PUBLIC CONSULTATION WITH DOK KRAI FISHERY RESOURCE MANAGEMENT GROUP

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
➢ Quality of effluent should be nearly similar to that in natural water sources to prevent impact on ecological system. ➢ The project's effluent should be treated to meet the established standards.	➢ Most of the effluent from the project is water from the cooling system. Its properties, especially temperature, will be checked in accordance with the established standards. The project will provide the holding pond to reduce temperature of water from the cooling system before transmitting to the holding pond of the industrial park and then discharging into Huai Phu Sai. Thus, accumulated amounts of BOD and TDS will not occur.	Environmental impact prevention and mitigation measures have been established. ➢ **Surface Water Quality Measures** Cooling Water Management Measures - Two cooling water holding ponds shall be provided with the holding capacity of 19,000 cu.m. each for at least one (1) day discharge volume. These two cooling water holding ponds will hold the blowdown from a cooling tower. The ponds shall be paved with (HDPE) or concrete to prevent leakage. - The online monitoring system shall be installed at the water holding ponds to check the temperature, pH, conductivity and dissolved oxygen. The monitoring results shall be reported to the display in front of the project area and wastewater control center of Pluak Daeng Industrial Park. - The Project shall control the quality of effluent discharged from a cooling tower to

TABLE 7.7-11

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE 2nd PUBLIC CONSULTATION WITH DOK KRAI FISHERY RESOURCE MANAGEMENT GROUP (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		be in compliance with the measures of Pluak Daeng Industrial Park. The Industrial Park requires that the quality of cooling water shall meet the Notification of Ministry of Industry and temperature shall not exceed 34 ºC. - One emergency pond with the capacity of 19,000 cu.m. shall be provided with the holding capacity of at least one (1) day discharge volume. The emergency pond will hold the blowdown from a cooling tower. In case the monitoring results show that the quality of effluent from a cooling water does not comply with the measures of Pluak Daeng Industrial Park.
➢ Utilization of sediments from water quality improvement will cause any impact? ➢ Any chemical is used in sedimentation?	➢ Quality of sediments from different power plants is not similar, depending on the sources of raw water supplied to the power plants. If water from Dok Krai reservoir is used to produce service water, the sediments are from the suspended sediments in Dok Krai reservoir and are	Effluent Management Measures - The quality of effluent to be carried to the central wastewater treatment system of Pluak Daeng Industrial Park shall comply with the requirements of Pluak Daeng Industrial Park.

TABLE 7.7-11

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE 2nd PUBLIC CONSULTATION WITH DOK KRAI FISHERY RESOURCE MANAGEMENT GROUP (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
	not suitable for agricultural activities as they must be mixed with husks and sand before use. ➢ During preliminary improvement of water quality, chemicals are added to cause sedimentation of suspended matters. RO method will be used to produce demineralized water for use in HRSG.	An oil separator shall be provided to separate oil from oil contaminated effluent. Then the contaminated effluent shall be carried to a wastewater holding pond for quality check prior to being discharged to the central wastewater treatment system of Pluak Daeng Industrial Park. - The wastewater holding pond of the project, which can hold the effluent for 24 hours at minimum, shall be provided so that the quality of effluent is checked before being discharged to the central wastewater treatment system of Pluak Daeng Industrial Park. - The online monitoring system shall be installed at the wastewater holding pond to check the temperature, pH and conductivity. The monitoring results shall be reported to the wastewater control center of Pluak Daeng Industrial Park.

TABLE 7.7-11

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE 2nd PUBLIC CONSULTATION WITH DOK KRAI FISHERY RESOURCE MANAGEMENT GROUP (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		- The effluent that passes quality check from the wastewater holding pond shall be carried through the drain pipe for treatment at the central wastewater treatment system of Pluak Daeng Industrial Park. Environmental impact monitoring measures have been established. ➢ **Surface Water Quality Measures** - Surface water quality should be measured in Huai Phu Sai and Dok Krai reservoir twice a year during the construction and operation periods.
➢ Reliability and precision of measurement tools/measurement results	➢ All measurement tools will be calibrated every year. For example, air quality will be measured at the power plant stacks and compared. The measurement results will be sent to relevant government offices and representatives of local communities will monitor the project's environmental quality.	Environmental impact prevention and mitigation measures have been established. ➢ **Air Quality Measures** - Air pollution emissions shall not exceed the values determined in the environmental impact assessment report. - The Continuous Emission Monitoring System (CEMS) shall be installed at the stacks

TABLE 7.7-11

SUMMARY OF INQUIRIES, COMMENTS, AND SUGGESTIONS ON EIA RESULT AND DRAFT ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND DRAFT ENVIRONMENTAL IMPACT MONITORING MEASURES DURING THE 2nd PUBLIC CONSULTATION WITH DOK KRAI FISHERY RESOURCE MANAGEMENT GROUP (CONT'D)

Inquiries	Answers/Explanations	Utilization/Determination of Environmental Impact Prevention and Mitigation Measures to Relieve Anxieties
		emission of the power plant for continuous emission Monitoring. The display of air quality monitoring results shall be installed in front of the project area. Monitoring results shall be reported to Pluak Daeng Industrial Park throughout the project life. - CEMS shall be audited once a year throughout the project life.
➢ The company's experience in operations of other power plants, e.g. community relations	➢ Community relations activities conducted in the project areas will link between the Company and local communities and will be the channel for disseminating the company's information and events to communities and collecting problems from communities for further correction. As for community relations activities of other power plants under Gulf Group, community relations staff regularly conduct activities with local communities since the pre-construction period until the operation period, such as support of annual community activities, annual religious ceremony, etc.	-

Anxieties about Project Development

90.9% of respondents are not worried about the impact from the project development whereas 9.1% are. They are worried about effluent management.

Comments and Suggestions about the Project Development

Some respondents expressed comments and suggestions on the project development as follows:

- Since the project is not started yet, the project should organize the site visit. However, no impact on community is anticipated from the project development.

7.7.9 Participation in Community Activities/CSR Activities

In order to sustainably live with communities, the project will return benefits to communities by mutually conducting activities with local communities. This will strengthen good relationship and create a channel for communication between local communities and the project via community relations staff.

Gulf PD Company Limited has continually conducted activities during 2015-2016 and also gathered people's opinions during visits to local people, community leaders and government offices in the study area. There were 6 major activities which can be summarized in **Table 7.7-12** and photos of participation activities illustrated in **Photo 7.7-13**.

(1) Children and youth promotion activities
(2) Sports promotion activities
(3) Cultural and religious promotion activities
(4) Social and public benefit promotion activities
(5) Knowledge and occupational promotion activities
(6) Health-related activities

TABLE 7.7-12

SUMMARY OF CSR ACTIVITIES DURING 2015-2016

Activity	Date	Venue
(1) Children and Youth Promotion Activities		
- Giving of scholarships and educational materials	10th January 2015	- Mae Nam Khu Sub-district Administrative Organization
- Recreational activities	10th January 2015	- Pluak Daeng Sub-district Administrative Organization
- Pluak Daeng District Non-Formal Education Center Project	June, 2015	- Pluak Daeng District Non-Formal Education Center
- Support of audio equipment for the children development center	November, 2015	- Mae Nam Khu Sub-district Administrative Organization
- Making a religious offering for education at Nikhomsangtoneng 10 School	15th January 2559	- Nikhomsangtoneng 10 School

TABLE 7.7-12
SUMMARY OF CSR ACTIVITIES DURING 2015-2016 (CONT'D)

Activity	Date	Venue
(2) Sports Promotion Activities		
- "We Love Map Yang Phon" Charity Rally	18th February 2015	- Map Yang Phon Sub-district Administrative Organization
- Motocross Project in Pluak Daeng District	June, 2015	- Pluak Daeng District Office
- Sports activities at Pluak Daeng Police Station	21th August 2015	- Pluak Daeng Police Station
- Thai Cup Football Program 2015	21th August 2015	- Pluak Daeng Sub-district Administrative Organization
- Cycling for Health and Relationship Project	21th August 2015	- Mae Nam Khu Sub-district Administrative Organization
- Provision of sport T-shirts	6th October 2015	- Pluak Daeng District Office
- Support of sports activities to students in Pluak Daeng district	22rd October 2015	- Pluak Daeng Sub-district Administrative Organization
- Charity rally of the alumni of Pluak Daeng Phitthayakhom School	17th November 2015	- Pluak Daeng Phitthayakhom School
- "We Love Map Yang Phon" Charity Rally	27th November 2015	- Map Yang Phon Sub-district Administrative Organization
- Rayong Senior Football League	20th January 2559	- Pluak Daeng Sub-district Administrative Organization
- Chak Man Thet Cup Football Program	14th February 2559	- Moo 4 Mae Nam Khu Sub-district
(3) Cultural and Religious Promotion Activities		
- Support of Construction of Church in Map Luk Chan Temple	6th March 2015	- Map Luk Chan Temple, Pluak Daeng sub-district
- Offering of Candles for Buddhist Lent to temples in Pluak Daeng District	27th -29th July 2015	- Nai Temple, Pluak Daeng district
- Support of annual Dok Krai Temple Fair in 2015	13th August 2015	- Office of Village Headman (Moo 6)
- Hosting of Kathin Festival 2015	31th October 2015	- Map Yang Phon Temple
- Hosting of Kathin Festival 2015	15th November 2015	- Thammanurak Temple
(4) Social and Public Benefit Promotion Activities		
- Support of Pluak Daeng Sub-district community meeting	6th February 2015	- Pluak Daeng Sub-district Administrative Organization
- Support of Mae Nam Khu SAO's new building opening ceremony	6th February 2015	- Mae Nam Khu Sub-district Administrative Organization

TABLE 7.7-12

SUMMARY OF CSR ACTIVITIES DURING 2015-2016 (CONT'D)

Activity	Date	Venue
- Support of farewell party for Pluak Daeng District Chief	11th February 2015	- Pluak Daeng District Office
- Support of "Doen Tam Roi Pho, Yu Yang Pho Phiang" Activity No. 2	27th February 2015	- Pluak Daeng District Office
- Provision of a lawnmower to Moo 7, Mae Nam Khu Sub-district	27th February 2015	- Pluak Daeng Sub-district Administrative Organization
- Support of Map Yang Phon SAO activity	27th February 2015	- Map Yang Phon Sub-district Administrative Organization
- Support of "Lao Khan Tamnan Mueang Rayong Festival"	14th May 2015	- Pluak Daeng District Non-Formal Education Center
- Support of sweet pineapple activity in Pluak Daeng district	June, 2015	- Pluak Daeng District Office
- Expansion of village pavilion in Moo 4, Mae Nam Khu Sub-district	June, 2015	- Mae Nam Khu Sub-district Administrative Organization
- Support of Kamnan Day activity	August, 2015	- Pluak Daeng District Office
- Anti-drug Day	24th August 2015	- Pluak Daeng District Office
- Provision of warm-up jackets to Pluak Daeng Police Station	16th November 2015	- Pluak Daeng Police Station
- Support of farewell party for Pluak Daeng District Chief	27th November 2015	- Pluak Daeng District Office
- Support of Pluak Daeng Sub-district community meeting	15th January 2016	- Pluak Daeng Sub-district Administrative Organization
(5) Knowledge and Occupational Promotion Activities		
- Training program for Pluak Daeng civil defence volunteers	14th May 2015	- Pluak Daeng Sub-district Administrative Organization
- Environmental protection program "Ban Suai, Mueang Sa-at, Pratsachak Khaya"	24th September 2015	- Pluak Daeng District Office
- Support of training program for sub-district headmen and village headmen	19th February 2016	- Pluak Daeng District Office -
- Personnel potential development program	June, 2015	- Pluak Daeng Sub-district Administrative Organization
(6) Health-Related Activities		
- Training program for village health volunteers	11th February 2015	- Pluak Daeng Sub-district Administrative Organization
- Dengue fever prevention campaign	24th December 2015	- Map Yang Phon Sub-district Administrative Organization

Source: Summary of CSR activities of Gulf PD Company Limited during 2015-2016

PHOTO 7.7-13: PUBLIC PARTICIPATION ACTIVITIES DURING 2015-2016

7.8 Summary of Public Participation Activities Results

Public participation activities of the **Pluak Daeng Power Plant Project** in Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province of Gulf PD Company Limited aimed to provide clear and accurate information about the project at the project start and during the EIA process. Various forms of public participation activities were used to be suitable for each area, such as meetings with related government offices to introduce and explain the project information; meeting with representatives of related government agencies, public consultations with people and related persons, survey of socio-economic conditions and opinions about the project development, and visits to power plants of Gulf Group. The activities would relieve local government authorities and people's anxieties because they had opportunity to express opinions, concerns and anxieties. Suitable environmental impact prevention and mitigation measures and monitoring measures of the project were established. Good relationship between communities and Gulf PD Company Limited would be built through these activities. The undertaken public participation activities can be summarized as follows:

(1) Implementation of Public Participation in Social Impact Assessment of the Office of Natural Resources and Environmental Policy and Planning, B.E. 2549

(a) PR Media for Public Consultation to Collect Opinions from People and Stakeholders: Personal media and document media were used in both public consultations. Personal media was found efficient as it was the two-way communication used during conversation, discussion, and exchange of opinions. Since the activities covered all levels of stakeholders, reaction of local communities towards the project development was obtained.

- The document media used in both public consultations included PowerPoint presentations, PR documents for the project, questionnaires which made the target groups understand the project details and could show their opinions via different channels. Therefore, the project information was disclosed to the public at large.

(b) Content for PR Documents

- PR document (January, 2016) consisting of the project background, preliminary project details, study area, place, process, and period of development, and guidelines for environmental impact study.
- PR document (May, 2016) consisting of EIA result, draft environmental impact prevention and mitigation measures and draft environmental impact monitoring measures, communication channel, etc.

Because of the continual dissemination of the project information, people understood and knew the project updates during the EIA study and report preparation.

(c) Awareness of Project Information: People and related parties were allowed throughout the study period to express opinions, worries, concerns, and helpful suggestions for the project implementation via different channels, e.g. socio-economic survey, personnel of the Consultant, two public consultations, and questionnaires in the public consultation. Participants in the two public consultations were categorized in accordance with the guidelines for public participation and social impact assessment in EIA process B.E. 2549 of the Office of Natural Resources and Environmental Policy and Planning as presented in **Table 7.8-1**.

TABLE 7.8-1
GROUPS OF PARTICIPANTS IN THE PUBLIC CONSULTATION
PLUAK DAENG POWER PLANT PROJECT OF GULF PD COMPANY LIMITED

Groups of Stakeholders and Participants in Public Consultation	Public Consultation	
	Project Start	During EIA Process
1. Affected people (positive/negative) - Community leaders/people residing within the 5-km radius of the project area	392	566
2. The entities responsible for EIA report preparation		
- Gulf PD Company Limited	14	7
- TEAM Consulting Engineering and Management Co., Ltd.	5	5
3. The agencies in charge of considering EIA report		
- Office of the Energy Regulatory Commission (ERC)	-	1
- Office of Natural Resources and Environmental Policy and Planning	-	-
4. Government agencies at different levels	66	37
5. Environmental non-governmental organizations, non-governmental organizations, local educational institutions, tertiary academic institutions, and independent scholars	7	2
6. Local mass media	2	2
7. People in general	135	103
Total	**621**	**723**

Remark: Each participant, project owner, and consultant was counted as 1

According to the 1st and 2nd public participation activities in Pluak Daeng sub-district, participants from Pluak Daeng sub-district were fewer than other relevant sub-districts. The Pluak Daeng Power Plant Project is located in Map Yang Phon sub-district and the 5-km radius from the project site cover 2 districts and 4 sub-districts as presented in **Table 7.8-2.**

TABLE 7.8-2

STUDY AREA OF 5-KM RADIUS

Province	District	Sub-district	Village no.	Radius	
				0-3 km	3-5 km
Rayong	Pluak Daeng	Map Yang Phon	Village no.1 Ban Map Toei	✓	-
			Village no.2 Ban Noen Sawan	✓	✓
			Village no.3 Ban Map Yang Phon	✓	✓
			Village no.5 Ban Wang Tan Mon	✓	✓
			Village no.6 Ban Map Yang Mai	✓	✓
			Village no.7 Ban Chak Oi	✓	✓
		Pluak Daeng	Village no.4 Ban Wang Ta Phin	-	✓
			Village no.6 Ban Thap Tong	✓	✓
		Mae Nam Khu	Village no.4 Ban Chak Man Thet	-	✓
			Village no.7 Ban Wang Pradu	✓	✓
	Nikhom Phatthana	Phana Nikhom	Village no.4 Ban Khao Maphut	✓	✓
			Village no.5 Ban Khlong Phlu	✓	✓
			Village no.6 Ban Nong Rakam	-	✓
			Village no.7 Ban Wang Pla	✓	✓
			Village no.8 Ban Soi 13	✓	✓
1 Province	**2 Districts**	**4 Sub-districts**	**15 Villages**	**12 Villages**	**14 Villages**

Pluak Daeng Sub-district covers 2 villages located in the radius of the project study area. Pluak Daeng Sub-district is covered by urban communities, and industrial zone. Industrial factories are predominant. People are familiar with the industrial sector. The schedule of public consultations might not be convenient for them to attend. Thus, the number of participants from Pluak Daeng sub-district were fewer than other sub-districts.

However, before implementation of the public consultation, the project coordinated with local community leaders to post the notice inviting all interested people to attend the public consultations and communication channels were provided. The public consultation schedule was also posted at local government offices, e.g. Pluak Daeng District Office, Pluak Daeng Sub-district Administrative Organization, Pluak Daeng District Public Health Office, etc.

After the project's public consultation activities, major issues and anxieties can be summarized for further application as follows:

- The issues obtained from the 1st public consultation at the project start were used to establish the draft environmental impact prevention and mitigation measures for presentation in the documents for the 2nd public consultation.
- The issues obtained from the 2nd public consultation were considered to improve the project's environmental impact prevention and mitigation measures and included in the EIA report in **Chapter 9 Environmental Action Plan**.

According to the public consultations to collect opinions from people and related parties from the start and during the EIA report preparation process for "**Pluak Daeng Power Plant Project**" in Map Yang Phon sub-district, Pluak Daeng district, Rayong province, major issues and anxieties were taken account of to determine the environmental impact prevention and mitigation measures and environmental impact monitoring measures as presented in **Table 7.8-3**.

(2) Implementation of Rule of the Office of the Prime Minister on Public Consultation

The EIA for the "**Pluak Daeng Power Plant Project**" in Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province of Gulf PD Company Limited focuses on creation of knowledge and understanding among the public to bring about acceptance of the project. The project is pleased to provide collaboration in monitoring of the project operation by all levels of target groups in compliance with the Constitution of the Kingdom of Thailand B.E. 2550 (2007), Articles 56 and 57 under Part 10 Right to Information and Complaints and Article 67 under Part 12 Community Right; the Guidelines for Public Participation in Social Impact Assessment of the Office of Natural Resources and Environmental Policy and Planning; and the Rule of the Office of the Prime Minister on Public Consultation B.E. 2548 (2005). The project implementation in accordance with the Rule of the Office of the Prime Minister on Public Consultation can be summarized in **Table 7.8-4**.

TABLE 7.8-3

SUMMARY OF ANXIETIES/SUGGESTIONS FROM PUBLIC CONSULTATIONS WITH PEOPLE AND RELATED PARTIES FOR IMPACT ASSESSMENT AND DETERMINATION OF ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND ENVIRONMENTAL IMPACT MONITORING MEASURES

Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
A. Project Information		
• Consideration of the project's green area	• Green area should be considered or there should be the green area for local people to use, e.g. physical exercise, recreational activities.	**Green Area and Aesthetics** – At least 5.7% of the project area shall be provided as the green area. – Soil improvement in the green area shall be made for plant growing suitability.
	• The environmental quality measurement should cover several environmental aspects, e.g. air quality, and surface water quality. Water quality measurement stations should be also installed at natural water bodies.	**General Measures:** – Environmental impact prevention and mitigation measures as well as monitoring measures shall be followed in the form of environmental action plans proposed in the Environmental Impact Assessment (EIA) Report of Pluak Daeng Power Plant Project located in Pluak Daeng Industrial Park, Map Yang Phon Sub-District, Pluak Daeng District, Rayong Province. The environmental action plans will be adopted by relevant agencies, people and organizations as control, supervision, and monitoring guidelines. – In the event of complaints by communities, the Company shall quickly solve problems and record the issues in a report.

TABLE 7.8-3
SUMMARY OF ANXIETIES/SUGGESTIONS FROM PUBLIC CONSULTATIONS WITH PEOPLE AND RELATED PARTIES FOR IMPACT ASSESSMENT AND DETERMINATION OF ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND ENVIRONMENTAL IMPACT MONITORING MEASURES (CONT'D)

Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
		– Gulf PD Co., Ltd. shall report on the compliance with environmental action plans to Office of the Energy Regulatory Commission (OERC), Department of Industrial Works, Office of Natural Resources and Environmental Policy and Planning (ONEP), Rayong Province and Rayong Provincial Office of Natural resources and Environment for consideration every 6 months. This shall comply with ONEP's guidelines for environmental monitoring report.
• Consideration of the project area whether it obstructs water flow		**Drainage and Flood Control Measures** **Operation Period** – The storm water ponds of at least 99,797 cu.m. shall be provided. The storm water ponds shall hold stormwater for 3 hours for appropriate drainage rates and flood prevention in the project area.
B. Environmental Quality		
• Frequency and season of environmental quality measurement • Pollutants from the project operation • Impact on air quality • Change in temperature/heat generated from cooling system • Change in temperature may affect agricultural products	• Impact on air quality/temperature change • Dust problem from the project activities, e.g. transport of construction materials and equipment • In the long run, people's health will be affected from breathing air emissions from the power plant. • Impact on agriculture/agricultural products • Stacks of the power plant may cause seasonal change (no raining due to the power plant's air emissions)	**Air Quality Measures** **Construction Period** – Water shall be sprayed at the construction site, earth piles or the areas where construction activities cause diffusion of dust, such as roads, land leveling, etc., to reduce dust diffusion at least twice a day (morning-afternoon). However, when it is dry or windy and it is considered that the sprayed areas are getting dry and dust dispersion is likely to occur, water spraying will be additionally done.

TABLE 7.8-3

SUMMARY OF ANXIETIES/SUGGESTIONS FROM PUBLIC CONSULTATIONS WITH PEOPLE AND RELATED PARTIES FOR IMPACT ASSESSMENT AND DETERMINATION OF ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND ENVIRONMENTAL IMPACT MONITORING MEASURES (CONT'D)

Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
		<u>Operation Period</u> – The Continuous Emission Monitoring System (CEMs) shall be installed at the stacks emission of the power plant for continuous emission Monitoring. Measurement parameters include nitrogen oxides (NO_x), sulphur dioxide (SO_2), total suspended particulate (TSP), oxygen (O_2) and the flow rate. In addition, the display of air quality monitoring results (NO_X, SO_2 and TSP) shall be installed in front of the project area. Monitoring results shall be reported to Pluak Daeng Industrial Park throughout the project life. – CEMs shall be audited once a year throughout the project life. – Air pollution emissions shall not exceed the values determined in the environmental impact assessment report. Details are provided below. In case of the air pollution control system failure and the emission rate exceeds the control value, the project will stop the gas turbine engine in order to check NOx control system immediately and fix the problem quickly. – Knowledgeable personnel shall be provided for regulating the air emission rates of the Project. <u>Measures on Safety of Life and Property</u> – If it is proven that the power plant is the cause of any impact, the problem shall be solved urgently. The

TABLE 7.8-3

SUMMARY OF ANXIETIES/SUGGESTIONS FROM PUBLIC CONSULTATIONS WITH PEOPLE AND RELATED PARTIES FOR IMPACT ASSESSMENT AND DETERMINATION OF ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND ENVIRONMENTAL IMPACT MONITORING MEASURES (CONT'D)

Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
		database of an affected person or affected group shall be created. The impact prevention measures shall be established.
Smell • Odor from the project operation	• Odor from the project operation	**Note:** The project does not cause smell problem. Thus, there is no measure for smell impact.
Noise • Measurement of noise in communities surrounding the project area	• Noise from the project operation	<u>Noise Measures</u> – Noisy machinery of Pluak Daeng Power Plant Project shall be installed with a silencer at the end of the pipe that may cause loud noise. Cover structure for machinery shall be built for a combustion chamber of a gas turbine, gas turbine generator, pump motor and the Heat Recovery Steam Generator (HRSG). A cooling unit fan shall cause low noise, etc. – Noise level at the fence of the project shall not exceed 70 decibels (A). – Noise mapping/noise contour shall be created to determine the noisy area of the project in the first year of service and every 3 years.
Surface Water Quality and Groundwater Quality • Sampling of water and organisms • Impact on aquatic ecology		**<u>Surface Water Quality and Groundwater Quality Measures</u>** <u>Cooling Water Management Measures</u> – Two cooling water holding ponds shall be provided with the holding capacity of 19,000 cu.m. each for at least one (1) day discharge volume. These two cooling

TABLE 7.8-3

SUMMARY OF ANXIETIES/SUGGESTIONS FROM PUBLIC CONSULTATIONS WITH PEOPLE AND RELATED PARTIES FOR IMPACT ASSESSMENT AND DETERMINATION OF ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND ENVIRONMENTAL IMPACT MONITORING MEASURES (CONT'D)

Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
		water holding ponds will hold the blowdown from a cooling tower. The ponds shall be paved with high density polyethylene (HDPE) or concrete to prevent leakage. – The online monitoring system shall be installed at the water holding ponds to check the temperature, pH, conductivity and dissolved oxygen. The monitoring results shall be reported to the display in front of the project area and wastewater control center of Pluak Daeng Industrial Park. – The Project shall control the quality of effluent discharged from a cooling tower to be in compliance with the measures of Pluak Daeng Industrial Park. The Industrial Park requires that the quality of cooling water shall meet the Notification of Ministry of Industry, No.2 (B.E.2539) on determination quality of wastewater discharged from factories, except total dissolved solid shall be complied with RID is standard of effluent quality discharge into irrigation system (TDS shall not exceed 1,300 mg/l) and temperature shall not exceed 34 °C.

TABLE 7.8-3

SUMMARY OF ANXIETIES/SUGGESTIONS FROM PUBLIC CONSULTATIONS WITH PEOPLE AND RELATED PARTIES FOR IMPACT ASSESSMENT AND DETERMINATION OF ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND ENVIRONMENTAL IMPACT MONITORING MEASURES (CONT'D)

Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
Drainage and Flood Control • Drainage/flood control • Management of wastewater from the project/discharge of wastewater into natural water sources	• Wastewater management • Wastewater management/ recycling of wastewater without discharge outside • Effluent from the cooling system which may affect temperature of natural water sources if it is discharged into water sources.	<u>Measures for Management of Effluent from Power Generating Process</u> – The wastewater holding pond of the project, which can hold the effluent for 24 hours at minimum, shall be provided so that the quality of effluent is checked before being discharged to the central wastewater treatment system of Pluak Daeng Industrial Park. – The online monitoring system shall be installed at the wastewater holding pond to check the temperature, pH and conductivity. The monitoring results shall be reported to the wastewater control center of Pluak Daeng Industrial Park. – The effluent that passes quality check from the wastewater holding pond shall be carried through the drain pipe for treatment at the central wastewater treatment system of Pluak Daeng Industrial Park. <u>Cooling Water Management Measures</u> – Two cooling water holding ponds shall be provided with the holding capacity of 19,000 cu.m. each for at least one (1) day discharge volume. These two cooling water holding ponds will hold the blowdown from a cooling tower. The ponds shall be paved with high density polyethylene (HDPE) or concrete to prevent leakage. – The online monitoring system shall be installed at the water holding ponds to check the temperature, pH,

TABLE 7.8-3

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Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
		conductivity and dissolved oxygen. The monitoring results shall be reported to the display in front of the project area and wastewater control center of Pluak Daeng Industrial Park. – The Project shall control the quality of effluent discharged from a cooling tower to be in compliance with the measures of Pluak Daeng Industrial Park. The Industrial Park requires that the quality of cooling water shall meet the Notification of Ministry of Industry, No.2 (B.E.2539) on determination quality of wastewater discharged from factories, except total dissolved solid shall be complied with RID is standard of effluent quality discharge into irrigation system (TDS shall not exceed 1,300 mg/l) and temperature shall not exceed 34 °C. – In the event that blowdown from the cooling tower will be used for watering plant within the project area, SAR shall be control in the range 0-10. Conductivity shall not exceed 2,000 micromho/cm. and TDS shall not exceed 1,300 mg/l. if these effluent parameters do not comply with the criteria, they shall be improved prior to watering plant within the project area. – One emergency pond with the capacity of 19,000 cu.m. shall be provided with the holding capacity of at least one (1) day discharge volume. The emergency

TABLE 7.8-3

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Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
		pond will hold the blowdown from a cooling tower. In case the monitoring results show that the quality of effluent from a cooling water does not comply with the measures of Pluak Daeng Industrial Park, which is based on the Notification of Ministry of Industry, No.2 (B.E.2539) on determination quality of wastewater discharged from factories. This is exceptional for total dissolved solids which shall comply with RID is standard of effluent quality discharge into irrigation system (TDS shall not exceed 1,300 mg/l and temperature shall not exceed 34 °C) (In normal working conditions, the emergency pond shall be dry.) – Regular check and maintenance shall be performed for condenser and cooling towers so as to control the quality of effluent from the cooling tower prior to discharging out of the project.
Water Use • Impact on sources of water for consumption • Water volume used in the project should not affect local communities and agriculture.	• Water volume used in the project may impact on water consumption of local people and cause water conflict.	<u>Water Use Measures</u> <u>Construction Period</u> – Contractors shall provide sufficient water for construction activities. – Contractors shall provide sufficient and safe drinking water for construction workers. – Contractors shall coordinate with Pluak Daeng Industrial Park for water allocation regarding hydrostatic test for natural gas transmission pipeline and fuel pipeline within the project.

TABLE 7.8-3

SUMMARY OF ANXIETIES/SUGGESTIONS FROM PUBLIC CONSULTATIONS WITH PEOPLE AND RELATED PARTIES FOR IMPACT ASSESSMENT AND DETERMINATION OF ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND ENVIRONMENTAL IMPACT MONITORING MEASURES (CONT'D)

Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
		Operation Period – Efficient water use shall be considered, such as reduction in water drainage from the cooling system or recirculation of water within the project, etc. – Water pipes shall be checked. Leaking pipes shall be fixed immediately to prevent water loss. – In the event of water shortage and Eastern Water Resources Development and Management PLC. is unable to convey water to the project, the project shall reduce power generation capacity or stop the operation.
Solid Waste Management • Management of solid waste of the project • Contaminants from the project operation	• Contaminants from the project operation	**Solid Waste Management Measures** – Adequate covered waste bins shall be provided for solid waste collection. Collected waste shall be carried for disposal by the agency authorized by government agencies. Waste disposal shall be made by means required by law. – A storage place for solid waste shall be provided. The storage place shall be roofied and floored with concrete. Waste shall be sorted and labelled. – Drums/tanks shall be provided to collect solid waste, such as resin, oil, etc. from power generation process before sending for disposal by the the agency authorized by government agencies. Alternatively, the collected solid waste may be sold to solid waste disposal companies authorized by government agencies.

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Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
Transport • Transport problem during construction period, e. g. transport of construction materials and equipment, transport route, transport period • Traffic surface conditions after transport of construction materials and equipment	• Transport routes should be clearly identified so that local people are aware of	<u>Transport Measures</u> <u>Construction Period</u> – Transportation routes of construction materials and equipment shall be planned to avoid traffic problems. – Regular review and modification of Transportation routes of construction materials and equipment shall be performed so as to be in line with current situation. – Transport of construction materials during rush hours, i.e. from 07.30-08.30 hr and 16.00-17.00 hr, shall be avoided to reduce traffic congestion. If it is necessary to transport construction materials during rush hours, prior permission or approval shall be obtained from relevant agencies. Additionally, communities shall be notified 2 weeks in advance. – Trucks shall be covered with tarpaulin sheets to prevent materials from falling onto the road. – Contractors shall supervise drivers to strictly follow traffic rules. – Truck weight limits shall be controlled to comply with law. – Coordination with traffic police regarding transport of materials and equipment. – Truck speed limits shall be 80 kilometers/hour for the highway according to the Land Transport Act, B.E.2522 and the Highway Act, Volume 2 and Volume 3,

TABLE 7.8-3

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Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
		B.E.2542. Also, speed limits shall not exceed 40 kilometers/hour in communities. – A telephone number of the responsible person shall be posted on transportation trucks as a channel for complaints to the project. – Security guards shall be provided for facilitation at the access road. **Operation Period** – Drivers shall strictly follow traffic rules. – Transport and safety regulations shall be established for vehicles coming in and out of the Project so as to prevent accidents. – Types and volume of vehicles coming in the project area shall be recorded. The obtained information shall be used for traffic management in the project area, especially in the parking space, where parking outside the designated area within the Project area shall be prohibited. – A telephone number of the responsible person shall be posted on transportation trucks as a channel for complaints to the project. – The transportater company of hazardous chemicals or waste shall be supervised to strictly adhere to relevant laws. (such as the manual for transport of hazardous objects of Pollution Control Department, September 2011, the manual for hazardous chemical

TABLE 7.8-3

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Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
		management and handling in the place of business, July 2013, and the Notification of Department of Industrial Works on manual for storage of hazardous chemicals and objects, B.E.2550 and the Notification of Ministry of Industry on transportation of hazardous substances responsible by Department of Industrial Works, B.E.2558, etc.)
Occupational Health and Safety • Impacts on local communities, e.g. explosion/ gas leakage	• Emergency response plan/ rehearsal of emergency response plan • Safety of communities • Long-term impacts, e.g. gas leakage/ explosion	**Measures on Public Health, Occupational Health and Safety** <u>Operation Period</u> – The occupational health, safety and working environment committee shall be appointed to oversight operations. The occupational health, safety and working environment committee meeting shall be held at least once a month to evaluate, suggest solutions for problems, make improvements and promote occupational health, safety and working environment activities. – A fire protection system and fire fighting system shall be provided by the power plant according to National Fire Protection Association (NFPA) and related requirements and standards. – An emergency shall be established for operations in emergency cases.

TABLE 7.8-3

SUMMARY OF ANXIETIES/SUGGESTIONS FROM PUBLIC CONSULTATIONS WITH PEOPLE AND RELATED PARTIES FOR IMPACT ASSESSMENT AND DETERMINATION OF ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND ENVIRONMENTAL IMPACT MONITORING MEASURES (CONT'D)

Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
		<u>Measures on Major Hazards</u> <u>Construction Period</u> – The area where natural gas pipeline system will be connected with diesel fuel transfer system is restrictive area. Hot work shall be prohibited in the area. A warning sign shall be installed in that restrictive area. In the event that it is necessary to enter into the area, permit work governance shall be required with strict inspection and control. – A barrier shall be provided for the welding area. Furthermore, a warning sign indicating restriced area shall be installed and a work permit system shall be adopted. – A safety officer shall be provided to control and check operating conditions and ensure workers wear suitable personal protective equipment while working. <u>Operation Period</u> Preventive Measures for Natural Gas Transmission Pipeline and Diesel Oil Transmission Pipeline System in the Project Area – The Metering and Regulation Station (MRS) is a restrictive area. Hot work shall be prohibited in the area. A warning sign shall be installed in the Metering and Regulation Station (MRS) area. In the event that it is necessary to enter into the area, permit work governance shall be required with strict inspection and control.

TABLE 7.8-3

SUMMARY OF ANXIETIES/SUGGESTIONS FROM PUBLIC CONSULTATIONS WITH PEOPLE AND RELATED PARTIES FOR IMPACT ASSESSMENT AND DETERMINATION OF ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND ENVIRONMENTAL IMPACT MONITORING MEASURES (CONT'D)

Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
		– Maintenance of natural gas and diesel fuel transmission pipeline system and equipment shall be performed for readiness to use. Regular monitoring shall be done for safety. – The thickness and level of wear of the natural gas pipeline shall always be checked. – Leakage survey on natural gas and diesel fuel transmission pipeline system shall be performed according to involved standards. – Hazardous zones shall be defined. Furthermore, control and preventive measures shall be established and strictly followed for safety purpose. For example, smoking prohibition zone or hot work area shall be permitted, etc. – The natural gas leak detection system shall be provided using a gas meter to detect gas leak at the joint above the ground level at the Metering and Regulation Station (MRS) and gas compressor manual for project safety procedures. – The sign indicating pipeline alignment and warning shall be provided to prevent any action in the area above the pipeline, which may affect the pipeline. The person who notice an abnormal situation shall keep the responsible person informed.

TABLE 7.8-3

SUMMARY OF ANXIETIES/SUGGESTIONS FROM PUBLIC CONSULTATIONS WITH PEOPLE AND RELATED PARTIES FOR IMPACT ASSESSMENT AND DETERMINATION OF ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND ENVIRONMENTAL IMPACT MONITORING MEASURES (CONT'D)

Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
		– The shutdown control system and relief valve shall be provided to correctly and rapidly check abnormal pressure in the pipe.
Public Health • Impact on people's health/health checkup for local people/monitoring of people's health/collection of people's health data prior to the project start. • Impact on children/local people	• Impact on people's health • Health checkup should be provided to local people living around the project area before the start of the project.	<u>Measures on public health, occupational health and safety</u> <u>Public Health</u> <u>Construction Period</u> – Construction workers shall be trained on hygiene and disease prevention, supervised for their behaviors, annoyance and narcotics. – Contractors shall be supervised to follow the labour law on conducting health check-up and health check-up according to risk-factor related work. – The list of construction workers shall be created. The number of construction workers and the congenital disease of the construction workers shall be notified to the responsible public facilities before starting operations. – Adequate public utilities and facilities shall be provided for a temporary workers' camp. Apart from this, the related standards or laws shall be followed, i.e. the Notification of Ministry of Public Health No. 7/2538 on the number of workers per space of workers' camp, etc. – Security and safety shall be provided at the workers' camp.

TABLE 7.8-3

SUMMARY OF ANXIETIES/SUGGESTIONS FROM PUBLIC CONSULTATIONS WITH PEOPLE AND RELATED PARTIES FOR IMPACT ASSESSMENT AND DETERMINATION OF ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND ENVIRONMENTAL IMPACT MONITORING MEASURES (CONT'D)

Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
		– Construction workers' behavior shall be closely controlled to prevent nuisance and for the safety of nearby communities. – Communicable disease surveillance shall be provided by local public health agencies and the project. – Contractors shall be supervised to strictly adhere to terms and conditions, such as monitoring a worker's camp, narcotics sampling, segregrating solid waste at the workers' camp based on the monitoring method of sub-contractor's waste management. __Operation Period__ – Health promotion activities shall be organized. Public relations campaign about environmental aspect and health issues for communities shall be done. – Local public health facilities shall be supported in terms of health promotion, rehabilitation, disease prevention and healthcare for communities. – Morbidity survey on people living within 5 km. radius of the project location shall be conducted.
Social Conditions/ Public Relations and Public Participation • Impacts from migrant workers/ non- registered population working in the project area, e.g. crime, theft, and narcotics problems • Remedial action should be taken in case of impacts from the project operation.	• Contractors' strict adherence to the project's measures • Confidence about the project should be created among local people.	**General Measures for the Project** – Environmental impact prevention and mitigation measures as well as monitoring measures shall be followed in the form of environmental action plans proposed in the Environmental Impact Assessment (EIA) Report of Pluak Daeng Power Plant Project located in

TABLE 7.8-3

SUMMARY OF ANXIETIES/SUGGESTIONS FROM PUBLIC CONSULTATIONS WITH PEOPLE AND RELATED PARTIES FOR IMPACT ASSESSMENT AND DETERMINATION OF ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND ENVIRONMENTAL IMPACT MONITORING MEASURES (CONT'D)

Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
• Channels for communication with the project, for filing complaints on the project development, and for contact in emergency cases • Employment • Benefits from the project development to local people, e. g. support of community activities, religious/ traditional activities, education, health activities, etc.	• Remedial action/ compensation in case of impacts from the project operation • Monitoring of environmental quality measurement results • Environmental quality measurement plan should be informed to local communities in advance. • Local people should be considered to work with the company. • Regular visit to local people • Support of communities/ corporate social responsibility activities/benefits to communities • Site visit to create better understanding • Site visit/training to create understanding about the project • People should be given chance to participate in the project, such as monitoring of environmental impacts. • Channels for communication/ filing complaints/contact in case of emergency	Pluak Daeng Industrial Park, Map Yang Phon Sub-District, Pluak Daeng District, Rayong Province. The environmental action plans will be adopted by relevant agencies, people and organizations as control, supervision, and monitoring guidelines. - Gulf PD Co., Ltd. shall report on the compliance with environmental action plans to Office of the Energy Regulatory Commission (OERC), Department of Industrial Works, Office of Natural Resources and Environmental Policy and Planning (ONEP), Rayong Province and Rayong Provincial Office of Natural resources and Environment for consideration every 6 months. This shall comply with ONEP's guidelines for environmental monitoring report. - In case of potential environmental problems as shown by the environmental quality monitoring results as well as complaints from communities, Gulf PD Co., Ltd. shall solve the problems quickly. The Company shall notify Office of the Energy Regulatory Commission, Department of Industrial Works, Rayong Province and Rayong Provincial Office of Natural Resources and Environment every time for information and coordination in the problem-solving. - In the event of complaints by communities, the Company shall quickly solve problems and record the issues in a report.

TABLE 7.8-3

SUMMARY OF ANXIETIES/SUGGESTIONS FROM PUBLIC CONSULTATIONS WITH PEOPLE AND RELATED PARTIES FOR IMPACT ASSESSMENT AND DETERMINATION OF ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND ENVIRONMENTAL IMPACT MONITORING MEASURES (CONT'D)

Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
		– Gulf PD Co., Ltd. shall perform regular maintenance of the cooling system to be in good condition, ready for use, safe for operators and people living in the vicinities. **Socio-economic Measures** **Pre-Construction Period** – The project staff shall build good relationship with local officials and people. – The information of Pluak Daeng Power Plant Project shall be continuously publicized throughout the construction phase. The information to be provided include: construction schedule, environmental monitoring action plan, etc., through media. Optionally, any of the following methods may be adopted: local radio, installation of signboards at important places, e.g. office of community leaders, in front of the the Sub-district Administrative Organization (SAO) or other methods which are consistent with the objectives of the measures, one month in advance before the construction begins. – In case of conflicts between the power plant and communities, the project information shall be urgently disseminated to people through channels or media so that people acknowledge facts. This means the project is responsible for communities and aware of people's concerns.

TABLE 7.8-3

SUMMARY OF ANXIETIES/SUGGESTIONS FROM PUBLIC CONSULTATIONS WITH PEOPLE AND RELATED PARTIES FOR IMPACT ASSESSMENT AND DETERMINATION OF ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND ENVIRONMENTAL IMPACT MONITORING MEASURES (CONT'D)

Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
		<u>**Public Relations and Public Participation**</u> <u>**Pre-Construction Period**</u> – The information of Pluak Daeng Power Plant Project shall be continuously publicized throughout the construction phase. The information to be provided include: construction schedule, environmental monitoring action plan, etc., through media. Optionally, any of the following methods may be adopted: local radio, installation of signboards at important places, e.g. office of community leaders, in front of the the Sub-district Administrative Organization (SAO) or other methods which are consistent with the objectives of the measures, one month in advance before the construction begins. – Support will be provided for community activities as appropriate to build good relationship with communities, and return to community and society. – The environmental impact monitoring committee shall be appointed at least one month before the start of the construction phase. The environmental impact monitoring committee shall perform duties from the pre-construction phase to the operation phase. <u>**Construction Period**</u> – A "Complaint Center" shall be established to disseminate the project information, hear people's opinion, recommendations and complaints. Affected

TABLE 7.8-3

SUMMARY OF ANXIETIES/SUGGESTIONS FROM PUBLIC CONSULTATIONS WITH PEOPLE AND RELATED PARTIES FOR IMPACT ASSESSMENT AND DETERMINATION OF ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND ENVIRONMENTAL IMPACT MONITORING MEASURES (CONT'D)

Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
		persons can make complaints or raise problems through any channels, as appropriate, such as verbal communication, telephone, memo, letter, electronic mail, fax, etc., as shown in Figure 7.2-8. – Environmental impact prevention and mitigation measures shall be strictly adhered to. – Complaints and sufferings of people in communities due to construction activities shall be received and solved urgently. **Measures on Safety of Life and Property** – Qualified local people shall be given priority to be hired for any vacancy. – A register of migrant labour and foreign labour shall be established. – A project supervisor shall be assigned to supervise construction workers. Moreover, staff shall be provided to strictly supervise the entrance and exit to the construction site. – Construction activities and construction workers' behavior shall be supervised to prevent impacts on local people. – The boundaries of temporary workers' camp and construction site shall be clearly demarcated. – Working regulations shall be explicitly established. Construction workers shall be supervised strictly.

TABLE 7.8-3

SUMMARY OF ANXIETIES/SUGGESTIONS FROM PUBLIC CONSULTATIONS WITH PEOPLE AND RELATED PARTIES FOR IMPACT ASSESSMENT AND DETERMINATION OF ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND ENVIRONMENTAL IMPACT MONITORING MEASURES (CONT'D)

Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
		– In the event that workers' camp is close to a community, workers' behavior shall be closely supervised to prevent disturbance and annoyance. – If it is proven that the power plant is the cause of any impact, the problem shall be solved urgently. The database of an affected person or affected group shall be created. The impact prevention measures shall be established. – A resgister of affected persons shall be established. Complaints or incidence shall be registered. Facts, remedial action and negitiations shall be compliled and registered to be used as evidence of the power plant operation. **Public Relations Measures** – The information of Pluak Daeng Power Plant Project shall be continuously publicized throughout the construction phase. The information to be provided include: project name, construction schedule, contractor company, project owner, project coordinator, contact telephone number, environmental monitoring action plan, etc., through media. Optionally, any of the following methods may be adopted: local radio, installation of signboards at important places, e.g. office of community leaders, in front of the project location or other methods which are consistent with

TABLE 7.8-3

SUMMARY OF ANXIETIES/SUGGESTIONS FROM PUBLIC CONSULTATIONS WITH PEOPLE AND RELATED PARTIES FOR IMPACT ASSESSMENT AND DETERMINATION OF ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND ENVIRONMENTAL IMPACT MONITORING MEASURES (CONT'D)

Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
		the objectives of the measures, throughout the construction phase. – Receive information from communities regularly and continuously – Support, such as scholarship, sponsorship for sporting goods, medical devices/check-up will be provided for community activities as appropriate to build good relationship with communities, and to return to community and society. <u>Operation Period</u> **Socio-economic Measures** – Qualified local people shall have the priority to be hired for any vacancy in order to mitigate the impact of relationship between the Project and people and communities. Local people should be always notified for any vacancy every time. – Measures for benefit return for communities shall be established, such as maintenance of Huai Phu Sai with Pluak Daeng Industrial Park, other factories or involved agencies, support for local educational institutes or public health facilities, promotion of religious maintenance, contribution to public health benefit, etc. – Responsible persons shall be assigned for receiving complaints, hearing comments and suggestions. Affected persons can complain via channels like

TABLE 7.8-3

SUMMARY OF ANXIETIES/SUGGESTIONS FROM PUBLIC CONSULTATIONS WITH PEOPLE AND RELATED PARTIES FOR IMPACT ASSESSMENT AND DETERMINATION OF ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND ENVIRONMENTAL IMPACT MONITORING MEASURES (CONT'D)

Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
		verbal communication, telephone, memo, letter, electronic mail, fax, etc. to the power plant. – People in nearby communities shall have an opportunity to visit the power plant to ease their concern. – The quality of life improvement policy shall be set up. Community businesses shall be supported and promoted for sustainable economic and social development. – Project's action plan shall be implemented and strictly adhered to so as to reduce accidents and impacts on the Project and communities. – If it is proven that the power plant is the cause of any impact, the problem shall be solved urgently. The database of an affected person or affected group shall be created. The impact prevention measures shall be established. – A register of affected persons shall be established. Complaints or incidence shall be registered. Facts, remedial action and negitiations shall be compliled and registered to be used as evidence of the power plant operation. – In case of conflicts between the power plant and communities, the project information shall be urgently disseminated to people through channels or media so that people acknowledge facts. This means

TABLE 7.8-3

SUMMARY OF ANXIETIES/SUGGESTIONS FROM PUBLIC CONSULTATIONS WITH PEOPLE AND RELATED PARTIES FOR IMPACT ASSESSMENT AND DETERMINATION OF ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND ENVIRONMENTAL IMPACT MONITORING MEASURES (CONT'D)

Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
		the project is responsible for communities and aware of people's concerns. **Public Relations and Public Participation Measures** – Public relations campaign about the project information shall be made for communities through leaflet, media or other activities, which are in line with the objectives of established measures. Moreover, local people shall have an opportunity to monitor the project throughout the project life. – Measures for benefit return for communities shall be established, such as participation in Huai Phu Sai maintenance with the Pluak Daeng Industrial Park, other factories or involved agencies, support for local educational institutes or public health facilities, promotion of religious maintenance, contribution to public benefit, etc. – A good relationship with local government officers and local people shall be made through regular visit and prompt solutions to problems that may arise due to the project development – Receive information from communities regularly and continuously – Responsible persons shall be assigned for receiving complaints, hearing comments and suggestions. Affected persons can complain via channels like

TABLE 7.8-3

SUMMARY OF ANXIETIES/SUGGESTIONS FROM PUBLIC CONSULTATIONS WITH PEOPLE AND RELATED PARTIES FOR IMPACT ASSESSMENT AND DETERMINATION OF ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES AND ENVIRONMENTAL IMPACT MONITORING MEASURES (CONT'D)

Issues/Anxieties from Public Consultation Activities		Environmental Impact Prevention and Mitigation Measures
The 1st Public Consultation	The 2nd Public Consultation	
		verbal communication, telephone, memo, letter, electronic mail, fax, etc. to the power plant. – Support for aquatic animals or environmental preservation, such as fish breeding by the involved agency at Dok Krai Reservoir, canal, other local water bodies. – The environmental impact monitoring committee shall be appointed at least one month before the start of the construction phase. The environmental impact monitoring committee shall perform duties from the pre-construction phase to the operation phase. – The committee shall hold a position for 4 years each term from the appointment date and can take a position consecutively for not more than 2 terms.

TABLE 7.8-4
SUMMARY OF THE PROJECT'S IMPLEMENTATION OF PUBLIC PARTICIPATION ACTIVITIES PURSUANT TO THE RULE OF THE OFFICE OF THE PRIME MINISTER ON PUBLIC CONSULTATION

Rule of the Office of the Prime Minister	Project Implementation Process/Method
Clauses 1, 2, 3 and 4 Definitions	-
Clause 5. A State agency in charge of the State's project shall, prior to the commencement of the State's project, disseminate information under clause 7 to the public and may also conduct one or more public consultation methods under clause 9.	The public participation activities under the EIA of the Pluak Daeng Power Plant Project in Map Yang Phon Sub-district, Pluak Daeng District, Rayong Province are as follows. **1. Dissemination of Project Information** - Meetings with important persons to present the project information, and consultation with provincial-level offices to explain and disseminate the project details, including gathering of comments, concerns and suggestions about the project development. The persons attending the meetings comprised Rayong Provincial Governor, Head of Rayong Provincial Energy Office, representative of the provincial office for natural resource and environment, district chiefs, etc. - Posting of notices on invitation to two public consultations at the start of the project and during the preparation of the draft EIA report Prior to the public consultations, project documents and others PR media were distributed so that participants were aware of the project information
	2. Public Consultation Gulf PD Company Limited and the Consultant laid importance to the public consultation with people and related parties and organized public consultation activities for the target groups to express their opinions and exchange their information, reflecting their thoughts via two-way communication.

TABLE 7.8-4

SUMMARY OF THE PROJECT'S IMPLEMENTATION OF PUBLIC PARTICIPATION ACTIVITIES PURSUANT TO THE RULE OF THE OFFICE OF THE PRIME MINISTER ON PUBLIC CONSULTATION (CONT'D)

Rule of the Office of the Prime Minister	Project Implementation Process/Method
	– Meeting/consultation with related government agencies in order to provide the project information, request for their advice for further operation, and gather opinions and useful suggestions prior to the public consultation activities – The 1st public consultation at "the project start" was held to provide and disseminate the project information, both positive and negative, to people in general and related parties. Public consultation was organized at five forums during 25th- 27th January 2016. There were totally 605 participants (1 forum at provincial level with 23 participants, and 4 forums at sub- district level with 582 participants). – The 2nd public consultation "during the preparation of the draft EIA report" was organized to present the EIA result, the draft environmental impact prevention and mitigation measures and the draft environmental impact monitoring measures, as well as to listen to opinions and suggestions about the measures. Public consultation activities were held during 25th-27th June 2016 attended by totally 711 people (1 forum at provincial level with 25 participants, and 4 forums at sub- district level with 686 participants). Besides, two public consultations with Dok Krai Fishery Resource Management Goup were organized as follows: – The 1st public consultation with Dok Krai Fishery Resource Management Group at "the project start" was held on 8th March 2016 attended by 31 people.

TABLE 7.8-4
SUMMARY OF THE PROJECT'S IMPLEMENTATION OF PUBLIC PARTICIPATION ACTIVITIES PURSUANT TO THE RULE OF THE OFFICE OF THE PRIME MINISTER ON PUBLIC CONSULTATION (CONT'D)

Rule of the Office of the Prime Minister	Project Implementation Process/Method
	– The 2nd public consultation with Dok Krai Fishery Resource Management Group "during the preparation of the draft EIA report" was held on 13th June 2016 attended by 34 people. **3. Survey of Socio-Economic Conditions and Opinions about the Project Development** were conducted with 605 people during February-March, 2016. **4. Power Plant Visit** The objective of this activity was to create knowledge and understanding about the project development and collect opinions of communities and their reaction. 402 people visited the power plant during March, 2016.
Clause 6. In the case where the State agency fails to conduct public consultation prior to the commencement of the State's project under clause 5 paragraph one, the Minister with respect to a central administration, or the local administration, upon request of an interested person, order the State agency to conduct public consultation. In this case, the State agency shall conduct public consultation without delay.	Pluak Daeng Power Plant Project conducted two public consultations since the start of the project and during the preparation of the draft EIA report.
Clause 7. Information related to the State's project to be disseminated to the public by State agency shall, at least, consist of the following: (1) justification, necessity, and objective of the project; (2) substantial matter of the project; (3) operator and project's area; (4) implementation process and period of operation; (5) outputs and outcomes of the project; (6) possible impacts on people who live or work within project's area and its vicinity and on general public, including measures to prevent, revise or remedy injury or damage which may be	The project emphasized creation of knowledge and understanding about the project to related organizations and people by disseminating the information in Clause 7 of the Rule of the Office of the Prime Minister on Public Consultation as follows. **(1) Personal Media** – Gulf PD Company Limited: project engineers, environmental officers, community relations officers, etc. – The Consultant: environmental specialists, environmental impact officers, and public participation officers

TABLE 7.8-4
SUMMARY OF THE PROJECT'S IMPLEMENTATION OF PUBLIC PARTICIPATION ACTIVITIES PURSUANT TO THE RULE OF THE OFFICE OF THE PRIME MINISTER ON PUBLIC CONSULTATION (CONT'D)

Rule of the Office of the Prime Minister	Project Implementation Process/Method
caused by such impacts; estimated costs; in the case where the project is undertaken by a State agency, the source of money financing the project shall also be specified.	**(2) Document Media** Gulf PD Company Limited and the Consultant mutually prepared PR materials to provide knowledge and information to the target groups as follows: - PR documents (January, 2016) used in the 1st public consultation to gather opinions about the study scope and approaches of the project included justification, necessity and objectives of the project, substantial matter, operator, project area, outputs and outcomes of the project, implementation process, and public participation guidelines. - PR documents (May, 2016) used in the 2nd public consultation to collect opinions about the EIA study results, draft environmental impact prevention and mitigation measures, and draft environmental impact monitoring measures covered justification, necessity and objectives of the project, substantial matter, operator, project area, outputs and outcomes of the project, draft environmental impact prevention and mitigation measures, and draft environmental impact monitoring measures. - Presentation by using computer program to report the justification, background, project features/ details, construction process, EIA process, and EIA results
Clause 8. In conducting public consultation, a State agency shall establish correct understanding on the State's project to the public and shall gather public comments on the projects as well as injury or damage which may occur to the public. A State agency may conduct public consultation and disseminate information to the public simultaneously.	In conducting two public consultations, the study team emphasized creation of correct understanding among the target groups through the following. (1) Dissemination of project information by distributing PR materials as aforementioned to ensure people have the accurate project information

TABLE 7.8-4
SUMMARY OF THE PROJECT'S IMPLEMENTATION OF PUBLIC PARTICIPATION ACTIVITIES PURSUANT TO THE RULE OF THE OFFICE OF THE PRIME MINISTER ON PUBLIC CONSULTATION (CONT'D)

Rule of the Office of the Prime Minister	Project Implementation Process/Method
	(2) In public consultation, people were invited to make inquiries, give suggestions, and express their opinions about the project. (3) Collection of people's opinions about the project, including problems and damage that may occur to the public, via the following methods: - Inquiries made in the meetings (recorded by making notes or tape recording) and questionnaires distributed in the meetings. - The collected opinions were used as information for establishing the environmental impact prevention and mitigation measures in accordance with the demand and conditions of communities.
Clause 9. In conducting public consultation under clause 8, one or more of the following methods may be conducted: (1) Opinion survey, through the following methods: (a) individual interview (b) submitting opinion by post, telephone or facsimile, information networks system or other means; (c) giving the public an opportunity to obtain information from and to express opinion to the State agency in charge of the project; (d) small group discussion; (2) Consultative meeting, through the following methods: (a) public hearing; (b) public discussion; (c) information exchange; (d) workshop (3) other methods as prescribed by the Office of the Permanent Secretary to the Office of the Prime Minister	A combination of methods were used in conducting public consultation by considering suitability for the target groups as follows. (a) Meetings to provide the project information, consult and coordinate with sub-district and district level organizations, including request for advice and prepare readiness for public consultation (b) Meetings with representatives of government offices at sub-district, district, and provincial levels to introduce the project, present study results, and listen to comments and useful suggestions for the project operation. (c) Two public consultations: - The 1st public consultation at "the project start" was held to provide and disseminate to people in general and related parties the project information, background, objectives, project area, scope of EIA. - The 2nd public consultation "during the preparation of the draft EIA report, draft environmental, social and health impact

TABLE 7.8-4

SUMMARY OF THE PROJECT'S IMPLEMENTATION OF PUBLIC PARTICIPATION ACTIVITIES PURSUANT TO THE RULE OF THE OFFICE OF THE PRIME MINISTER ON PUBLIC CONSULTATION (CONT'D)

Rule of the Office of the Prime Minister	Project Implementation Process/Method
	prevention and mitigation measures and the draft environmental, social, and health impact monitoring measures" to present the EIA results, draft environmental impact prevention and mitigation measures and the draft environmental impact monitoring measures (d) Survey of socio-economic conditions and opinions about the project development after the 1st public consultation.
Clause 10. In the case where a State agency considers that the conduct of any public consultation method other than the methods prescribed in Clause 9 would achieve the objective of public consultation under clause 8, the State agency may conduct such public consultation method. In this case, the State agency shall, upon the completion of such public consultation, notify such conduct to the Office of the Permanent Secretary to the Office of the Prime Minister for information.	The public consultations were successful and met the objectives. It is not necessary to conduct the public consultation by using other methods.
Clause 11. In conducting public consultation, a State agency shall notify the public the consultation methods to be conducted and duration, place and other information which are sufficient for the public to comprehend the consultation and to express their opinions. The notification under paragraph one shall be posted openly at a noticeboard of the State agency and project's area for a period of not less than fifteen days prior to the commencement date of the public consultation. Such notification shall also be notified in the information networks system provided by the Office of the Permanent Secretary to the Office of the Prime Minister in accordance with this Rule.	The notices on invitation to the public consultation were prepared and posted at least 15 days before the public consultations as follows: - The notice on invitation to the 1st public consultation at the project start was posted on 7th January 2016. - The notice on invitation to the 2nd public consultation during the preparation of the draft EIA report was posted on 3rd May 2016. The notices were posted at Rayong Provincial Public Relations Office, Rayong provincial energy office, Rayong Provincial Office for Natural Resource and Environment, Rayong Provincial Industrial Office, Rayong Provincial Public Health Office, Pluak Daeng District Office, Nikhom

TABLE 7.8-4
SUMMARY OF THE PROJECT'S IMPLEMENTATION OF PUBLIC PARTICIPATION ACTIVITIES PURSUANT TO THE RULE OF THE OFFICE OF THE PRIME MINISTER ON PUBLIC CONSULTATION (CONT'D)

Rule of the Office of the Prime Minister	Project Implementation Process/Method
	Phathhana District Office, Map Yang Phon Sub-district Administrative Organization, Mae Nam Khu Sub-district Administrative Organization, Phana Nikhom Sub-district Administrative Organization, and Offices of Relevant Sub-district and Village Headmen.
Clause 12. Upon the completion of public consultation, a State agency shall prepare a public consultation report and notify such report to the public within fifteen days as from the completion date of public consultation. The provisions of clause 11 paragraph two shall apply mutatis mutandis to the notification under this clause.	The public consultation reports were prepared and notified to the public within 15 days upon the completion of the two public consultations. - The 1st public consultation report was posted on 9th February 2016. - The 2nd public consultation report was posted on 9th June 2016. The public consultation reports were posted at Rayong Provincial Public Relations Office, Rayong provincial energy office, Rayong Provincial Office for Natural Resource and Environment, Rayong Provincial Industrial Office, Rayong Provincial Public Health Office, Pluak Daeng District Office, Nikhom Phathhana District Office, Map Yang Phon Sub-district Administrative Organization, Mae Nam Khu Sub-district Administrative Organization, Phana Nikhom Sub-district Administrative Organization, and Offices of Relevant Sub-district and Village Headmen.
Clause 13. If it appears from a public consultation that an undertaking under any State's project may cause more impacts to the public than impacts disseminated to the public under clause 7 (7) but it is necessary to continue such project, a State agency shall provide, as necessary, additional measures to prevent, revise or remedy injury or damage which may be caused by such impacts and shall notify such measures to the public. The provision of clause 11 paragraph two shall apply mutatis mutandis to the notification under this clause.	Gulf PD Company Limited's staff have worked in the project area since the pre-construction period, during the study period, and will continue their duties until the construction and test run periods in order to mitigate the impacts other than those obtained from assessment. The environmental measures were also established. These staff have the following duties: (1) To regularly disseminate the project information as appropriate, and to provide the project details to communities within the study areas before the project commencement

TABLE 7.8-4

SUMMARY OF THE PROJECT'S IMPLEMENTATION OF PUBLIC PARTICIPATION ACTIVITIES PURSUANT TO THE RULE OF THE OFFICE OF THE PRIME MINISTER ON PUBLIC CONSULTATION (CONT'D)

Rule of the Office of the Prime Minister	Project Implementation Process/Method
	(2) To collect opinions, suggestions from the public and to provide explanations to relieve people's concerns about the project activities (3) To accept all complaints about damage resulting from construction activities and to coordinate with related persons to correct or remedy the problems and damage (4) To monitor contractors to ensure they strictly follow the environmental impact prevention and mitigation measures

CHAPTER 8

GRIEVANCE REDRESS MECHANISM

CHAPTER 8
GRIEVANCE REDRESS MECHANISM

8.1 COMMUNITY GRIEVANCES

Complaints related to communities' issues complaints or inconveniences caused by the project during construction and implementation shall be handled and prioritized for immediate resolution. Scheme of operation on GPD Power Plant Project's complaint receiving as shown in **Figure 8.1-1** and **Figure 8.1-2**.

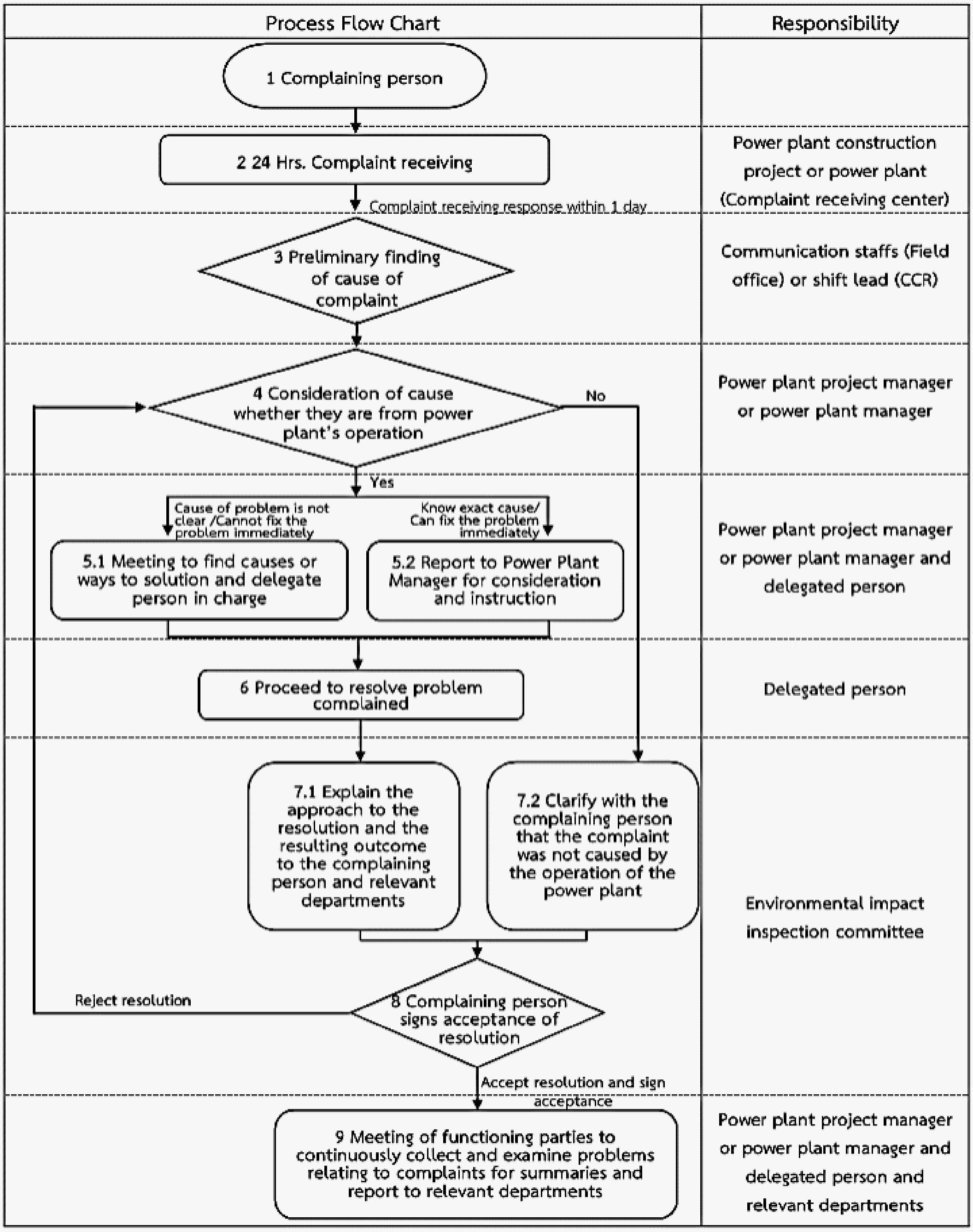
The power plant will be the complaint receiving center (***CRC***) and this information will be continuously disseminated by the public relations staff including project information using local radio, announcement post on strategic areas such as community leader offices and sub district organization offices, and other methods which are related to objectives for a month before starting construction activities. Local peoples could send complaints by verbal, telephone, memorandum, letters, e-mail, and fax. Timely and effective redress of stakeholder grievances contribute to bringing sustainability in the operations of a project. In particular, it will help advocate the process of forming and strengthening relationships between the project and the stakeholder community groups and bridge any gaps to create a common understanding, providing the project management a good environment to operate in the area. The grievance redress mechanism proposed for the Project will help achieve the objectives of sustainability and cooperation by dealing with the environmental and social issues of the Project.

The proposed grievance redress mechanism will be designed to cater for the issues of the people that can be affected by the Project. The population that can be affected by the Project has been identified in previous sections (Description of Socioeconomic Environment), and comprises of the people residing within three kilometers from both banks of the river.

8.2 FRAMEWORK FOR GRIEVANCE REDRESS MECHANISM

8.2.1 External Communications

GSRC will implement and maintain a procedure for external communications that includes methods to (i) receive and register external communications from the public; (ii) screen and assess the issues raised and determine how to address them; (iii) provide, track, and document responses, if any; and (iv) adjust the management program, as appropriate. In addition, GSRC is encouraged to make publicly available periodic reports on their environmental and social sustainability.



Note: 1. Report causes/resolutions/solving time to complaining party within 5 days.
2. Report progress in resolving problems to the complaining party every 7 days or as agreed.

FIGURE 8.1-1 : SCHEME OF OPERATION ON GPD POWER PLANT PROJECT'S COMPLAINT RECEIVING

8.2.2 Grievance Mechanism for Affected Communities

Where there are affected communities, GSRC will establish a grievance mechanism to receive and facilitate resolution of Affected Communities' concerns and grievances on the power plant's construction and operation. The grievance mechanism should seek to resolve concerns promptly, using an understandable and transparent consultative process that is culturally appropriate and readily accessible, and at no cost and without retribution to the party where the issue or concern. The mechanism should not impede access to judicial or administrative remedies. The client will inform the Affected Communities about the mechanism in the course of the stakeholder engagement process.

Ongoing Reporting to Affected Communities

GSRC will provide periodic reports to the affected communities that describe progress of implementation of the agreed action plan/remedial measures on issues raised. The frequency of these reports will be proportionate to the concerns of affected communities but not less than annually.

Proposed Mechanism for Grievance Redress

Under the Project the following will be established or appointed to ensure timely and effective handling of grievances:

- Complaint Receiving Center (CRC), which will be responsible to receive, log, and resolve complaints.
- Local Committee or Environmental Impact Committee, may be leaders or representatives from each community or village that can be approached by the community members for their grievances against the Project. The Local Committee or Environmental Impact Committee also forms part of a group in charge of monitoring environmental impacts of the project. Facilitation of grievance resolution will be their additional function

Details of the proposed mechanism are given below.

Function and Structure of CRC

During the construction period when the issues are mainly expected to arise, public relations staff will be responsible for coordinating correspondence and preparing documentation work and will assist the unit. The local staff assigned at the site will be responsible to prepare the documentation which will be reviewed by the head of CRC. The CRC will be responsible to receive, log, and resolve grievances.

Function and Structure of CRC

The CRC will function as an independent body that will operationalize the grievance redress process. It will comprise of:

- Manager of environment, health and safety department, GSRC
- Site Manager / Plant Manager that is responsible to oversee the contractors, GSRC Operation Manager
- Maintenance Manager
- Administrative Manager
- A representative of Community Relation Department

The CRC will meet with the Local Committee or the Environmental Impact Committee once every three months to review the grievance redress process; the frequency can be changed depending on the nature and frequency of grievances received. The performance will be gauged in terms of the effectiveness and the timeliness with which grievances were managed. In case there are any unresolved or pending issues, the CRC will deliberate on mechanisms to resolve those and come up with solutions acceptable to everyone.

Procedure of Filing and Resolving Grievances

Grievances will be logged and resolved using the following steps:

Step 1: Receive and Acknowledge Complaint

Once the CRC receives a complaint, which could be the complainant giving it in person, via letter or email, through phone call, or through the Local Committee or the Environmental Impact Inspection Committee (LC/EIIC), an acknowledgement of receipt of the complaint will be sent within one working days to the complainant. Complaints could be able to be anonymous as well.

Step 2: Investigation

The CRC will work to understand the cause of the grievance for which the CRC may need to contact the complainant again and obtain details. The CRC will be required to complete preliminary investigations within five working days upon receipt of complaint and send a response to the complainant documenting the results of their investigations and what the CRC plans to do ahead.

Step 3: Resolution through CRC

Once the CRC have investigated a grievance, it will share with the complainant the proposed course of action to resolve the complaint, should CRC believe any to be necessary. If the complainant considers the grievance to be satisfactorily resolved, the CRC will log the complaint as resolved in their records.

In case the grievance remains unresolved it will be reassessed and LC/EIIC will have further dialogue with the complainant to discuss if there are any further steps, which may be taken to reach a mutually agreed resolution to the problem.

For minor or less complex grievances, Steps 1, 2 and 3 or Steps 2 and 3 can be merged.

Step 4: Resolution through LC/EIIC

In case the CRC is unable to resolve the issue, the matter will be referred to LC/EIIC. All complaints that could not be resolved within four weeks will by default be referred to LC/EIIC. However, the complainant or the CRC can convene the LC/EIIC at any point in time, depending on the nature and urgency of the issue.

If the complainant is still not satisfied with the resolution of issues or complaints, he/she can go to local judicial proceedings.

Operating Principles for CRC

The CRC will operate on the principles of transparency, approachability and accountability. To achieve these, the CRC will be required to:

- be equipped to handle grievances in the local languages;
- be equipped to work through all possible modes of communication, such as, emails, by-post and face-to-face meetings at plant site or requiring visits;
- maintain a log of all grievances, with record of the date and time of the complaint logged and stakeholder information, such as, name, designation and contact details;
- provide opportunity to the stakeholder to revert with their comments on the proposed plan of action;
- keep the stakeholder informed of the progress in grievance resolution;
- obtain stakeholder consent on the mechanism proposed to redress the grievance and document consent; and
- maintain confidentiality of the stakeholder, if requested so.

Stakeholder Awareness

The stakeholders will be informed of the establishment of the CRC through a short and intensive awareness campaign. Under the awareness campaign, the proponent will share:

- objective, function and the responsibilities of the CRC;
- means of accessing the CRC and the mechanics of registering a grievance at the CRC;
- operating principles of the CRC; and
- contact details.

Additional awareness campaigns may be organized, if necessary.

8.3 WORKERS GRIEVANCE

For workers' grievance, the HR department will be responsible for overall workers in our company, including those working at the site. Grievances/issues will be handled according the regulation of Ministry of Labour. The HR Manager will take the lead in Grievance redress mechanism for workers and grievances will be logged and reported by the HR Department as part of E&S Annual Report for the project.

For grievance mechanism for contractors, subcontractors and their workers, workers can feedback to their supervisor, foreman, or administration officer for the issues they have. Also, EPC Construction Contract clause 4.1.8 (b) states that "Contractor shall not take any action to prevent its employees from lawfully exercising their right of free association and their right to organize and bargain collectively. Contractor further agrees to observe applicable Legal Requirements relating to a minimum age for employment of children, acceptable conditions of work with respect to minimum wages, hours of work, and occupational health and safety, and not to use forced labor. Contractor shall give its employees the right to remove themselves from work situations or areas that present serious danger to life or health without jeopardizing their future employment."

CHAPTER 9

ENVIRONMENTAL MANAGEMENT PLAN

CHAPTER 9
ENVIRONMENTAL MANAGEMENT PLAN

Gulf PD Co., Ltd. has planned to construct Plaug Daeng Power Plant, which is a combined cycle power plant using natural gas as primary fuel and diesel oil as reserve fuel, with a total power generation capacity of 2,920 Megawatts (MW). The power plant encompasses the area of approx. 492 rai in Plauk Daeng Industrial Park, Map Yang Phon sub-district, Plauk Daeng district, Rayong Province. All of the generated electricy will be sold to Electricity Generating Authority of Thailand (EGAT). According to environmental impact assessment during the construction phase and the operation phase, the Project will cause environmental impacts at low to moderate levels. As a result, environmental impact prevention and mitigation measures as well as monitoring measures were established to prevent and minimize potential impacts and enable the sustainable use of natural resources.

Not only the specific action plans for environmental and social aspects, but also general action plan such as guideline of preparation of monitoring report, requirements of modification of the project description, etc. was prepared. The details of a general action plan are as follows:

(1) Environmental impact prevention and mitigation measures as well as monitoring measures shall be followed in the form of environmental action plans proposed in the Environmental Impact Assessment (EIA) Report of Pluak Daeng Power Plant Project located in Pluak Daeng Industrial Park, Map Yang Phon Sub-District, Pluak Daeng District, Rayong Province. The environmental action plans will be adopted by relevant agencies, people and organizations as control, supervision, and monitoring guidelines.

(2) Gulf PD Co., Ltd. shall incorporate measures in the environmental action plans into the conditions of contractor contract. These shall be strictly adhered to for effective implementation.

(3) Gulf PD Co., Ltd. shall report on the compliance with environmental action plans to Office of the Energy Regulatory Commission (OERC), Department of Industrial Works, Office of Natural Resources and Environmental Policy and Planning (ONEP), Rayong Province and Rayong Provincial Office of Natural resources and Environment for consideration every 6 months. This shall comply with ONEP's guidelines for environmental monitoring report.

(4) Gulf PD Co., Ltd. shall perform regular maintenance of the cooling system to be in good condition, ready for use, safe for operators and people living in the vicinities.

(5) In case of potential environmental problems as shown by the environmental quality monitoring results as well as complaints from communities, Gulf PD Co., Ltd. shall

solve the problems quickly. The Company shall notify Office of the Energy Regulatory Commission, Department of Industrial Works, Rayong Province and Rayong Provincial Office of Natural Resources and Environment every time for information and coordination in the problem-solving.

(6) In case Gulf PD Co., Ltd. intends to change the project descriptions and/or environmental impact prevention and mitigation measures or environmental monitoring measures, the Company shall notify the permitting authority as follows:

- If the permitting authority deems that such changes will have more positive or equivalent impacts on the environment, comparing to the approved measures in the EIA report, the permitting authority shall record such changes according to the criteria and conditions stipulated by relevant laws, and a copy thereof will be submitted to ONEP.
- If the permitting authority deems that such changes may affect the essence of the approved EIA report, the permitting authority shall submit the addendum report to ONEP for submission to the relevant Expert Review Committee for comment prior to making changes.

(7) In the event of complaints by communities, the Company shall quickly solve problems and record the issues in a report.

(8) When the project is fully operated and has reached a steady state and the value of air pollution emission is found to be lower, such value shall be applied as the emission limit value. Office of Natural Resources and Environmental Policy and Planning shall be notified without delay.

The action plans propose the details for mitigation measures and responsible party for both construction and operation phases. There are 14 action plans as follows:

(1) Air Quality Action Plan
(2) Noise Action Plan
(3) Surface Water Quality and Groundwater Quality Action Plan
(4) Transportation Action Plan
(5) Water Use Action Plan
(6) Waste Management Action Plan
(7) Drainage and Flood Control Action Plans
(8) Socio-economic Action Plan
(9) Public Participation and Relation Action Plan
(10) Public Health/Occupational Health and Safety Action Plan
(11) Major Hazard Action Plan
(12) Green Area and Aesthetics Action Plan
(13) Monitoring Action Plan on the Heat Generated from the Power Plant
(14) pH of Rainwater and Sulfate Radicals in Soil Monitoring Action Plan

Details of each action plan are as follows:

TABLE 9-1

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Environmental Aspect	Impact or Risk to related activities to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
Construction Phase					
1. Air Quality	- Dust dispersion and exhaust emission impact from construction activities	- Trucks transporting construction materials shall be covered and/or fastened to prevent the falling of materials and reduce the diffusion of dust. - While being transported, construction materials will be covered with tarpaulin sheets to prevent accidents and dust. - Water shall be sprayed at the construction site, earth piles or the areas where construction activities cause diffusion of dust, such as roads, land leveling, etc., to reduce dust diffusion at least twice a day (morning-afternoon). However, when it is dry or windy and it is considered that the sprayed areas are getting dry and dust dispersion is likely to occur, water spraying will be additionally done. - Inspection, maintenance or checking of vehicles and construction engines/machinery shall be performed on a monthly basis to reduce air pollution emissions. - Truck wheels shall be washed before the trucks leave the construction site or construction-related areas to prevent dirt and sand from falling onto the roads, both inside and outside the project area. - Truck speed limits shall be 20 kilometers/hour for the construction site and Pluak Daeng Industrial Park and 80 kilometers/hour for the highway. - Construction waste or garbage shall not be incinerated or disposed of at the construction site. - Construction site shall be controlled and construction works undertaken quickly. - Workers shall be provided to clean the road surface in front of the project area after the arrival-departure of trucks.	- The result of ambient air quality monitoring within National Ambient Air Quality Standard and WHO Ambient Air Quality Guidelines.	Gulf PD Co., Ltd.	Included in total construction contract cost
2. Noise	- Noise impact from construction activities	- Noisy construction equipment shall be only used during daytime during 08.00-17.00 hr. If it is necessary to use such construction equipment outside the aforesaid period, permission or approval must be sought from involved agencies. Furthermore, adjacent communities and factories shall be notified 2 weeks in advance. - Relations campaigns shall be conducted to inform the nearby communities of the planned noise-generating construction activities together with noise control measures at least 2 weeks in advance before construction. - Regular inspection, maintenance and repair shall be carried out for tools, machinery and equipment to be in good condition at all times and maintenance manuals shall be continuously complied with. - A warning sign shall be installed in the noisy area. Personal protective equipment, e.g. ear plugs or ear muffs, shall be provided for construction workers in the noisy area where noise level exceeds 85 decibels (A). Furthermore, construction workers shall be instructed to wear personal protective equipment in noisy areas. - Contractors shall be supervised to strictly adhere to noise mitigation measures. Equipment/ machinery generating low noise level will be used. - Temporary noise barriers shall be installed in the west, the south and the north of the project where pile driving is undertaken. Metal sheets having the thickness of 1.27 mm (Steel 18 ga) or thicker will be selected. Optionally, other materials with sound transmission loss (TL) of 25 decibels (A) may be used. Three sides of the barriers are determined to be 5 m high from the ground.	- The result of noise monitoring within National Noise Standard and WHO Community Noise Guidelines.	Gulf PD Co., Ltd.	Included in total construction contract cost

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
3. Surface Water Quality and Groundwater Quality	- Surface water contamination	**Pre-construction phase** **Groundwater quality measures** - The groundwater flow direction at the boundary of the project area shall be made during the pre-construction phase after the construction of groundwater monitoring wells to investigate the suitable locations of four groundwater monitoring wells. The locations of groundwater monitoring wells shall be relative to the ones of drums of diesel oil. The baseline report of groundwater in the project area shall be made before operation phase. **Construction phase** **Stormwater management measures** - Temporary drainage ditches and sedimentation pond shall be provided for stormwater storage and sedimentation in the project area. Solids will be separated from stormwater while clear water will be used to spray the project area to alleviate dust diffusion. The remaining water will be drained into the storm drains of Pluak Daeng Industrial Park. - If material scrap falls into the drainage ditches and block or obstruct the water flow, it should be removed. - Material scrap and dirt shall not be dumped into the drainage ditch. **Wastewater management measures: wastewater from construction workers and construction activities** - Sanitary toilets shall be adequately provided for construction workers as required by law. Additionally, a septic tank or prefabricated wastewater treatment tank shall be constructed to treat wastewater from water use and consumption by construction workers so that treated effluents meet the effluent standards. The responsible agency shall be contacted to pump out sewage in the prefabricated wastewater treatment tank for further disposal. The prefabricated wastewater treatment tank will be always maintained to ensure its efficiency throughout the construction phase. The plant shall treat wastewater from bathrooms and toilets of construction workers to meet the effluent quality standards of Building Type C according to the Notification of the Ministry of Natural Resources and Environment on Establishment of Building Effluents Standards for some Building Types and Sizes. Effluent parameters include pH, BOD, suspended solids, sulfide, Total Dissolved Solids, settleable solids, oil and grease, and TKN. A monitoring pond shall be provided for effluent storage for at least 1 day for inspection once a month before contacting the responsible agency for further disposal. - The drainage ditch and wastewater holding pond shall be provided at the construction site to hold uncontaminated wastewater from construction activities. The uncontaminated wastewater quality shall be inspected for compliance with the requirements of Pluak Daeng Industrial Park prior to being drained into the central wastewater treatment system of Pluak Daeng Industrial Park.	- The result of wastewater sampling within effluent quality standards of Thailand and Effluent guidelines for thermal power plant	Gulf PD Co., Ltd.	Included in total construction contract cost
		- Contaminated wastewater e.g. wastewater from changing engine oil, shall be controlled, and will be kept in a drum and delivered to the agency authorized by government agencies for disposal. - Regular maintenance shall be performed for vehicles and all types of machinery to prevent oil leakage. The maintenance shall be performed in the designated area or on solid surface with a pad to prevent oil leakage into Huai Phu Sai.			

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
3. Surface Water Quality and Groundwater Quality (Cont'd)		**Wastewater management measures: wastewater from workers' camp** - Sanitary toilets shall be adequately provided for construction workers as required by law. Additionally, a septic tank or prefabricated wastewater treatment tank shall be constructed to treat wastewater from water use and consumption by construction workers so that treated effluents meet the effluent standards. The responsible agency shall be contacted to pump out sewage in the prefabricated wastewater treatment tank for further disposal. The prefabricated wastewater treatment tank will be always maintained to ensure its efficiency throughout the construction phase. The plant shall treat wastewater from bathrooms and toilets of construction workers to meet the effluent quality standards of Building Type C according to the Notification of the Ministry of Natural Resources and Environment on Establishment of Building Effluents Standards for some Building Types and Sizes. Effluent parameters include pH, BOD, suspended solids, sulfide, Total Dissolved Solids, settleable solids, oil and grease, and TKN. A monitoring pond shall be provided for effluent storage for at least 1 day for inspection once a month before contacting the responsible agency for further disposal. **Wastewater management measures for Discharges from the Power Plant and Hydrostatic Test** - Screens shall be installed at the drain pipe to trap garbage and solids in water discharges after hydrostatic tests. - The characteristics of hydrostatic test water discharges, i.e. pH, temperature, total suspended solids, oil and grease, shall be checked to strictly comply with the requirements of Pluak Daeng Industrial Park. - In the event that the effluent quality does not comply with the one required by Pluak Daeng Industrial Park, it will be sent for disposal by the agency authorized by government agencies.			
4. Transportation	- Traffic congestion and accident from project transportation	- Transportation routes of construction materials and equipment shall be planned to avoid traffic problems. - Regular review and modification of Transportation routes of construction materials and equipment shall be performed so as to be in line with current situation. - Transport of construction materials during rush hours, i.e. from 07.30-08.30 hr and 16.00-17.00 hr, shall be avoided to reduce traffic congestion. If it is necessary to transport construction materials during rush hours, prior permission or approval shall be obtained from relevant agencies. Additionally, communities shall be notified 2 weeks in advance. - Trucks shall be covered with tarpaulin sheets to prevent materials from falling onto the road. - Contractors shall supervise drivers to strictly follow traffic rules. - Truck weight limits shall be controlled to comply with law. - Drivers shall be trained and supervised to strictly follow traffic rules. - Regular check and maintenance shall be performed for vehicles used in the project. - Coordination with traffic police regarding transport of materials and equipment. - Truck speed limits shall be 80 kilometers/hour for the highway according to the Land Transport Act, B.E.2522 and the Highway Act, Volume 2 and Volume 3, B.E.2542. Also, speed limits shall not exceed 40 kilometers/hour in communities. - A warning sign shall be installed and speed shall not exceed 20 kilometers per hour at the construction site. - A telephone number of the responsible person shall be posted on transportation trucks as a channel for complaints to the project. - Security guards shall be provided for facilitation at the access road.	- Record of daily traffic accident occurred during the project construction phase and produce a monthly report.	Gulf PD Co., Ltd.	Included in total construction contract cost

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
5. Water Use	- Water shortage	- Contractors shall provide sufficient water for construction activities. - Contractors shall provide sufficient and safe drinking water for construction workers. - Contractors shall coordinate with Pluak Daeng Industrial Park for water allocation regarding hydrostatic test for natural gas transmission pipeline and fuel pipeline within the project.	- Water is sufficient for use during construction period.	Gulf PD Co., Ltd.	Included in total construction contract cost
6. Solid Waste Management	- Hygiene problem	- Responsible workers shall be assigned to collect solid waste in the designated area at least once a day. - Hazardous waste shall be sent for disposal to the agency authorized by government agencies according to the Notification of Ministry of Industry on disposal of waste or unusable materials, B.E. 2548. - Adequate covered waste bins shall be provided in the areas at the construction site. Coordination shall be made with the agency authorized by government agencies for waste collection and disposal. Waste disposal shall be made at the disposal sites. - Scraps of materials, dirt and construction waste shall be compiled, packed and disposed in an appropriate way. - Oil management, such as oil change, construction materials, etc. shall be controlled. The oil shall be contained in a drum and carried for disposal by the agency authorized by government agencies. - Construction workers shall be supervised to throw solid waste in a waste bin. Waste shall be disposed regularly. - Stackpiles shall be place in the designated area. - Waste shall not be incinerated at the construction site. - The collected recyclable waste of the project, such as scraps of wood, scrap iron, rubble, paint tin, paint brush, spray can, etc. should be sorted for reuse or sale to waste purchasing companies. - Contractors shall coordinate with the Sub-district Administrative Organization or the agency authorized by local government agencies for collection so that the solid waste is not left in the project area, which will be the carrier of diseases and the source of unpleasant smell.	- Record of type and volume of general garbage and waste from construction activities.	Gulf PD Co., Ltd.	Included in total construction contract cost
7. Drainage and Flood Control	- Flooding in the construction area	- Debris and waste generated from construction activities shall be collected and sorted before sending to the authorized agency for proper disposal so as to prevent bebris and construction waste from clogging the drainage ditch of the project. - The storm drainage system of the project shall be designed to prevent blockage of existing waterway and flooding in adjacent areas. - Construction waste and construction debris shall not be dumped into the drainage ditch. - Regular maintenance shall be performed for the drainage ditch to prevent clogging.	- No flood in construction area.	Gulf PD Co., Ltd.	Included in total construction contract cost
8. Socio-economic	- During the construction period, people in the communities might still have some opinion conflicts regarding concerns about the project.	Pre-Construction phase General Measures - The project staff shall build good relationship with local officials and people. - The information of Pluak Daeng Power Plant Project shall be continuously publicized throughout the construction phase. The information to be provided include: construction schedule, environmental monitoring action plan, etc., through media. Optionally, any of the following methods may be adopted: local radio, installation of signboards at important places, e.g. office of community leaders, in front of the the Sub-district Administrative Organization (SAO) or other methods which are consistent with the objectives of the measures, one month in advance before the construction begins. - Support will be provided for community activities as appropriate to build good relationship with communities, and return to community and society.	- Results from socio-economic survey and opinion interview with households, people, community leader/local leader, representatives of relevant agencies, local organization and sensitive receptors around the project site i.e. hospital, temple, school and measurement stations of environmental quality	Gulf PD Co., Ltd.	Included in total construction contract cost

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
8. Socio-economic (Cont'd)		- In case of conflicts between the power plant and communities, the project information shall be urgently disseminated to people through channels or media so that people acknowledge facts. This means the project is responsible for communities and aware of people's concerns. Public relations campaign measure 1) Objectives of Public relations campaign - To provide people living in the project vicinities an opportunity to acknowledge the project information continuously from the pre-construction, construction and operation phases, to serve as a communication channel between people living in the project vicinities and the project, to hear the opinions and recommendations of people who may be affected by the project operation. **2) At least one of the following channels for public relations campaign/dissemination of project information or other activities which are consistent with the objectives, i.e.** - **Through local media:** such as wire broadcasting from local government agency and community or local cable media, as appropriate - **Through notice board/signboard of local government agency, community or in public place that is visible**: such as signboard of the district involved with the project, signboard of municipality/Sub-district Administrative Organization involved with the project, signboard of public health facility in the study area and the project location. - **Through public relations material/leaflet:** to disseminate the project details, progression (during each phase), safety data and emergency prevention, communication channel in case of emergency, complaint receiving channel and communication channel of the project, etc. The public relations material/leaflet should be placed at the public relations unit of the government agency, community or the place where people can access. - Through meeting: • The project's details/progress shall be explained in the meeting through local government agencies (provincial and district levels), at least once before the construction or within the first month of construction. • The project's details/ progress shall be explained in the meeting for the involved villages/ communities/ sub- districts. The meeting shall be organized once before the commencement of construction or within the first month of construction. - **Through community participation committee:** throughout the duration that the committee serves as the community participation committee - **Through other methods of public relations, as appropriate**: such as personal visit, public address, etc. Public relations campaign shall include the project details and progress during the construction phase, environmental impacts, and environmental impact prevention and mitigation measures, communication channel and complaint receiving channel as well as contact in case of emergency.			

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
8. Socio-economic (Cont'd)		**Construction phase** **Environmental impact prevention and mitigation measures** - A "Complaint Center" shall be established to disseminate the project information, hear people's opinion, recommendations and complaints. Affected persons can make complaints or raise problems through any channels, as appropriate, such as verbal communication, telephone, memo, letter, electronic mail, fax, etc., as shown in **Figure 9-1** - Environmental impact prevention and mitigation measures shall be strictly adhered to. - Complaints and sufferings of people in communities due to construction activities shall be received and solved urgently. Life and asset safety measures - Qualified local people shall be given priority to be hired for any vacancy. - A register of migrant labour and foreign labour shall be established. - A project supervisor shall be assigned to supervise construction workers. Moreover, staff shall be provided to strictly supervise the entrance and exit to the construction site. - Construction activities and construction workers' behavior shall be supervised to prevent impacts on local people. - The boundaries of temporary workers' camp and construction site shall be clearly demarcated. - Working regulations shall be explicitly established. Construction workers shall be supervised strictly. - In the event that workers' camp is close to a community, workers' behavior shall be closely supervised to prevent disturbance and annoyance. - In case of conflicts between the power plant and community people, the project information shall be disseminated urgently through channels or media to show the responsibility and care for people's concerns. - If it is proven that the power plant is the cause of any impact, the problem shall be solved urgently. The database of an affected person or affected group shall be created. The impact prevention measures shall be established. - A resgister of affected persons shall be established. Complaints or incidence shall be registered. Facts, remedial action and negitiations shall be compliled and registered to be used as evidence of the power plant operation. **Public relations campaign measures** **1) Objectives of Public relations campaign** - To continuously provide the project information during the pre- construction, construction and operation phases for people living in the project vicinities. - To serve as a communication channel between communities nearby and the project, listen to the comments of affected persons and receive recommendations from people. **2) At least one of the following channels for public relations campaign/dissemination of project information or other activities which are consistent with the objectives, i.e.** - **Through local media:** such as wire broadcasting from local government agency and community or local cable media, as appropriate	- Results from Socio-economic survey and opinion interview with households, people, community leader/local leader, representatives of relevant agencies, local organization and sensitive receptors around the project site i.e. hospital, temple, school and measurement stations of environmental quality		

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
8. Socio-economic (Cont'd)		- **Through notice board/signboard of local government agency, community or in public place that is visible**: such as signboard of the district involved with the project, signboard of municipality/sub-district administrative organization involved with the project, signboard of public health facility in the study area and the project location. - **Through public relations material/leaflet:** to disseminate the project details, progression (during the operation phase), safety data and emergency prevention, communication channel in case of emergency, complaint receiving channel and communication channel of the project, etc. The public relations material/leaflet should be placed at the public relations unit of the government agency, community or the place where people can access. - **Through other methods of public relations, as appropriate**: such as personal visit, public address, etc. Public relations campaign shall include the project details and progress during the construction phase, advantages and disadvantages, communication channel and complaint receiving channel as well as contact in case of emergency.			
9. Public Participation and Relation	- During the construction period, people in the communities might still have some opinion conflicts regarding concerns about the project.	Pre-construction phase - The information of Pluak Daeng Power Plant Project shall be continuously publicized throughout the construction phase. The information to be provided include: construction schedule, environmental monitoring action plan, etc., through media. Optionally, any of the following methods may be adopted: local radio, installation of signboards at important places, e.g. office of community leaders, in front of the the Sub-district Administrative Organization (SAO) or other methods which are consistent with the objectives of the measures, one month in advance before the construction begins. - Support will be provided for community activities as appropriate to build good relationship with communities, and to return to community and society. - The environmental impact monitoring committee shall be appointed at least one month before the start of the construction phase. The environmental impact monitoring committee shall perform duties from the pre-construction phase to the operation phase. • The committee chairman will be selected from the committee meeting and will hold a position for 4 years each term. He/she shall consecutively hold the position for 2 terms at maximum. • The respresentative committee from the people sector will hold a position for 4 years each term and can take a position consecutively for not more than 2 terms. • The expert will hold a position for 4 years each term and can take a position consecutively for not more than 2 terms. • The committee shall hold a position for 4 years each term from the appointment date and can take a position consecutively for not more than 2 terms. Compositions The environmental impact monitoring committee of the project consists of community representatives, representatives from the government agencies, experts and the power plant representative. Details are given below.	- Record of activities that the project arranges for local communities.	Gulf PD Co., Ltd.	Included in total construction contract cost

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
9. Public Participation and Relation (Cont'd)		- Community representatives comprise sub-district representatives and representatives from administrative divisions within 5 km. radius of the power plant as defined in the EIA report. (The number of community representatives shall not be less than half of a total number of the environmental impact monitoring committee.) • **Two (2) representatives from the village located by the power plant**: Village no. 5 Map Yang Phon sub-district • **One (1) representative for each village in the study area:** ⇨ <u>Map Yang Phon sub-district</u>: Village no. 1 Ban Map Toei, Village no. 2 Ban Nuen Sawan, Village no. 3 Ban Map Yang Phon, Village no. 6 Ban Map Yang Mai and Village no. 7 Ban Chak Oi ⇨ <u>Pluak Daeng sub-district</u>: Village no. 4 Ban Wang Ta Phin and Village no. 6 Ban Thaptong ⇨ <u>Mae Nam Khu sub-district</u>: Village no. 4 Ban Chak Munthet and Village no. 7 Ban Wang Pradu ⇨ <u>Phana Nikhom sub-district</u>: Village no. 4 Ban Khao Maphut, Village no. 5 Ban Khlong Phlu, Village no. 6 Ban Nong Rakam, Village no. 7 Ban Wang Pla and Village no. 8 Ban Soi 13 - Four to six (4-6) representatives from the government agencies comprise representative from Pluak Daeng district, representative from Nikhom Phatthana district, 1 representative from each involved Sub-district Administrative Organization and 1 representative each from other involved government agencies - Two (2) experts knowledgeable for environmental impact monitoring or approved by the community - One (1) representative from the power plant Selection process • Community representatives may be selected, elected or appointed as detailed below. • Pluak Daeng Power Plant sends a letter to the agencies in the project area (Sub-District Administrative Organization) within 5-km radius requesting nomination of qualified community representatives, through specific means of each sub-district. The name of qualified community representatives shall be sent to Pluak Daeng Power Plant within 30 days upon receipt of the letter. • The representatives' name shall be included not less than 1 year in a house registration in the sub-district before the selection date or appointment date. • Representatives shall not be under 25 years old on the selection, election or appointment date. • Disqualifications: : Misconduct, corruption. : Bankrupt or sentenced to imprisonment, except petty offence or guilty of negligence. : Insane, mental infirmity, incompetent person by court order or quasi incompetent person.			

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
9. Public Participation and Relation (Cont'd)		- Representatives from the government agencies will be appointed by Pluak Daeng chief officer and the chief executive of the involved SAO (one representative from each agency). Regarding selection of representatives from other government agencies, the power plant representative shall determine with community representatives. For example, the representatives may be from provincial office of natural resources and environment, provincial industrial office or other involved government agencies. Then each agency shall nominate its representative to the power plant representative. - Experts shall be jointly selected by community representatives and the power plant representative. The experts shall be knowledgeable about environmental impact monitoring, or the ones who are approved by community. Then the experts are nominated to the power plant representative for consideration and approval, and 2 experts will be selected. - The power plant representative shall be appointed by the power plant management. Authority - Determine approaches and procedures for environmental impact monitoring during the construction phase and the operation phase of the power plant. - Receive, consider and make a decision on complaints and recommendations from people about environmental impacts due to the construction and the operation of the power plant. - Comment or suggest any improvement or change in construction and operation of the power plant so as to be consistent with the requirements in the EIA Report. - Make recommendations to government agencies to temporarily suspend the construction and operation of the power plant in case of non-compliance with the requirements in the EIA report. - Appoint assistants as appropriate. Responsibilities - Organize a meeting at least once every 3 months - Conduct public relations campaigns to provide accurate information on the power plant to people - Conduct site inspection of the construction and operation of the power plant - Post the petition or complaint submitted by people to the committee and publicly announce the committee's decision at offices of local government agencies. The announcement of the committee's decision shall be publicized and posted at least in 3 public places - Establish regulations for complaints and appeals or other regulations required for operations. - Consider compensation for damage if proven that such damage has resulted from the project operation. **Remark:** The requirements stipulated by the committee may be later changed according to the decision of the committee. Such change must not have impact on the environmental impact assessment or the essence in the EIA report such as term of office and elements that will reduce the proportion of people sector from that specified in the EIA report.			

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
9. Public Participation and Relation (Cont'd)		Construction phase - The information of Pluak Daeng Power Plant Project shall be continuously publicized throughout the construction phase. The information to be provided include: project name, construction schedule, contractor company, project owner, project coordinator, contact telephone number, environmental monitoring action plan, etc., through media. Optionally, any of the following methods may be adopted: local radio, installation of signboards at important places, e.g. office of community leaders, in front of the project location or other methods which are consistent with the objectives of the measures, throughout the construction phase. - The project staff shall build good relationship with local officials and people through regular visits and shall be ready to solve any problem that may arise due to the project - Receive information from communities regularly and continuously - Support, such as scholarship, sponsorship for sporting goods, medical devices/check-up will be provided for community activities as appropriate to build good relationship with communities, and to return to community and society.	- Record of activities that the project arranges for local communities. - Record of activities of the Environmental Impacts Monitoring Committee are occurred every 6 months	Gulf PD Co., Ltd.	Included in total GPD Cost
10. Public Health / Occupational Health and Safety	Health/ Occupational Health and Safety impact on worker	Public Health - First aid unit, basic medical supplies and an ambulance shall be provided in case of emergency according to the Ministerial Regulation of the Ministry of Labour concerning the Provision of Labour Welfare in Workplace, B.E.2548. - Clean drinking water shall be provided for construction workers. - Sanitary toilets shall be provided for construction workers: 15 persons/unit. - Construction workers shall be trained on hygiene and disease prevention, supervised for their behaviors, annoyance and narcotics. - Contractors shall be supervised to follow the labour law on conducting health check-up and health check-up according to risk-factor related work. - The list of construction workers shall be created. The number of construction workers and the congenital disease of the construction workers shall be notified to the responsible public facilities before starting operations. - Before the commencement of construction, construction workers, project staff, etc. should be trained on health issues and how to cope with severe accidents or emergencies. - Environmental sanitation shall be provided at workers' camp and the construction site. - Adequate public utilities and facilities shall be provided for a temporary workers' camp. Apart from this, the related standards or laws shall be followed, i.e. the Notification of Ministry of Public Health No. 7/2538 on the number of workers per space of workers' camp, etc. - The accommodation of staff shall be provided according to the announcement of the Labour Welfare Committee on labour welfare measures for accommodation of workers for construction business. - Security and safety shall be provided at the workers' camp. - Construction workers' behavior shall be closely controlled to prevent nuisance and for the safety of nearby communities.	- Statistical record of accidents - Minute of meeting of Occupational Health, Safety and Environment Committee	Gulf PD Co., Ltd.	Included in total construction contract cost

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
10. Public Health / Occupational Health and Safety (Cont'd)		- Communicable disease surveillance shall be provided by local public health agencies and the project. - Contractors shall be supervised to strictly adhere to terms and conditions, such as monitoring a worker's camp, narcotics sampling, segregrating solid waste at the workers' camp based on the monitoring method of sub-contractor's waste management. - Contractors shall be supervised to coordinate with schools, especially a kindergarten to an elementary school, at least 6 months in advance in case construction workers want their children to attend schools in the project area.			
		Occupational Health, Safety and Environment **Measures on General Safety** - The agreement on occupational health and safety with the contractor shall be clearly identified. • The project determined that the contractor and team perform operation within the power plant in the contract. It is mandatory that the contractor adheres to the occupational health, safety and working environment measures in terms of design, construction and operation so as to comply with the standards and regulations of occupational health and safety. • Knowledgeable personnel shall be assigned to be responsible for occupational health, safety and working environment. • The project and the main contractor shall appoint the safety, occupational health and working environment committee. The committee shall cover the supervisors from sub-contractors of the project. The Environmental health, and safety manager shall directly report to the project manager. A meeting shall be organized at least once a month for evaluation and suggestions. • First aid, basic medical supplies and an ambulance shall be provided in case of emergency according to Ministry of Labour regulation on Labour Welfare at workplace, B.E.2548. • Personal Protective Equipment shall be regulary checked according to the manual for project safety procedures. **Risks Mitigation Measures** - A steel structure shall be installed for the Heat Recovery Steam Generator. Also, a walkway and a ladder shall be provided for stability and safety. - The insulation of the steam pipe system and hot water shall be installed for safety while operating. - Equipment installation and construction shall be performed by the reliable and experienced contractor. A safety officer shall supervise the operations for compliance with safe work practices. The installation shall be checked and tested whether it meets the standard by an engineer. - Before the commissioning is performed, the safety of the Heat Recovery Steam Generator shall be checked also, the operating conditions of a safety valve shall be tested and controlled by the authorized engineer for boiler testing according to the Engineering Act.	- Statistical record of accidents - Minute of meeting of Occupational Health, Safety and Environment Committee	Gulf PD Co., Ltd.	Included in total construction contract cost

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
10. Public Health / Occupational Health and Safety (Cont'd)		**Fire control and fire fighting systems** - The main contractor shall prepare adequate fire fighting equipment for operators working in the dangerous area or works related to heat with the risk of fire. For example, while welding, the welders shall always have chemical fire extinguisher at the work station. As for welding on a high place, an insulation shall be paved under the area of welding to prevent splash from falling beneath which is unsafe for those working beneath. - The main contractor shall prepare the cooperation plan with the local fire fighting agency for readiness in case of emergency. - The entrance-exit of dangerous area due to the construction work and traffic shall be controlled by a supervisor or a safety officer. - Working conditions and construction equipment shall be checked, especially in the area where danger or fire is likely to occur. - Fire fighting equipment shall be always checked according to the manual for project safety procedures.			
11. Major Hazard	Explosion/fire during construction	- Specify natural gas pipeline and diesel pipeline interconnecting area as restrictive areas. Hot work shall be prohibited in the area. A warning sign shall be installed in that restrictive area. In the event that it is necessary to enter into the area, permit work governance shall be required with strict inspection and control. - A barrier shall be provided for the welding area. Furthermore, a warning sign indicating restriced area shall be installed and a work permit system shall be adopted. - Before the construction begins, the contractors shall establish and send the operation plan of safety and occupational health to Gulf PD Co., Ltd. for approval. Controls shall be performed to be in line with the operation plan. - Adequate personal protective equipment shall be provided for all staff, and shall be suitable for working conditions. - A safety officer shall be provided to control and check operating conditions and ensure workers wear suitable personal protective equipment while working. - Adequate portable chemical fire extinguishers shall be provided in the areas where construction activities may cause fire. - First aid, basic medical supplies and an ambulance shall be provided in case of emergency according to Ministry of Labour regulation on Labour Welfare at workplace, B.E.2548. - A warning sign shall be installed in the hazardous area. Working in the area for a prolonged period of time without wearing personal protective equipment shall be prohibited. - Coordination with nearby hospitals shall be made to carry patients in emergency cases.	- No explosion/fire during construction		
12. Green area and aesthetics		-			
13. Heat Generated from power plant		-			

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
14. pH of Rainwater and Sulfate Radicals in soil		-			
Operation Period					
1. Air Quality	- Air emission impact from operation activities	- The Continuous Emission Monitoring System (CEMs) shall be installed at the stacks of the power plant for continuous emission monitoring. Measurement parameters include nitrogen oxides (NO_x), sulphur dioxide (SO_2), total suspended particulate (TSP), oxygen (O_2) and the flow rate. In addition, the display of air quality monitoring results (NO_X, SO2 and TSP) shall be installed in front of the project area. Monitoring results shall be reported to Pluak Daeng Industrial Park throughout the project life. - CEMs shall be audited once a year throughout the project life. - Air pollution emissions shall not exceed the values determined in the environmental impact assessment report. Details are provided below. - Natural gas as fuel scenario • Full load ⇨ SO_2 : concentration not to exceed 10 ppm at 7% O_2 and emission rate not to exceed 13.9 g/s/stack ⇨ NO_x : concentration not to exceed 59 ppm at 7% O_2 and emission rate not to exceed 58.6 g/s/stack ⇨ Particulate : concentration not to exceed 20 mg/m^3 at 7% O_2 and emission rate not to exceed 9.7 g/s/stack • Minimum load ⇨ SO_2 : concentration not to exceed 10 ppm at 7% O_2 and emission rate not to exceed 8.4 g/s/stack ⇨ NO_x : concentration not to exceed 59 ppm at 7% O_2 and emission rate not to exceed 35.4 g/s/stack ⇨ Particulate : concentration not to exceed 20 mg/m^3 at 7% O_2 and emission rate not to exceed 5.9 g/s/stack - Diesel oil as fuel scenario • Full load ⇨ SO_2 : concentration not to exceed 20 ppm at 7% O_2 and emission rate not to exceed 21.0 g/s/stack ⇨ NO_x : concentration not to exceed 99 ppm at 7% O_2 and emission rate not to exceed 74.0 g/s/stack ⇨ Particulate : concentration not to exceed 35 mg/m^3 at 7% O_2 and emission rate not to exceed 12.9 g/s/stack • Minimum load ⇨ SO_2 : concentration not to exceed 20 ppm at 7% O_2 and emission rate not to exceed 17.6 g/s/stack	- The result of air emission of stack within limit pre-set in the EIA report - The result of ambient air quality monitoring within National Ambient Air Quality Standard and WHO Ambient Air Quality Guidelines.	Gulf PD Co., Ltd.	Included in operation cost

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
1. Air Quality (Cont'd)		⇨ NO_x : concentration not to exceed 99 ppm at 7% O_2 and emission rate not to exceed 61.2 g/s/stack ⇨ Particulate : concentration not to exceed 35 mg/m^3 at 7% O_2 and emission rate not to exceed 10.6 g/s/stack - In case of using natural gas as fuel: Dry low NOx combustion shall be applied to control NOx during combustion. - In case of using diesel oil as fuel: Water injection system shall be applied to control NOx during combustion. - The concentration of the above pollutants is calculated in the normal temperature of 25 degree Celsius, one atmospheric pressure and 7% of excess oxygen during combustion. - In case of the air pollution control system failure and the emission rate exceeds the control value, the project will stop the gas turbine engine in order to check NOx control system immediately and fix the problem quickly. - Knowledgeable personnel shall be provided for regulating the air emission rates of the Project.			
2. Noise	- Noise impact from operation activities	- A warning sign shall be installed in the noisy area, such as a combustion chamber of a gas turbine, where noise level exceeds 85 decibels (A). The operator in the noisy area shall be worn or supervised to wear personal protective equipment, e.g. ear plugs or ear muffs. - The average sound level of noisy machinery and equipment, such as gas turbine, steam turbine and fuel gas compressor or sound absorption material shall not exceed 85 decibels (A) from the distance of 1 m. - Noisy machinery of Pluak Daeng Power Plant Project shall be installed with a silencer at the end of the pipe that may cause loud noise. Cover structure for machinery shall be built for a combustion chamber of a gas turbine, gas turbine generator, pump motor and the Heat Recovery Steam Generator (HRSG). A cooling unit fan shall cause low noise, etc. - Noise level at the fence of the project shall not exceed 70 decibels (A). - A silencer shall always be checked and inspected for its efficiency. - Noise mapping/noise contour shall be created to determine the noisy area of the project in the first year of service and every 3 years. - The staff of the power plant shall be trained at least once a year for the understanding and good attitude and the right behavior regarding occupational health and safety at work. - A Hearing Conservation Program shall be established to prevent staff from being exposed to loud noise for a prolonged period of time. For example, the duration of work shall be determined so that workers will be less exposed to loud noise. Also, alternation of shifts/alternation of working days in the noisy area shall be made. The information shall be updated at least once a year.	- The result of noise monitoring within National Noise Standard and WHO Community Noise Guidelines.	Gulf PD Co., Ltd.	Included in operation cost

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
3. Surface Water Quality and Groundwater Quality	Surface water and groundwater contamination	**Cooling water management measures** - Two cooling water holding ponds shall be provided with the holding capacity of 19,000 cu.m. each for at least one (1) day discharge volume. These two cooling water holding ponds will hold the blowdown from a cooling tower. The ponds shall be paved with high density polyethylene (HDPE) or concrete to prevent leakage. - The online monitoring system shall be installed at the water holding ponds to check the temperature, pH, conductivity and dissolved oxygen. The monitoring results shall be reported to the display in front of the project area and wastewater control center of Pluak Daeng Industrial Park. - The Project shall control the quality of effluent discharged from a cooling tower to be in compliance with the measures of Pluak Daeng Industrial Park. The Industrial Park requires that the quality of cooling water shall meet the Notification of Ministry of Industry, No.2 (B.E.2539) on determination quality of wastewater discharged from factories, except total dissolved solid shall be complied with RID's standard of effluent quality discharge into irrigation system (TDS shall not exceed 1,300 mg/l) and temperature shall not exceed 34 °C. - One emergency pond with the capacity of 19,000 cu.m. shall be provided with the holding capacity of at least one (1) day discharge volume. The emergency pond will hold the blowdown from a cooling tower. In case the monitoring results show that the quality of effluent from a cooling water does not comply with the measures of Pluak Daeng Industrial Park, which is based on the Notification of Ministry of Industry, No.2 (B.E.2539) on determination quality of wastewater discharged from factories. This is exceptional for total dissolved solids which shall comply with RID is standard of effluent quality discharge into irrigation system (TDS shall not exceed 1,300 mg/l) and temperature shall not exceed 34 °C (In normal working conditions, the emergency pond shall be dry.) - An aerator shall be installed in cooling water holding ponds to increase dissolved oxygen in the effluent. - The aerator shall be run when dissolved oxygen in the effluent is lower than 4 mg/l and shall be run until dissolved oxygen is higher than 4 mg/l. - Chlorite in blowdown from the cooling tower shall not exceed 1 mg/l. If chlorite exceeds the criteria, the effluent shall not be discharged from the project. - In the event that blowdown from the cooling tower will be used for watering plant within the project area, SAR shall be control in the range 0-10. Conductivity shall not exceed 2,000 micromho/cm. and TDS shall not exceed 1,300 mg/l. if these effluent parameters do not comply with the criteria, they shall be improved prior to watering plant within the project area. - Management of blowdown from the cooling tower (**Figure 9-2**) • **Cooling water holding pond and emergency pond:** Before being discharged from the power plant, cooling water will be held in the cooling water holding pond 1, which is capable of managing water at least for 1 day. The cooling water holding ponds 2 and 3 are capable of holding the effluent for 1 day each. The cooling water holding ponds will be paved with HDPE or of concrete type to prevent leakage. Typically, either the cooling water holding pond 2 or 3 will be used. The one that is not in use will be kept dry as an emergency pond.	- The result of wastewater sampling within limit pre-set in the EIA report	Gulf PD Co., Ltd.	Included in operation cost

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
3. Surface Water Quality and Groundwater Quality (Cont'd)		• **Control valve**: The system consists of the 1st valve which will be closed when the quality of water at the cooling tower exceeds the standards. The 2nd valve and the 3rd valve manage to convey blowdown water to the cooling water holding ponds 2 and 3, respectively. The 6th valve and the 7th valve manage blowdown from the cooling tower before it is drained into the cooling tower holding pond of Pluak Daeng Industrial Park for the increase in effluent management. • **Water pump**: The effluent from the cooling water holding pond 2 or 3 will be pumped by the water pump and conveyed outside the power plant. The size of water pump will be designed for pumping capacity that makes the basin dry within a short period of time and ready to used as an emergency pond • **Water quality and control at cooling tower, blowdown and blowdown management:** Water in the cooling system will be checked and improved all the time to control the quality of recirculated water and the water released from the cooling system, such as control of pH, concentration, water filling and partial drainage of water, etc. Measurements will be made for the temperature, pH, dissolved oxygen and conductivity. This is a continuous monitoring. The control signal will be sent to a valve/water pump. Furthermore, the values of continuous monitoring will be displayed at a control room. The characteristics of blowdown from the cooling tower shall comply with the requirements of Pluak Daeng Industrial Park. Blowdown management can be performed in various ways, depending on causes of problems. For example, the blowdown may be sent to the pH neutralization system within the power plant, or it may be sent for disposal by the authorized agency. - Regular check and maintenance shall be performed for condenser and cooling towers so as to control the quality of effluent from the cooling tower prior to discharging out of the project. Management measures for effluent from the process - The quality of effluent to be carried to the central wastewater treatment system of Pluak Daeng Industrial Park shall comply with the requirements of Pluak Daeng Industrial Park. - An oil separator shall be provided to separate oil from oil contaminated effluent. Then the contaminated effluent shall be carried to a wastewater holding pond for quality check prior to being discharged to the central wastewater treatment system of Pluak Daeng Industrial Park. - Adequate sanitary toilets shall be prepared for staff as required by law. In addition, a septic tank or prefabricated wastewater treatment tank shall be constructed to treat wastewater generated by utilization and consumption of staff before being discharged to the wastewater holding pond of the project and carried to the central wastewater treatment system of Pluak Daeng Industrial Park. - A neutralization pit shall be provided for pH neutralization before draining the effluent into the wastewater holding pond of the project and the central wastewater treatment system of Pluak Daeng Industrial Park. - The wastewater holding pond of the project, which can hold the effluent for 24 hours at minimum, shall be provided so that the quality of effluent is checked before being discharged to the central wastewater treatment system of Pluak Daeng Industrial Park.			

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
3. Surface Water Quality and Groundwater Quality (Cont'd)		- The online monitoring system shall be installed at the wastewater holding pond to check the temperature, pH and conductivity. The monitoring results shall be reported to the wastewater control center of Pluak Daeng Industrial Park. - The effluent that passes quality check from the wastewater holding pond shall be carried through the drain pipe for treatment at the central wastewater treatment system of Pluak Daeng Industrial Park.			
4. Transport	Traffic congestion and accidents from the project transportation.	- Drivers shall strictly follow traffic rules. - Transport and safety regulations shall be established for vehicles coming in and out of the Project so as to prevent accidents. - Sufficient parking space shall be provided in a suitable area. Also, traffic signs shall be installed within the project area and the access road. - A warning sign shall be installed and speed shall not exceed 20 kilometers per hour in the project area. - The number of vehicles coming in the generation unit shall be limited to reduce accidents in that area. - Types and volume of vehicles coming in the project area shall be recorded. The obtained information shall be used for traffic management in the project area, especially in the parking space, where parking outside the designated area within the Project area shall be prohibited. - The condition of transportation vehicles shall be checked regularly. - A telephone number of the responsible person shall be posted on transportation trucks as a channel for complaints to the project. - Hazardous chemicals or waste transporter companies shall be supervised to strictly adhere to relevant laws. (such as the manual for transport of hazardous objects of Pollution Control Department, September 2011, the manual for hazardous chemical management and handling in the place of business, July 2013, and the Notification of Department of Industrial Works on manual for storage of hazardous chemicals and objects, B.E.2550 and the Notification of Ministry of Industry on transportation of hazardous substances responsible by Department of Industrial Works, B.E.2558, etc.) - Chemical substance and waste transporting vehicles shall have the clear and easy to understand warning sign. The warning sign shall contain name of chemical substance and details according to international standards, such as UN Recommendations and HAZCHEM code, etc.	- Record of daily traffic accident occurred during the project construction phase and produce a monthly report.	Gulf PD Co., Ltd.	Included in operation cost
5. Water Use	Water shortage	- Efficient water use shall be considered, such as reduction in water drainage from the cooling system or recirculation of water within the project, etc. - Water pipes shall be checked. Leaking pipes shall be fixed immediately to prevent water loss. - In the event of water shortage and Eastern Water Resources Development and Management PLC. is unable to convey water to the project, the project shall reduce power generation capacity or stop the operation.	- Water is sufficient for use during operation period.	Gulf PD Co., Ltd.	Included in operation cost
6. Solid Waste Management	Hygiene problem	- Adequate covered waste bins shall be provided for solid waste collection. Collected waste shall be carried for disposal by the agency authorized by government agencies. Waste disposal shall be made by means required by law. - A storage place for solid waste shall be provided. The storage place shall be roofted and floored with concrete. Waste shall be sorted and labelled.	- Record of type and volume of general garbage and waste from construction activities.	Gulf PD Co., Ltd.	Included in operation cost

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
6. Solid Waste Management (Cont'd)		- The collected recyclable solid waste should be sorted and utilized as much as possible or sold to waste purchasing companies. The remaining waste shall be collected for disposal by the agency authorized by government agencies. Appropriate disposal shall be made according to the Notification of Ministry of Industry on disposal of waste or unusable materials, B.E.2548. - Solid waste that have characteristics and properties defined in the Notification of Ministry of Industry on disposal of waste or unusable materials, B.E.2548, such as lubricant oil and cleaning solutions for devices, etc. shall be separated from general waste and collected for disposal by the agency authorized by government agencies. - Drums/tanks shall be provided to collect solid waste, such as resin, oil, etc. from power generation process before sending for disposal by the the agency authorized by government agencies. Alternatively, the collected solid waste may be sold to solid waste disposal companies authorized by government agencies. - Types and volume of solid waste and transportation out of the project area shall be recorded. Purchasing companies or disposal sites shall be identified.			
7. Drainage and Flood Control	- Flooding in the project area	- Storm drains shall be provided in the project area and connected with the stormwater drainage system of Pluak Daeng Industrial Park. - The storm water ponds of at least 99,797 cu.m. shall be provided. The storm water ponds shall hold stormwater for 3 hours for appropriate drainage rates and flood prevention in the project area. - Contaminated stormwater shall be discharged to the oil separator to separate oil before releasing to the wastewater holding pond for quality check based on effluent standards established by Pluak Daeng Industrial Park. The effluent will then be drained into the central wastewater treatment system of Pluak Daeng Industrial Park. - The storm drains shall be checked continuously and regularly to prevent clog. - Drainage ditches shall be cleaned in the dry season each year to increase the efficiency of drainage in the project area. - The responsible agencies for Huai Phu Sai shall be supported for dredging activity.	- No flood in the project area.	Gulf PD Co., Ltd.	Included in operation cost
8. Socio-economic	- During the operation period, people in the communities might still have some opinion conflicts regarding concerns about the project.	General Measures - Qualified local people shall have the priority to be hired for any vacancy in order to mitigate the impact of relationship between the Project and people and communities. Local people should be always notified for any vacancy every time. - Measures for benefit return for communities shall be established, such as maintenance of Huai Phu Sai with Pluak Daeng Industrial Park, other factories or involved agencies, support for local educational institutes or public health facilities, promotion of religious maintenance, contribution to public health benefit, etc. - Responsible persons shall be assigned for receiving complaints, hearing comments and suggestions. Affected persons can complain via channels like verbal communication, telephone, memo, letter, electronic mail, fax, etc. to the power plant as shown in **Figure 9.1**. - People in nearby communities shall have an opportunity to visit the power plant to ease their concern. - The quality of life improvement policy shall be set up. Community businesses shall be supported and promoted for sustainable economic and social development. - Project's action plan shall be implemented and strictly adhered to so as to reduce accidents and impacts on the Project and communities.	- Results from socio-economic survey and opinion interview with households, people, community leader/local leader, representatives of relevant agencies, local organization and sensitive receptors around the project site i.e. hospital, temple, school and measurement stations of environmental quality.	Gulf PD Co., Ltd.	Included in operation cost

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
8. Socio-economic (Cont'd)		- If it is proven that the power plant is the cause of any impact, the problem shall be solved urgently. The database of an affected person or affected group shall be created. The impact prevention measures shall be established. - A register of affected persons shall be established. Complaints or incidence shall be registered. Facts, remedial action and negitiations shall be compliled and registered to be used as evidence of the power plant operation. - In case of conflicts between the power plant and communities, the project information shall be urgently disseminated to people through channels or media so that people acknowledge facts. This means the project is responsible for communities and aware of people's concerns. Public relations campaign measures 1) Objectives of Public relations campaign - To continuously provide the project information during the pre- construction, construction and operation phases for people living in the project vicinities. - To serve as a communication channel between communities nearby and the project, listen to the comments of affected persons and receive recommendations from people. **2) At least one of the following channels for public relations campaign/dissemination of project information or other activities which are consistent with the objectives, i.e.** - **Through local media:** such as wire broadcasting from local government agency and community or local cable media, as appropriate. - **Through notice board/signboard of local government agency, community or in public place that is visible**: such as signboard of the district involved with the project, signboard of municipality/sub-district administrative organization involved with the project, signboard of public health facility in the study area and the project location. - **Through public relations material/leaflet:** to disseminate the project details, progression (during the operation phase), safety data and emergency prevention, communication channel in case of emergency, complaint receiving channel and communication channel of the project, etc. The public relations material/leaflet should be placed at the public relations unit of the government agency, community or the place where people can access. - **Through other methods of public relations, as appropriate**: such as personal visit, public address, etc. Public relations campaign shall include the project details and progress during the construction phase, advantages and disadvantages, communication channel and complaint receiving channel as well as contact in case of emergency.			

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
9. Public Participation and Relation	- During the operation period, people in the communities might still have some opinion conflicts regarding concerns about the project.	- Public relations campaign about the project information shall be made for communities through leaflet, media or other activities, which are in line with the objectives of established measures. Moreover, local people shall have an opportunity to monitor the project throughout the project life. - Comments and suggestions • The focus group meeting/discussion shall be organized once in the first five years of the project operation. The focus group meeting/discussion then shall be organized once per three years throughout the project life of Pluak Daeng Power Plant. ⇨ Contacting and coordinating with government agencies and the Local Administration Organization ⇨ Making discussion in the sub-district/district level, focusing on the groups that data and information were collected in the study stage pre-construction phase and construction phase of Pluak Daeng Power Plant ⇨ Comparing socio-economics, the way of life of people and and the environmental aspect before and after the project development ⇨ Developing a questionnaire after the focus group meeting focusing on monitoring community people's opinions on the project ⇨ Drawing a conclusion from a focus group meeting - Measures for benefit return for communities shall be established, such as participation in Huai Phu Sai maintenance with the Pluak Daeng Industrial Park, other factories or involved agencies, support for local educational institutes or public health facilities, promotion of religious maintenance, contribution to public benefit, etc. - A good relationship with local government officers and local people shall be made through regular visit and prompt solutions to problems that may arise due to the project development - Receive information from communities regularly and continuously - Responsible persons shall be assigned for receiving complaints, hearing comments and suggestions. Affected persons can complain via channels like verbal communication, telephone, memo, letter, electronic mail, fax, etc. to the power plant. The flowchart/procedures of complaint receiving are shown in **Figure 9-1.** - Support for aquatic animals or environmental preservation, such as fish breeding by the involved agency at Dok Krai Reservoir, canal, other local water bodies.	- Record of activities that the project arranges for local communities. - Record of activities of the Environmental Impacts Monitoring Committee are occurred every 6 months	Gulf PD Co., Ltd.	Included in operation cost
10. Public Health / Occupational Health and Safety	Health/ Occupational Health and Safety impact on project staffs	Public Health - First aid, basic medical supplies and an ambulance shall be provided in case of emergency according to Ministry of Labour regulation on Labour Welfare at Workplace, B.E.2548. - Pre-placement examination and the annual health check-up shall be provided for staff at lease once a year. - Health promotion activities shall be organized. Public relations campaign about environmental aspect and health issues for communities shall be done. - Local public health facilities shall be supported in terms of health promotion, rehabilitation, disease prevention and healthcare for communities. - Morbidity survey on people living within 5 km. radius of the project location shall be conducted.	- Statistical record of accidents - Minute of meeting of Occupational Health, Safety and Environment Committee	Gulf PD Co., Ltd.	Included in operation cost

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
10. Public Health / Occupational Health and Safety (Cont'd)		**Occupational Health, Safety and Environment** - The occupational health, safety and working environment committee shall be appointed to oversight operations. The occupational health, safety and working environment committee meeting shall be held at least once a month to evaluate, suggest solutions for problems, make improvements and promote occupational health, safety and working environment activities. - Manual for project safety procedures shall be established for reference while working and providing training for the power plant staff. This manual is consistent with the details of machinery and equipment installed in the power plant. The manual also complies with the Occupational Safety, Health and Environment Act. For example, the training course on safety at work will be provided for all new staff. - Adequate personal protective equipment, which is suitable for working conditions shall be provided for all staff. - First aid, basic medical supplies and an ambulance shall be provided in the power plant in case of emergency according to Ministry of Labour regulation on Labour Welfare at Workplace, B.E.2548. - Types and number of safety equipment shall be identified. The equipment shall meet the standards. The equipment shall be checked regularly for readiness. - Lighting systems: The Project shall provide a backup electrical system in case of emergency. Lighting systems shall be designed for safety purpose and adequate light while working. - Pre-placement examination and the annual health check-up shall be provided for staff. - A safety week activity shall be organized to urge and perform safety drills. - A fire protection system and fire fighting system shall be provided by the power plant according to National Fire Protection Association (NFPA) and related requirements and standards. - The fire fighting system shall be always checked according to the manual for project safety procedures. - An emergency shall be established for operations in emergency cases. Emergencies can be divided into 2 levels (as illustrated in **Figure 9-3**). • <u>Emergency Level One</u>: It means the emergency that occurs in the power plant area. The emergency coordinator can control the situation. Damage can be limited by staff, workers and equipment available in the power plant until the situation returns to normal conditions. • <u>Emergency Level Two</u>: It means the emergency that occurs inside and outside the power plant. When the emergency coordinator evaluates that the emergency plan for the emergency level one is incapable, request for assistance shall be made in terms of manpower and equipment from Pluak Daeng Industrial Park to control the situation. • The annual emergency drill shall be performed for the power plant itself and together with Pluak Daeng Industrial Park. Moreover, training on emergency preparedness and response shall be provided for personnel at least once a year. **Diesel fuel transfer measures** - Training on emergency response plan • Environmental Health & Safety (EH&S) Committee shall provide the staff the training on working regulations, work instructions and related documents. In case of changes in the details of working regulations / support documents in relation to emergency preparedness, and emergency prevention and suppression, EH&S Committee shall notify all staff.			

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
10. Public Health / Occupational Health and Safety (Cont'd)		- Oil leakage prevention • The division/department that has to deal with oil shall follow the fuel oil unloading procedure. • The operator who handle oil shall work carefully to prevent oil spill to the outside environment. The operator shall follow the fuel oil unloading procedure and MSDS. - Preparation/inspection of equipment in case of emergency: The following equipment shall be prepare for emergency. • Personal protective equipment, such as rubber gloves, mask, air filter mask or other absorbing materials, as appropriate, such as sand, sawdust, cloth, or other materials having absorbing property or preventing oil diffusion. The operator who deals with oil shall operate carefully to prevent oilspill to the outside environment. The fuel oil unloading procedure and MSDS shall be follow. • Suitable personal protective equipment, such as rubber gloves, mask, air filter mask or other absorbing materials • The container of contaminated oil, drums, valves, and safety valves shall be checked on a monthly basis by the qualified person required by law. - The following materials shall be prepared all the time in response to emergency. • In case of small oil leak ⇨ The person who notice an abnormal situation shall solve the problem shortly. ⇨ Scatter sand, sawdust, or other materials prepared by the division/department around the area of oil leak to limit the boundary of oilspill. ⇨ Shortly notify the supervisor and the responsible staff to suppress the event. ⇨ Use remnant of cloth or oil absorbing material to clean the area of oil leak. ⇨ Compile all materials used for oil leak control and dump them into a hazardous waste container (according to solid waste management procedure). ⇨ Clean the area of oil leak to prevent environmental impacts. ⇨ The supervisor and the responsible person of the area where oil leaks organize the meeting to prevent the recurrence. • In case of large oil leak ⇨ The person who notice an abnormal situation shall immediately notify the supervisor or the responsible person of the area and involved persons to fix the problem. ⇨ The area of large oil leak shall be enclosed to prevent diffusion to a broader area and to make it convenient for control. ⇨ The operator who controls oil leak shall be in the windward side to avoid air vapour. The operator shall wear safety equipment, such as a vapor prevention mask. ⇨ Oil leak suppression shall be in accordance with the oil leak prevention and response plan.			

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
10. Public Health / Occupational Health and Safety (Cont'd)		**Safety measures for transport of chemicals** The operators of hazardous chemicals or objects shall adhere to the manual for project safety procedures for safe transport and the safety of communities, assets and the environment. Related laws and standards shall be followed. These include manual for transport of hazardous objects of Pollution Control Department, September 2011, manual for hazardous chemical management and handling in the place of business, July 2013 and the Notification of Department of Industrial Works on manual for storage of hazardous chemicals and objects, B.E.2550 and notification of Ministry of Industry on transport of hazardous objects under Department of Industrial Works, B.E.2558, such as - Applying for transportation permit - Affixing a label and tag on a chemical transport truck that meets the requirements of Department of Land Transport - Separating and transporting chemicals in an appropriate and safe manner - Preparing shipping paper - Preparing Material Safety Data Sheet (MSDS) based on the properties of specific material both in Thai and English - Providing personal protective equipment on a chemical transport truck - Providing training on the hazard of transported chemicals and skills for safe driving while transporting chemicals for drivers. Also, drivers shall be trained on a preliminary solution in case of emergency **Safety measures for chemical storage** Regarding safety measures for chemical storage, Pluak Daeng Power Plant shall follow the Notification of Department of Industrial Works on manual for storage of hazardous chemicals and objects, B.E.2550 and manual for hazardous chemical management and handling, July 2013, such as - Preparing Material Safety Data Sheet (MSDS) about the characteristics of hazardous objects both in Thai and English - Categories of hazardous object: Category 1 (The criteria and established method shall be followed.), Category 2 (The competent authority shall be notified before following the criteria and established method.) Category 3 (A license shall be obtained.) and Category 4 (Manufacturing, sale or possession shall be prohibited.) - The storage place and storage method of hazardous chemicals shall be safe based on the nature or properties of hazardous chemicals. **Measures for safe use of chemical substances** With regards to measures for safe use of chemical substances, Pluak Daeng Power Plant Project shall adhere to OSHA standard and the ministerial regulations on the management, handling, and operation of safety, occupational health and working environment on hazardous chemicals, B.E.2556. Details of such measures are provided in manual for project safety procedures. Details consist of - Preparing Material Safety Data Sheet (MSDS) about the characteristics of hazardous objects both in Thai and English. MSDS shall be available in working area - Installing the prohibition sign, instruction sign or warning sign for working with hazardous chemicals in a public place - Providing places and equipment for safety in working area for hazardous chemicals such as emergency eye wash, face and hand wash basin, and emergency showers			

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
10. Public Health / Occupational Health and Safety (Cont'd)		- Providing personal protective equipment for staff according to the hazards and severity of chemicals or the nature of work to prevent hazards that are likely to occur - Establishing preventive measures for chemicals in the storage place of hazardous chemicals; establishing preliminary measures for remedy of hazards, such as an appropriate ventilation system; preventing the potential cause of fire; constructing a dike to prevent the leak of hazardous chemicals from the storage place and providing drains for spills for safe disposal. Drains for spills shall be separated from the drainage system - Establishing preventive and control systems so that the atmospheric concentrations of hazardous chemicals in the workplace or the storage place shall not exceed the limits - Measuring and analyzing the atmospheric concentrations of hazardous chemicals of the workplace and storage place - Preparing fire fighting equipment and appropriate medical supplies for first aid - Assigning the responsible person (chemist) for improvement of chemical safety plan - The chemist and Environmental health and safety manager shall check and create a hazardous chemical checking plan for each working area. The hazardous chemical checking plan shall be reviewed and updated at least once a year - Providing training for staff working with chemicals on how to use chemicals safely and guidelines for prevention and check of chemical leak			
11. Major Hazard	Explosion/fire during operation period	**Preventive measures for natural gas and diesel fuel transmission pipeline system in the project area** - The Metering and Regulation Station (MRS) is a restrictive area. Hot work shall be prohibited in the area. A warning sign shall be installed in the Metering and Regulation Station (MRS) area. In the event that it is necessary to enter into the area, permit work governance shall be required with strict inspection and control. - Maintenance of natural gas and diesel fuel transmission pipeline system and equipment shall be performed for readiness to use. Regular monitoring shall be done for safety. - The thickness and level of wear of the natural gas pipeline shall always be checked. - Leakage survey on natural gas and diesel fuel transmission pipeline system shall be performed according to involved standards. - Hazardous zones shall be defined. Furthermore, control and preventive measures shall be established and strictly followed for safety purpose. For example, smoking prohibition zone or hot work area shall be permitted, etc. - The natural gas leak detection system shall be provided using a gas meter to detect gas leak at the joint above the ground level at the Metering and Regulation Station (MRS) and gas compressor manual for project safety procedures. - The sign indicating pipeline alignment and warning shall be provided to prevent any action in the area above the pipeline, which may affect the pipeline. The person who notice an abnormal situation shall keep the responsible person informed. - Working regulations shall be established and applicable for safety while performing natural gas pipeline work. - The shutdown control system and relief valve shall be provided to correctly and rapidly check abnormal pressure in the pipe.	- No explosion/fire during operation period	Gulf PD Co., Ltd.	Included in operation cost

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
11. Major Hazard (Cont'd)		- A diesel oil drum/tank shall be placed in a concrete dike, which can accommodate 100% of the fuel oil from the largest drum/tank in case the drum/tank is broken according to the ministerial regulation of Ministry of Industry, B.E.2556 on oil depot. - The oil pumping station for truck shall be surrounded by a concrete dike so that the leached oil stains will be conveyed to the wastewater collection pipe and the oil separator, respectively. **Monitoring measures** Hazardous areas shall be defined. The persons who enter into hazardous areas shall strictly follow the control and preventive measures for safety, such as - No smoking - A lighter, match or object that sparks a fire shall not be allowed in the designated hazardous areas. - Materials that stimulate combustion shall not be brought into or stored in hazardous areas. - Combustible materials shall not be brought into or stored in hazardous areas, such as yellow phosphorus or white phosphorus and magnesium alloys, etc. - Hot work like welding, metal cutting, etc. shall be permitted from the authorized person first. - Safety measures shall be planned before starting operations. - Uninvolved persons shall not be allowed to enter into hazardous areas. **Prevention and suppression plan for emergency and fire that causes by natural gas** 1) Objectives - To prevent fire due to natural gas - To prepare and take appropriate action when a fire breaks out 2) Basic information that should be known To be safe while operating on natural gas, it is necessary to realize properties of natural gas that cause hazard and general instructions. - Natural gas properties and the properties that cause hazard • Natural gas used for power generation units is mainly methane, that is called dry gas. • Vapor density of natural gas equals to 0.6 compared with the air weight (Air =1). • Methane is in the form of vapor in normal temperature and atmospheric pressure. • Compared with other gases, liquid methane expands many times if vaporized. • A mixture of methane and air which is flammable is called "Flammable and Explosive Limit", ranging from 5.0-14.0% (Low to High Limit). - Hazard from use of natural gas • Flow and emission to the atmosphere is harmful. (Methane is dangerous when it mixes with the air in appropriate amount.) • Natural gas is colorless and not harmful to humans. However, exposure to a mass of gas may cause loss of consciousness as result of suffocation - Instructions in case of gas leak • Approach to a fire or the position of gas leak shall be in the windward side • All persons shall leave the areas where a mass of gas and gas move. In addition, flammable objects shall be eliminated immediately • Staff who are required to work in the gas leak area shall be provided. Other people shall be at least 200 feet away from the gas leak area. • In case of gas leak but incombustible.			

TABLE 9-1 (CONT'D)

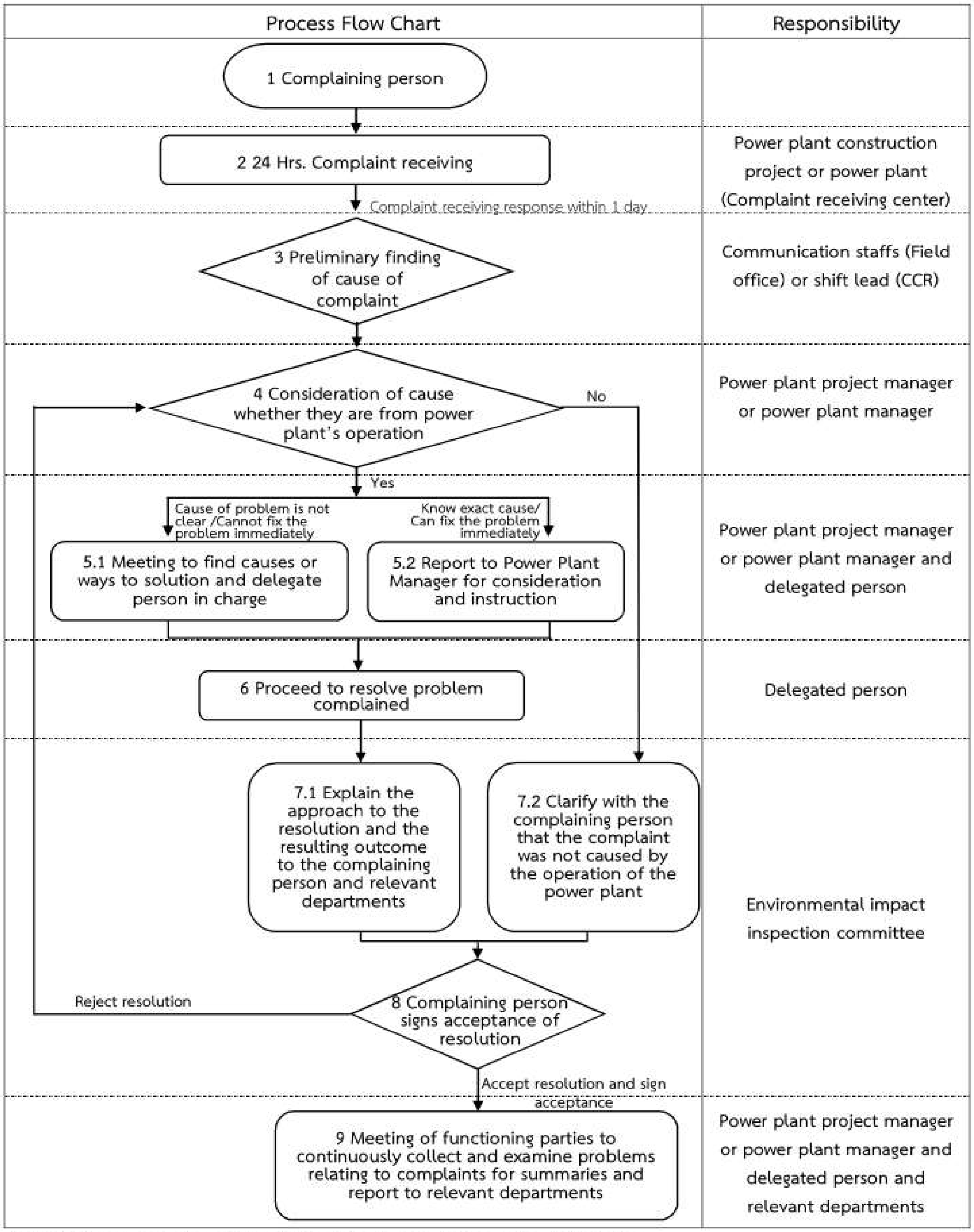
PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
11. Major Hazard (Cont'd)		: A valve shall be turned off to stop gas leak. : Water spraying shall be done in the reverse direction of the gas to reduce vapor. Spraying may be done to change into the safe direction. : In the event that gas leakage or a mass of gas cannot be stopped, flames shall be controlled through injecting considerable volume of water into hot metal, such as pipe, or hot surface of metal, etc. : Ignition sources shall be avoided. • In case of gas leak and combustible : A valve shall be turned off to stop gas leak. : A fire extinguisher shall not be used until the gas leak is completely stopped. : Water shall be injected into a very hot area, such as concrete, metal surface. Combustion shall be allowed at drains. : If the combustion takes place at the valve which is the equipment that stops gas leak, water spraying at the valve shall be done. The person who will turn off the valve shall wear fire fighter suits. : Dry chemical fire extinguisher is workable for small volume of gas. The dry chemicals shall be injected into gas leakage position. Additionally, CO_2 shall be used for fire extinguishment of gas in a very low pressure. : In case of an uncontrollable leak, vapor shall be controlled through injecting water to protect the equipment around the area where gas leak takes place. • Prevention of hazard in case of gas leak : When gas leak is recognized, all electrical equipment of non-explosion proof type in the leak area shall be stopped. : The valve shall be turned off to stop gas leak. : Sources of ignition, such as flame, heat, spark, etc. shall be controlled. : Air-Fuel Ratio at the leak position shall be measured in order to know hazardous level. Ventilation shall be performed to let gas dispersed outside. : Operators who do not wear protective outfit while working should check the clothing by themselves. This is because their clothing may be stained with gas, which may be dispersed and harmful after the operation is complete. - Detection for the position where gas may leak • The position where gas leak will be measured shall be determined. • The serial number of all valves and flanges to be checked shall be determined in order to create the check table. • The check table including check duration shall be created. • Gas leak shall be checked by a gas leak detector. • Maintenance or repairing of equipment or pipe that gas flows shall be performed. : The area shall be enclosed before repairing the equipment or pipe that the gas flows. : Ventilation shall be sufficient in the area of repair work. : Fuel-Air Ratio shall be intermittently measured before starting the repair work and while performing the repair work. : Repair tool or equipment shall be non-sparking type.			

TABLE 9-1 (CONT'D)

PREVENTION AND MITIGATION MEASURES FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DAENG DISTRICT, RAYONG PROVINCE

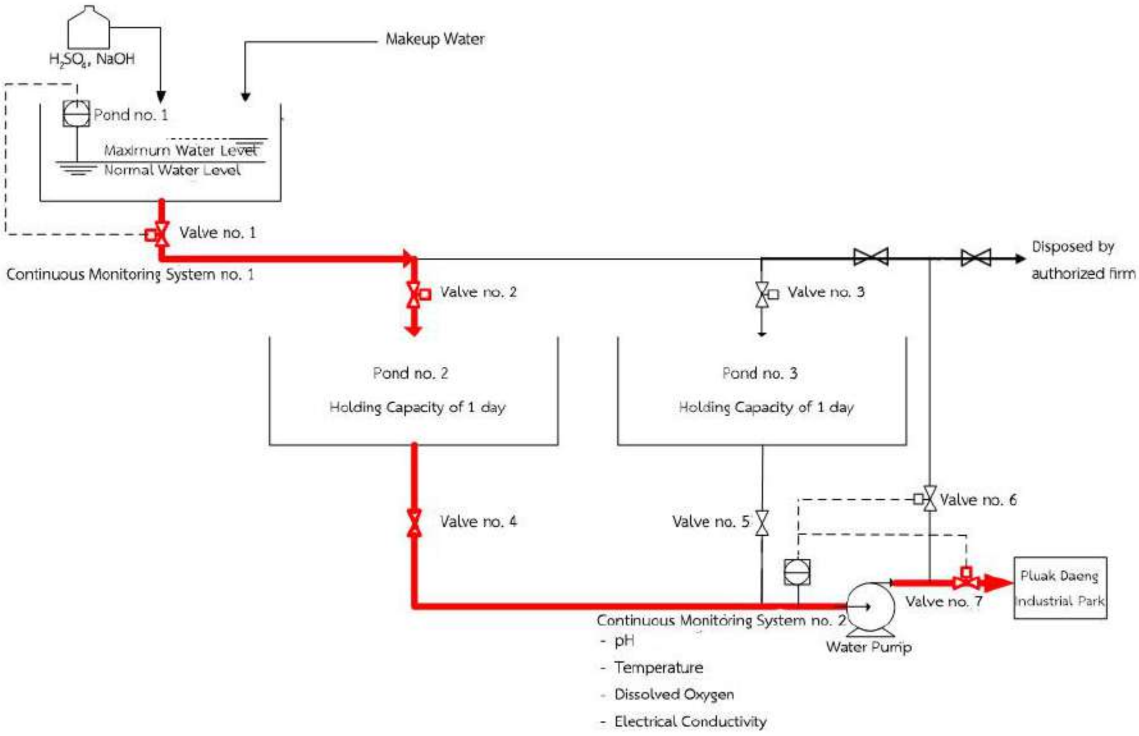
Project Component or Activity	Impact or Risk to be Mitigated	Mitigation Measures(s) including legislation/IFC EHS Guidelines	Performance Indicator(s)	Institutional Responsibilities	Cost Estimates
11. Major Hazard (Cont'd)		: Good maintenance shall be performed, such as regular check of facilities, check and measurement of the thickness of pipe, which may cause leakage, etc. • The annual emergency drills shall be performed at the power plant and with Pluak Daeng Industrial Park. Besides, training on emergency preparedness and response shall be provided for personnel at least once a year. **Emergency preparation plan for oil spill** - Diesel oil transfer measures in the public health/occupational health and safety action plan during the operation phase shall be followed.			
12. Green Area	Aesthetic impact	- At least 5.7% of the project area shall be provided as the green area. Perennial plants, shrubberies and grass shall be planted in the green area. Perennial plants and high-shaped shrubberies shall be grown in 3 rows in a twisting form. The selected trees shall be suitable for the project area conditions. The narrow shape trees with slightly fallen leaves with the diameter of not less than 5 inches such as Mast Tree (*Polylthia longifolia* (Benth) Hook. F. var.), Copper Pod (*Peltophorum pterocarpum* (DC.) K.Heyne), Khae Na (*Dolichandrone serrulata* (Wall. ex DC.) Seem.), and Yellow Silk Cotton (*Cochlospermum religiosum* (L.) Alston.), etc. will be selected. The spacing of trees is suitable for the fully grown shape of the species, as shown in **Figure 9-4.** - Soil improvement in the green area shall be made for plant growing suitability. - The dying or damaged trees shall be replaced within 1 month for maintaining the proportion of green area as designated - Maintenance for the green area shall be performed for aesthetics and orderliness. Automatic sprinklers shall be installed throughout the green area. In addition, sufficient budget for the green area shall be allocated on an annual basis.	-	Gulf PD Co., Ltd.	Included in operation cost
13. Heat Generated from power plant		-			
14. pH of Rainwater and Sulfate Radicals in soil		-			



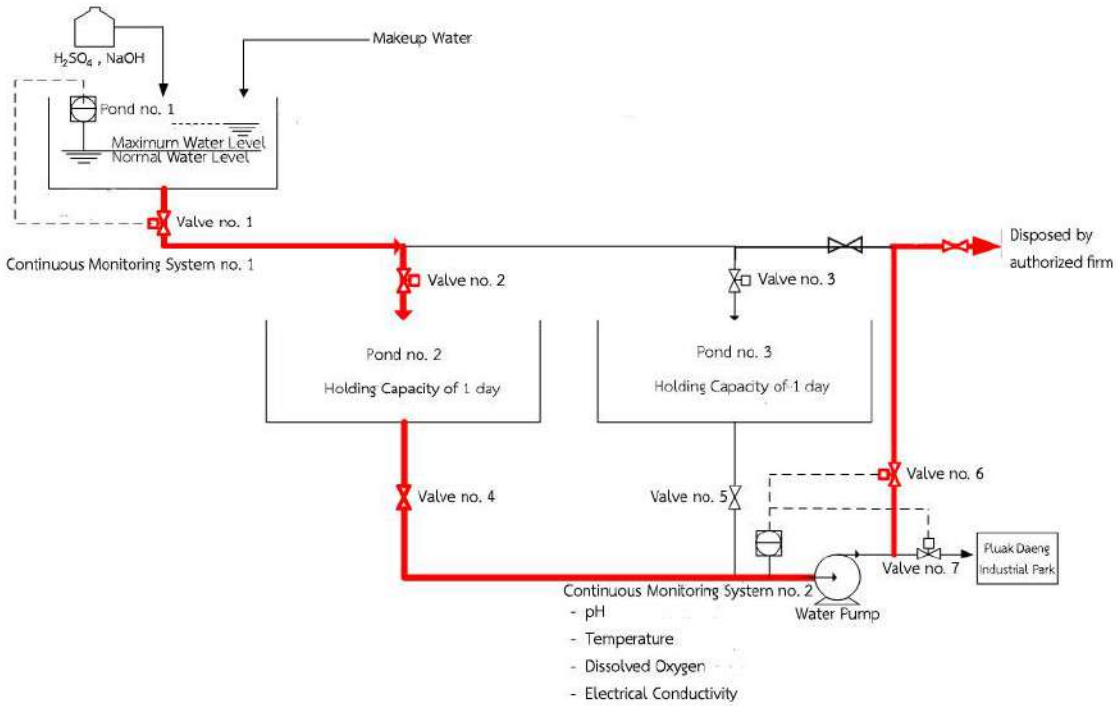
Note: 1. Report causes/resolutions/solving time to complaining party within 5 days.

2. Report progress in resolving problems to the complaining party every 7 days or as agreed.

FIGURE 9-1 : SCHEME OF OPERATION ON GSRC POWER PLANT PROJECT'S COMPLAINT RECEIVING



System diagram in case of blowdown water quality from cooling tower meets the standard.



System diagram in case of blowdown water quality from cooling tower does not meet the standard.

Source: Gulf PD Co.,Ltd., 2016

FIGURE 9-2 : MANAGEMENT OF BLOWDOWN FROM COOLING TOWER OF PLUAK DAENG POWER PLANT PROJECT

TEAM

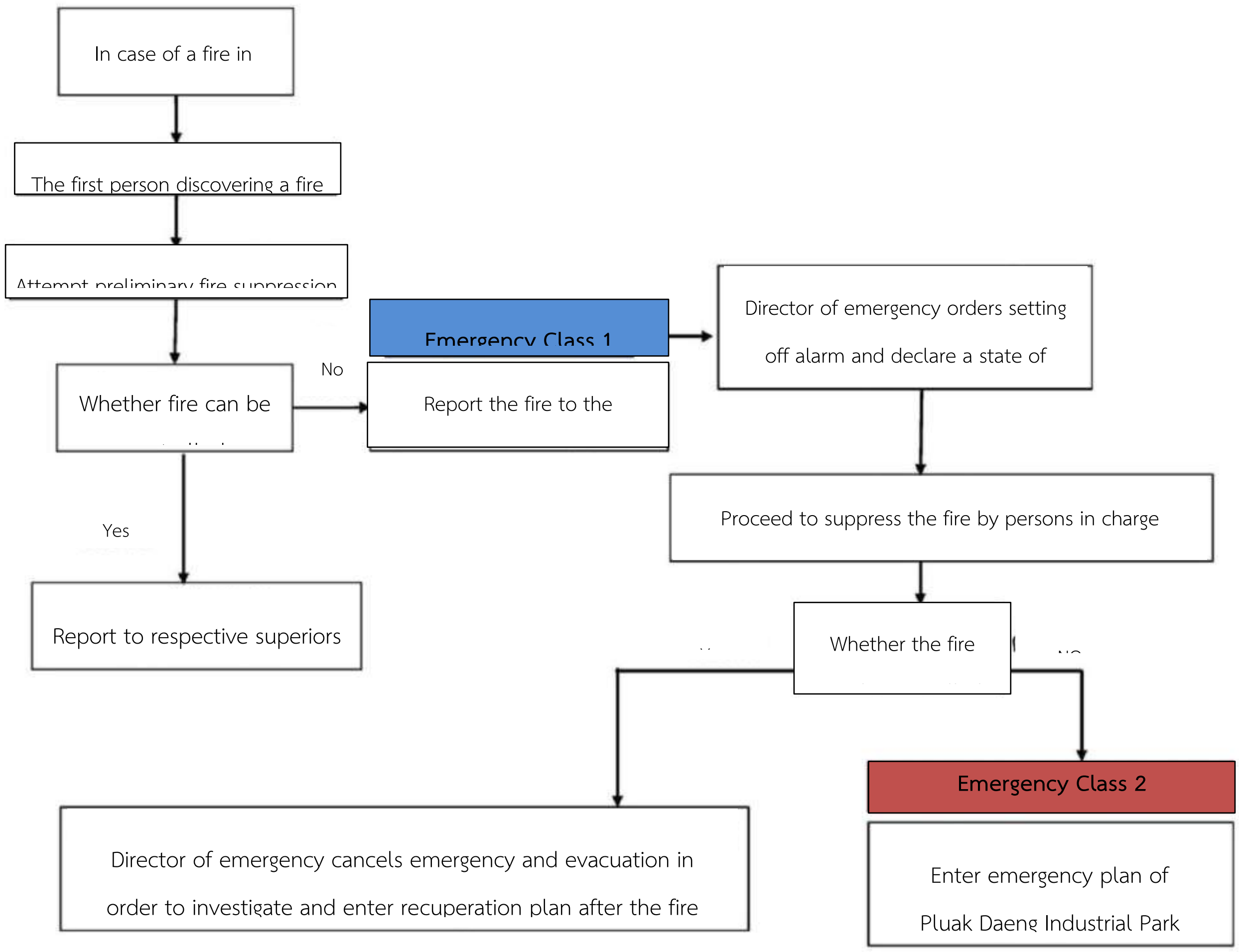
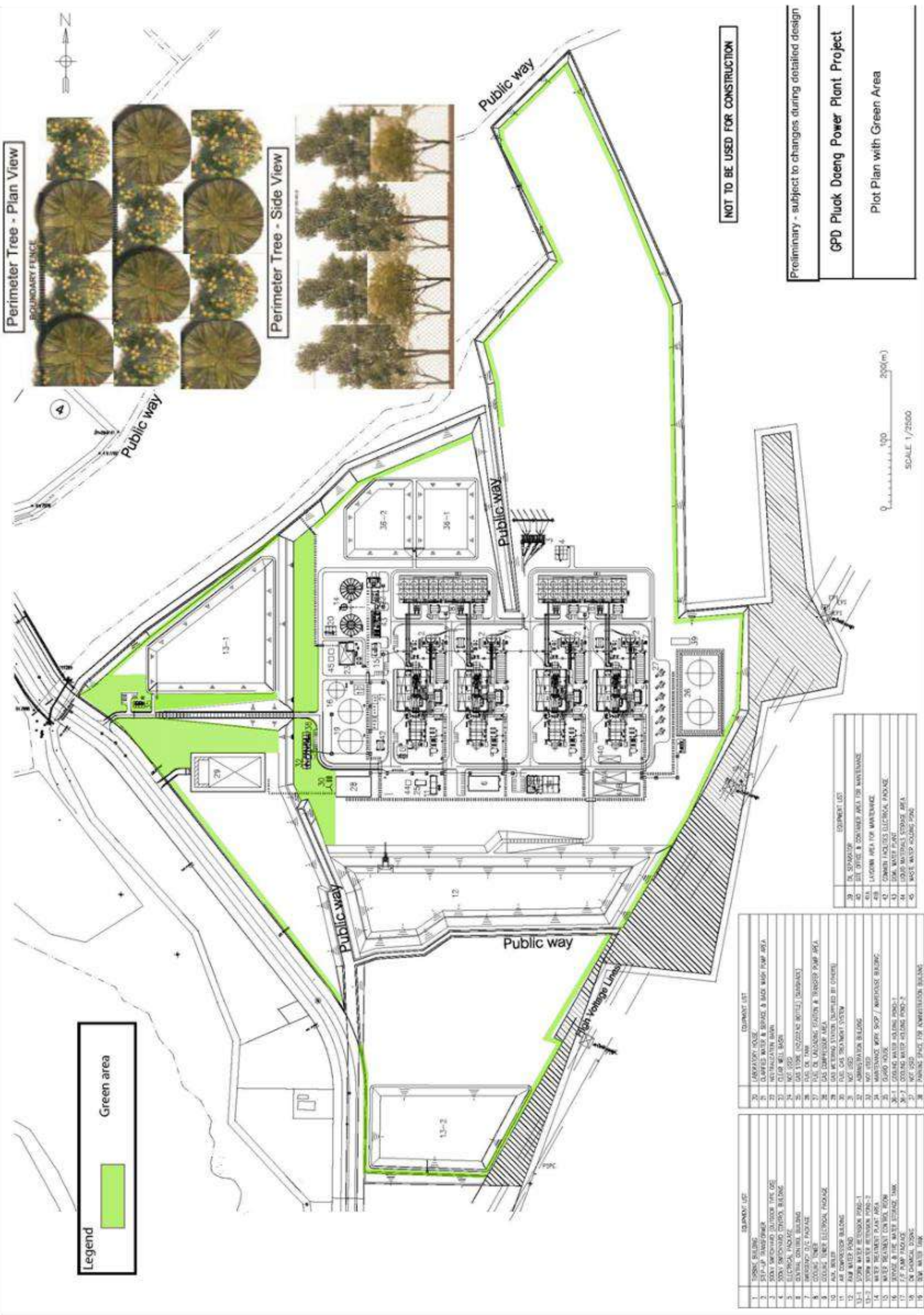


FIGURE 9-3 : FLOW CHART OF POWER PLANT EMERGENCY CONTROL



TEAM

FIGURE 9-4 : GREEN AREA WITHIN PLUAK DAENG POWER PLANT PROJECT

TABLE 9-2

MONITORING PROGRAM FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DISTRICT, RAYONG PROVINCE

<table>
<tr><th>Performance Indicator and Purpose</th><th>Monitoring Parameters</th><th>Monitoring Locations</th><th>Frequency and duration</th><th>Methods of measurement and detection limits</th><th>Responsibilities</th><th>Equipment/ Laboratory Tests Cost Estimate</th></tr>
<tr><td>Construction Phase</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">1. Air Quality
Applicable ambient air quality standards related to fugitive dust and exhaust emissions are as follows:
<table><tr><th>Pollutant</th><th>National Standard (µg/m³)</th><th>WHO Standard (µg/m³)</th></tr><tr><td>TSP (24 hrs)</td><td>330</td><td>-</td></tr><tr><td>PM-10 (24 hrs)</td><td>120</td><td>50</td></tr><tr><td>NO_2 (1 hr)</td><td>320</td><td>200</td></tr><tr><td>SO_2 (1 hrs)</td><td>780</td><td>-</td></tr><tr><td>SO_2 (24 hrs)</td><td>300</td><td>20</td></tr></table></td><td>Pre-construction Phase
- TSP (24 hr)
- PM-10 (24 hr)
- NO_2 (1 hr)
- SO_2 (1 and 24 hr)
- Wind speed and direction
- Temperature</td><td>Areas for monitoring at 5 stations, comprising (Figure 9-5)
- Station 1 Project Area
- Station 2 Village no. 2 Ban Nuen Sawan, Map Yang Phon sub-district
- Station 3 Prasittharam Temple or vicinities
- Station 4 Ban Map Toei School or vicinities
- Station 5 Village no. 5 Ban Wang Tan Mon, Map Yang Phon sub-district</td><td>Once, before construction activities, with 7 consecutive days covering holidays and workdays</td><td>- TSP by Gravimetric-High Volume
- PM-10 by Gravimetric-High Volume or U.S. EPA or governmental offices
- NO_2 by Chemiluminescence
- SO_2 by UV-Fluorescence
- Temperature, speed and direction of wind, sampling by using an aerovane</td><td>Contractor to monitor under supervision of Gulf PD Co., Ltd</td><td>550,000 Baht/time</td></tr>
<tr><td>Construction Phase
- TSP (24 hr)
- PM-10 (24 hr)
- NO_2 (1 hr)
- SO_2 (1 and 24 hr)
- Wind speed and direction
- Temperature</td><td>Areas for monitoring at 5 stations, comprising (Figure 9-5)
- Station 1 Project Area
- Station 2 Village no. 2 Ban Nuen Sawan, Map Yang Phon sub-district
- Station 3 Prasittharam Temple or vicinities
- Station 4 Ban Map Toei School or vicinities
- Station 5 Village no. 5 Ban Wang Tan Mon, Map Yang Phon sub-district</td><td>Six month time, each measurement takes 7 consecutive days covering holidays and workdays for the entire construction period, especially activities generated dust such as area adjustment.</td><td>- TSP by Gravimetric-High Volume
- PM-10 by Gravimetric-High Volume or U.S. EPA or governmental offices
- NO_2 by Chemiluminescence
- SO_2 by UV-Fluorescence
- Temperature, speed and direction of wind, sampling by using an aerovane</td><td>Contractor to monitor under supervision of Gulf PD Co., Ltd</td><td>550,000 Baht/time</td></tr>
<tr><td rowspan="3">2. Noise
Noise performance will be evaluated against the following standards:
- Standard as prescribed in the National Environment Board's Notification No. 15 re: Prescribing Noise Level Standard, B.E. 2540. (Leq 24 hrs not exceed 70 dB(A))
- Guidelines for Community Noise, World Health Organization (WHO), 1999.
<table><tr><th rowspan="2">Landuse</th><th colspan="2">Laeq 1 hr</th></tr><tr><th>Daytime (07.00-22.00)</th><th>Nighttime (22.00-07.00)</th></tr><tr><td>Residential; institutional; education</td><td>55</td><td>45</td></tr><tr><td>Industrial; commercial</td><td>70</td><td>70</td></tr></table></td><td>Pre-construction Phase
- Leq 24 hrs.
- Leq 1 hr.
- Leq 5 min
- L_{dn}
- L_{max}
- L_{90}</td><td>Measurement areas close the project site, at 3 stations (Figure 9-6) of:
- Station 1 project area
- Station 2 Village no. 2 Ban Nuen Sawan, Map Yang Phon sub-district in the west of the project
- Station 3 Village no. 5 Ban Wang Tan Mon, Map Yang Phon sub-district in the south of the project
- Station 4 Village no. 2 Ban Nuen Sawan, Map Yang Phon sub-district in the north of the project</td><td>Once, before the start of construction activities, by continuous measurement for 7 days, covering work days and holidays.</td><td>- Application of International Organization for Standardization (ISO1996) or methods assigned by governmental offices</td><td>Contractor to monitor under supervision of Gulf PD Co., Ltd</td><td>100,000 Baht/time</td></tr>
<tr><td>Construction Phase</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>- Leq 24 hrs.
- Leq 1 hr.
- Leq 5 min
- L_{dn}
- L_{max}
- L_{90}</td><td>Measurement areas close the project site, at 3 stations (Figure 9-6) of:
- Station 1 project area
- Station 2 Village no. 2 Ban Nuen Sawan, Map Yang Phon sub-district in the west of the project</td><td>- Twice a year. It must cover noisy activities, such as foundation piling, by continuous measurement for 7 days, covering work days and holidays.</td><td>- Application of International Organization for Standardization (ISO1996) or methods assigned by governmental offices</td><td>Contractor to monitor under supervision of Gulf SRC Co., Ltd</td><td>100,000 Baht/time</td></tr>
</table>

TABLE 9-2 (CONT'D)

MONITORING PROGRAM FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DEANG DISTRICT, RAYONG PROVINCE

Performance Indicator and Purpose	Monitoring Parameters	Monitoring Locations	Frequency and duration	Methods of measurement and detection limits	Responsibilities	Equipment/ Laboratory Tests Cost Estimate
2. Noise (Cont'd)		- Station 3 Village no. 5 Ban Wang Tan Mon, Map Yang Phon sub-district in the south of the project - Station 4 Village no. 2 Ban Nuen Sawan, Map Yang Phon sub-district in the north of the project				
3. Surface water quality and groundwater quality (Cont'd)	Pre-construction phase • Surface water quality Sampling time, cloud, air temperature, land use of both sides of the river, vegetable plants on both sides of the river, the river bed, etc. shall be recorded. If sampling is made at the overflow weir, the height of the overflow shall be recorded. - Depth - Flow rate - Temperature - pH - Total Dissolved Solids (TDS) - Suspended solids (SS) - BOD_5 - Dissolved Oxygen (DO) - Electrical conductivity (EC) - Chlorite (ClO_2^-) - Chlorophyll a (to monitor Eutrophication; According Water Quality Criteria for Aquatic Life of EPA, 1986, chlorophyll a that causes eutrophication ranges 8-25 mg/l) - Sodium (Na) (millimole/liter) (for SAR calculation) - Calcium (Ca) (millimole/liter) (for SAR calculation) - Magnesium (Mg) (millimole/liter) (for SAR calculation) - SAR = $\frac{Na}{\sqrt{(ca + M\sigma)}}$	7 Station (**Figure 9-7**) - Station 1: Huai Phu Sai in the area before the outfall of Amata City Industrial Estate (Rayong), about 4 km from the outfall of Pluak Daeng Industrial Park. - Station 2: Huai Phu Sai, about 1 km before the outfall of the cooling water holding ponds of Plauk Daeng Power Plant. Effluent sample shall be collected at Wang Tan Mon Weir before the overflow weir crest. - Station 3: Huai Phu Sai at the outfall of the cooling water holding ponds of Plauk Daeng Power Plant. Effluent sample shall be collected at the overflow weir on the Ror Yor 2026 roadside before the overflow weir crest. - Station 4: Huai Phu Sai at the tail of weir crest about 1 km on the Ror Yor 2026 roadside - Station 5: Huai Phu Sai, downstream about 3 km behind the outfall of the cooling water holding ponds of Plauk Daeng Power Plant (in communities area) - Station 6: Dok Krai Reservoir, about 1 km from the entrance of Huai Phu Sai - Station 7: Dok Krai Reservoir, about 2 km from the entrance of Huai Phu Sai	- 3 times before the commencement of construction, i.e. 2 times in the dry season (December and February) and once in the rainy season (May)	- Use methods identified in water quality standards of surface water sources in accordance with the notification of NEB, No. 8 (1994), and Standard Methods for the Examination of Water and Wastewater, regulated by APHA, AWWA and WEF, or methods identified by governmental agencies.	Contractor to monitor under supervision of Gulf PD Co., Ltd	140,000 Baht/time

TABLE 9-2 (CONT'D)

MONITORING PROGRAM FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DEANG DISTRICT, RAYONG PROVINCE

Performance Indicator and Purpose	Monitoring Parameters	Monitoring Locations	Frequency and duration	Methods of measurement and detection limits	Responsibilities	Equipment/ Laboratory Tests Cost Estimate
3. Surface water quality and groundwater quality (Cont'd)	• Groundwater quality - Temperature - pH - BOD_5 - Total Dissolved Solid (TDS) - Suspended Solid (SS) - Dissolved Oxygen (DO) - Oil and Grease - Chlorite (ClO_2^-)	- Monitoring Well (**Figure 9-8**)	- Once before construction	- Use methods identified in Standard Methods for the Examination of Water and Wastewater	Contractor to monitor under supervision of Gulf PD Co., Ltd	5,000 Baht/time
	Construction Phase • Wastewater from Hydrostatic Test - Temperature - pH - Suspended Solid (SS) - Oil & Grease	At the end of the drain of the wastewater from the hydrostatic test	- Once before drainage of the wastewater from the hydrostatic test	- Application of Standard Methods for the Examination of Water and Wastewater	Contractor to monitor under supervision of Gulf PD Co., Ltd	8,000 Baht/time
	• Wastewater from worker's camp/office building - pH - BOD_5 - Suspended Solid - Sulfide - Total Dissolved Solid - Settleable Solids - Oil & Grease - TKN - Fecal Coliform Bacteria	Retention pond at worker's camp/office building area	- Once a month throughout the construction period	- Application of Standard Methods for the Examination of Water and Wastewater	Contractor to monitor under supervision of Gulf PD Co., Ltd	5,000 Baht/time/station
	• Surface water quality Sampling time, cloud, air temperature, land use of both sides of the river, vegetable plants on both sides of the river, the river bed, etc. shall be recorded. If sampling is made at the overflow weir, the height of the overflow shall be recorded. - Depth - Flow rate - Temperature - pH - Total Dissolved Solids (TDS) - Suspended solids (SS) - BOD_5 - Dissolved Oxygen (DO) - Electrical conductivity (EC) - Chlorite (ClO_2^-)	7 Station (**Figure 9-7**) - Station 1: Huai Phu Sai in the area before the outfall of Amata City Industrial Estate (Rayong), about 4 km from the outfall of Pluak Daeng Industrial Park. - Station 2: Huai Phu Sai, about 1 km before the outfall of the cooling water holding ponds of Plauk Daeng Power Plant. Effluent sample shall be collected at Wang Tan Mon Weir before the overflow weir crest. - Station 3: Huai Phu Sai at the outfall of the cooling water holding ponds of Plauk Daeng Power Plant. Effluent sample shall be collected at the overflow weir on the Ror Yor 2026 roadside before the overflow weir crest. - Station 4: Huai Phu Sai at the tail of weir crest about 1 km on the Ror Yor 2026 roadside	- 3 times per year throughout the construction phase, i.e. 2 times in the dry season (December and February) and once in the rainy season (May)	- Use methods identified in water quality standards of surface water sources in accordance with the notification of NEB, No. 8 (1994), and Standard Methods for the Examination of Water and Wastewater, regulated by APHA, AWWA and WEF, or methods identified by governmental agencies.	Contractor to monitor under supervision of Gulf PD Co., Ltd	140,000 Baht/time

TABLE 9-2 (CONT'D)

MONITORING PROGRAM FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DEANG DISTRICT, RAYONG PROVINCE

Performance Indicator and Purpose	Monitoring Parameters	Monitoring Locations	Frequency and duration	Methods of measurement and detection limits	Responsibilities	Equipment/ Laboratory Tests Cost Estimate
3. Surface water quality and groundwater quality (Cont'd)	- Chlorophyll a (to monitor Eutrophication; According Water Quality Criteria for Aquatic Life of EPA, 1986, chlorophyll a that causes eutrophication ranges 8-25 mg/l) - Sodium (Na) (millimole/liter) (for SAR calculation) - Calcium (Ca) (millimole/liter) (for SAR calculation) - Magnesium (Mg) (millimole/liter) (for SAR calculation) - SAR = $\frac{Na}{\sqrt{(ca + M\sigma)}}$	- Station 5: Huai Phu Sai, downstream about 3 km behind the outfall of the cooling water holding ponds of Plauk Daeng Power Plant (in communities area) - Station 6: Dok Krai Reservoir, about 1 km from the entrance of Huai Phu Sai - Station 7: Dok Krai Reservoir, about 2 km from the entrance of Huai Phu Sai				
	• Groundwater quality - Temperature - pH - BOD_5 - Total Dissolved Solid (TDS) - Suspended Solid (SS) - Dissolved Oxygen (DO) - Oil and Grease - Chlorite (ClO^{-}_{2})	- Monitoring Well (Figure 9-8)	- 2 times per year in the dry season and the rainy season throughout the construction phase	- Use methods identified in Standard Methods for the Examination of Water and Wastewater	Contractor to monitor under supervision of Gulf PD Co., Ltd	5,000 Baht/time/station
4. Transportation Number of complaints filed through the complaint response channel	Construction Phase - Daily record the number of type of vehicle and time to enter the project construction area - Daily Record the number of truck transporting material and equipment - Statistical record of accidents occurred from transportation including cause, location, time, and preventive measures for every accident.	Construction area	- Everyday throughout the construction phase	- Record volume of daily traffic accident occurred during the project construction phase and produce a monthly report.	Contractor to monitor under supervision of Gulf PD Co., Ltd	Included in total construction contract cost
5. Water Use	-					
6. Solid Waste Management	-		-	-		
7. Drainage and Flood Control	-		-	-		

TABLE 9-2 (CONT'D)

MONITORING PROGRAM FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DEANG DISTRICT, RAYONG PROVINCE

Performance Indicator and Purpose	Monitoring Parameters	Monitoring Locations	Frequency and duration	Methods of measurement and detection limits	Responsibilities	Equipment/ Laboratory Tests Cost Estimate
8. Socio-Economic Number of complaints filed through the complaint response channel	**Pre-construction** - Public opinion	Representative of households within a 5 km radius of the project location cover 2 district and 4 sub-district in study area. (**Table 9-3** and **Figure 9-9**) - People living within 5 km radius of the project area - people living in the areas located by environmental monitoring stations - Community leaders, local leaders and involved government agencies	- Once, 3 months before construction activities - Once a year throughout the construction	- Interview and questionnaire. The sample size is based on statistical calculations.	Contractor to monitor under supervision of Gulf PD Co., Ltd	720,000 Baht/time
	Construction Phases - Public opinion	Representative of households within a 5 km radius of the project location cover 2 district and 4 sub-district in study area. (**Table 9-3** and **Figure 9-9**) - People living within 5 km radius of the project area - people living in the areas located by environmental monitoring stations - Community leaders, local leaders and involved government agencies	- Once, 3 months before construction activities - Once a year throughout the construction	- Interview and questionnaire. The sample size is based on statistical calculations.	Contractor to monitor under supervision of Gulf PD Co., Ltd	720,000 Baht/time
	- Record of complaints	Representative of households within a 5 km radius of the project location cover 2 district and 4 sub-district in study area. (**Table 9-3** and **Figure 9-9**)	- Every 6 months throughout the construction phase	- Complaints of communities relating to the project operation shall be recorded. Solution and the duration for problem solving shall also be recorded.	Contractor to monitor under supervision of Gulf PD Co., Ltd	Included in total construction contract cost
9. **Public Relations and Community Participation** Number of complaints filed through the complaint response channel	**Construction Phases** - Record of activities with communities, business premises in Pluak Daeng Industrial Park and local involved government agencies.	- Communities within a 5 km radius of the project site - Business premises within Pluak Daeng Industrial Park - Local involved government agencies	- Throughout the construction phase	- Activities with communities shall be recorded.	Gulf PD Co., Ltd	Included in total CSR cost
	- Establish Environmental Impact Monitoring Committee		- Every 6 month, Record summary's activities of Environmental Impacts Monitoring Committee.			
10. **Public Health/ Occupational Health and Safety**	• **Occupational Health and Safety** - Statistical record of accidents	- Project area	- Operation period (Once a year)	- Keep a record of the accidents, specifying causes and characteristics of the accidents, impacts on health and the number of persons injured. Specify the method of correction of the problems and the suggestions.	Gulf PD Co., Ltd	

TABLE 9-2 (CONT'D)

MONITORING PROGRAM FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DEANG DISTRICT, RAYONG PROVINCE

Performance Indicator and Purpose	Monitoring Parameters	Monitoring Locations	Frequency and duration	Methods of measurement and detection limits	Responsibilities	Equipment/ Laboratory Tests Cost Estimate
10. Public Health/ Occupational Health and Safety (cond't)				- Keep record accidents, causes, loss, corrective actions and methods to prevent recurrence		
	- Meeting of OHS Committees	- Project area	- Operation period	- Minutes of Meeting	Gulf PD Co., Ltd.	
11. Major Hazard	-	-	-	-	-	-
12. Green Area	-	-	-	-	-	-
13. Heat Generated from the Power Plant	**Pre-Construction and Construction Phases** - Spot imagery, showing temperature data	- Covering the project construction site and air quality measurement stations	- Three times before project commissioning, covering all seasons: Hot season (mid February – mid May), Rainy season (mid May – mid October) and cool season (mid October – mid February) (refer Meteorological Department of Thailand, www.tmd.go.th)	- Study and analysis of ground temperature based on data derived from the spot imagery, by Geo-Informatics and Space Technology Development Agency (Public Organization) (GISTDA) or capable agencies/ companies.	Contractor to monitor under supervision of Gulf PD Co., Ltd	90,000 Baht/time
14. pH of Rainwater and Sulfate Radicals in Soil Monitoring	**Pre-construction phase** pH of Rainwater	- Project area	- 2 times per year in the rainy season before the construction begins (May and September)	- A pH meter shall be used for measurement through the method specified in Standard Methods for the Examination of Water and Wastewater. The pH meter shall be always calibrated by the agency registered with the government agency, at least once a year. The calibration details shall be attached to the environmental impact monitoring report every time the calibration is made.	Contractor to monitor under supervision of Gulf PD Co., Ltd	
	Acid deposition - Soil pH - Sulphate radical in soil - Nitrate radical in soil - Organic Matter (OM) - Electrical conductivity (EC)	- Project area - Agriculture area near Khao Song Phi Nong Mountain, in the northwest of the project	- 2 times per year at the same time of Rainwater sampling	- Electrometric method - Leachate Extraction, Turbidimetric Method - Distillation and titrimetric Method - Wallkey-black Method - 1:5 Soil/Water Extract or method specified by the government agency	Contractor to monitor under supervision of Gulf PD Co., Ltd	

TABLE 9-2 (CONT'D)

MONITORING PROGRAM FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DEANG DISTRICT, RAYONG PROVINCE

<table>
<tr><th>Performance Indicator and Purpose</th><th>Monitoring Parameters</th><th>Monitoring Locations</th><th>Frequency and duration</th><th>Methods of measurement and detection limits</th><th>Responsibilities</th><th>Equipment/ Laboratory Tests Cost Estimate</th></tr>
<tr><td rowspan="2">14. pH of Rainwater and Sulfate Radicals in Soil Monitoring (cond't)</td><td>Construction phase
pH of Rainwater</td><td>- Project area</td><td>- 2 times per year at the rainy season (during May and September)</td><td>- A pH meter shall be used for measurement through the method specified in Standard Methods for the Examination of Water and Wastewater. The pH meter shall be always calibrated by the agency registered with the government agency, at least once a year. The calibration details shall be attached to the environmental impact monitoring report every time the calibration is made.</td><td>Contractor to monitor under supervision of Gulf PD Co., Ltd</td><td></td></tr>
<tr><td>Acid deposition (Soil depth 0-10 cm)
- Soil pH
- Sulphate radical in soil
- Nitrate radical in soil
- Organic Matter (OM)
- Electrical conductivity (EC)</td><td>- Project area
- Agriculture area near Khao Song Phi Nong Mountain, in the northwest of the project</td><td>- 2 times per year at the same time of sampling is performed</td><td>- Electrometric method
- Leachate Extraction, Turbidimetric Method
- Distillation and titrimetric Method
- Wallkey-black Method
- 1:5 Soil/Water Extract or method specified by the government agency</td><td>Contractor to monitor under supervision of Gulf PD Co., Ltd</td><td></td></tr>
<tr><td>Operation Period</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>1. Air Quality
Applicable air emission from power plant standards are as follows:
<table><tr><th>Pollutant</th><th>National Standard</th><th>IFC Standard</th></tr><tr><td>Gas</td><td></td><td></td></tr><tr><td>TSP (ppm)</td><td>60</td><td>-</td></tr><tr><td>NO2</td><td>120</td><td>25</td></tr><tr><td>SO2</td><td>20</td><td>-</td></tr><tr><td>Diesel</td><td></td><td></td></tr><tr><td>TSP (ppm)</td><td>120</td><td>50</td></tr><tr><td>NO2 (ppm)</td><td>180</td><td>74</td></tr><tr><td>SO2 (ppm)</td><td>260</td><td>Use of 1 % or less S fuel</td></tr></table></td><td>Operation Phase
• Air Quality from Emission Stacks
- CEMs: TSP, NO_x, SO_2, O_2 and flow rate
- Random sampling: TSP, NO_x, SO_2, and O_2
- Audit the CEMs (Audit/RAA/ RATA): TSP, NO_x, SO_2, O_2</td><td>4 emission stacks of the project</td><td>- CEMs measures continuously over the entire power generation period
- Random sampling of NO_x, SO_2, TSP and O_2 at the stack ends, every 6 month, which measure simultaneously with ambient air quality as well as specify % load operation and wind direction when measurements are being conducted.
- Examine the accuracy of CEMs audit, at least once a year</td><td>- Installation of CEMs at stack of project. Measuring NO_x, O_2, SO_2, TSP, and flow rate continuously for the entire period of power generation
Audit the CEMs to confirm that the measurement results from the CEMs are accurate. Measurement method following the U.S.EPA or governmental offices will be used for examination. The audit is divided into 2 parts;
1. System Audit is the examination for accuracy of CEMs working, by review qualitative evaluation and investigating CEMs working status.</td><td>Gulf PD Co., Ltd</td><td>- Installation of CEMs, about 2,000,000 Baht
- Maintenance 100,000 Baht/year
- Air sampling from stack 200,000 Baht/year</td></tr>
</table>

TABLE 9-2 (CONT'D)

MONITORING PROGRAM FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DEANG DISTRICT, RAYONG PROVINCE

Performance Indicator and Purpose	Monitoring Parameters	Monitoring Locations	Frequency and duration	Methods of measurement and detection limits	Responsibilities	Equipment/ Laboratory Tests Cost Estimate
1. Air Quality (Cont'd)				2. **Performance Audit** is the examination of CEMs working accuracy by quantitative evaluation. Measurement accuracy of NO_x, O_2 and SO_2 employs relative test audit (RATA), based on reading the value of NO_x, O_2 and SO_2 from CEMs and compare with the measurement results of air sampling from stack at the same time as reading. The comparison gives relative accuracy. The results will then be compared with the criteria for accuracy test.		
Applicable ambient air quality standards related to fugitive dust and exhaust emissions are as follows: Pollutant / National Standard (μg/m³) / WHO Standard (μg/m³): TSP (24 hrs): 330 / - PM-10 (24 hrs): 120 / 50 NO_2 (1 hr): 320 / 200 SO_2 (1 hrs): 780 / - SO_2 (24 hrs): 300 / 20	• **Ambient Air Quality** - TSP (24 hr) - PM-10 (24 hr) - NO_2 (1 hr) - SO_2 (1 and 24 hr) - Wind speed and direction - Temperature	- Areas for monitoring at 4 stations, comprising (**Figure 9-5**) - Station 1 Village no. 2 Ban Nuen Sawan, Map Yang Phon sub-district - Station 2 Prasittharam Temple or vicinities - Station 3 Ban Map Toei School or vicinities - Station 4 Village no. 5 Ban Wang Tan Mon, Map Yang Phon sub-district	Six month time, each measurement takes 7 consecutive days covering holidays and workdays for the entire construction period, especially activities generated dust such as area adjustment.	- TSP by Gravimetric-High Volume - PM-10 by Gravimetric-High Volume or U.S. EPA or governmental offices - NO_2 by Chemiluminescence - SO_2 by UV-Fluorescence - Temperature, speed and direction of wind, sampling by using an aerovane	Gulf PD Co., Ltd	400,000 Baht/time
2. Noise Noise performance will be evaluated against the following standards: - Standard as prescribed in the National Environment Board's Notification No. 15 re: Prescribing Noise Level Standard, B.E. 2540. (Leq 24 hrs not exceed 70 dB(A)) - Guidelines for Community Noise, World Health Organization (WHO), 1999.	**Operation Phase** - Leq 24 hrs. - Leq 8 hrs. - Leq 1 hr. - Leq 5 min - L_{dn} - L_{max} - L_{90}	• Measure Leq 24 hrs. Leq 1 hr. Leq 5 min and L_{90} in the areas close to the project site, at 4 stations of (**Figure 9-6**) : • Station 1 Project Area (at the fence in the northwest of the project) • Station 2 Village no. 2 Ban Nuen Sawan, Map Yang Phon sub-district in the west of the project • Station 3 Village no. 5 Ban Wang Tan Mon, Map Yang Phon sub-district in the south of the project	- Continuous measurement for 7 days covering work days and holidays for Leq 24 hrs, Leq 1 hr, Leq 5 min every 6 months, throughout the operation period.	- Application of International Organization for Standardization (ISO1996) or methods assigned by governmental offices	Gulf PD Co., Ltd	- Measurement of Leq 24 hrs., Leq 1 hr, Leq 5 min and L_{90} costs about 25,000 Baht/ time (2 time/year for the entire operation period) - Measurement of Leq 8 hrs. cost about 10,000 Baht/time/ station (2 time/year for the entire operation period)

TABLE 9-2 (CONT'D)

MONITORING PROGRAM FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DEANG DISTRICT, RAYONG PROVINCE

<table>
<tr><th>Performance Indicator and Purpose</th><th>Monitoring Parameters</th><th>Monitoring Locations</th><th>Frequency and duration</th><th>Methods of measurement and detection limits</th><th>Responsibilities</th><th>Equipment/ Laboratory Tests Cost Estimate</th></tr>
<tr><td>2. Noise (cond't)
<table><tr><th rowspan="2">Landuse</th><th colspan="2">Laeq 1 hr</th></tr><tr><th>Daytime (07.00-22.00)</th><th>Nighttime (22.00-07.00)</th></tr><tr><td>Residential; institutional; education</td><td>55</td><td>45</td></tr><tr><td>Industrial; commercial</td><td>70</td><td>70</td></tr></table></td><td></td><td>• Station 4 Village no. 2 Ban Nuen Sawan, Map Yang Phon sub-district in the north of the project
• Prepare a noise mapping/noise contour map of the project by identified noise sources, loud noise level, frequency and disturbed noise
• Measure Leq 8 hrs in the power block area i.e. combustion chamber of gas turbine</td><td>- Prepare a Noise Mapping/ Noise Contour Map of the project by identified noise sources, loud noise level, frequency and disturbed noise within the first year of operation and to carry on continuously every 3 years.
Twice a year, continuous measurement for Leq 8 hrs for 72 hrs throughout the operation period</td><td></td><td></td><td>- Noise contour map preparation costs about 150,000 Baht/ time (the first year of operation and to carry on continuously every 3 years.)</td></tr>
<tr><td rowspan="2">3. Surface water quality and groundwater quality</td><td>Operation Phase
1. The discharge water quality from cooling tower
• Water quality online Monitoring
- Temperature
- pH
- Conductivity
- Dissolved Oxygen</td><td>- Cooling water holding pond No. 2 or 3 in which has wastewater</td><td>- Throughout operation period</td><td>- Installation of water quality online monitoring system</td><td>Gulf PD Co., Ltd</td><td>include in operation cost</td></tr>
<tr><td>• Measurement by sampling
- Temperature
- pH
- Total Dissolved Solids (TDS)
- Suspended Solids (SS)
- BOD_5
- Dissolved Oxygen (DO)
- Chlorite (ClO^-_2)
- Sodium (Na) (millimole/liter) (for SAR calculation)
- Calcium (Ca) (millimole/liter) (for SAR calculation)
- Magnesium (Mg) (millimole/liter) (for SAR calculation)
- $SAR = \frac{Na}{\sqrt{(ca + M\sigma)}}$</td><td>- Cooling Water Holding Pond No. 2 or 3 in which has wastewater (**Figure 9-10**)</td><td>- monthly throughout the operation period</td><td>- Use methods identified in water quality standards of surface water sources in accordance with the notification of NEB, No. 8 (1994), and Standard Methods for the Examination of Water and Wastewater, regulated by APHA, AWWA and WEF, or methods identified by governmental agencies.</td><td>Gulf PD Co., Ltd</td><td>10,000 Baht/time</td></tr>
</table>

TABLE 9-2 (CONT'D)

MONITORING PROGRAM FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DEANG DISTRICT, RAYONG PROVINCE

Performance Indicator and Purpose	Monitoring Parameters	Monitoring Locations	Frequency and duration	Methods of measurement and detection limits	Responsibilities	Equipment/ Laboratory Tests Cost Estimate
3. Surface water quality and groundwater quality (Cont'd)	• Annual Measurement Follow Ministry of Industrial's Notification No. 2 (B.E2539) re: Prescribing Standards of Quality of Discharged Water Drain from Factories and the level of Total Dissolved Solid must be within the standards of the quality of water discharged into the Irrigation waterway of the Department of Royal Irrigation	- Cooling Water Holding Pond No. 2 or 3 in which has wastewater (**Figure 9-10**)	- Once a year throughout the operation period	- Use methods identified in water quality standards of surface water sources in accordance with the notification of NEB, No. 8 (1994), and Standard Methods for the Examination of Water and Wastewater, regulated by APHA, AWWA and WEF, or methods identified by governmental agencies.	Gulf PD Co., Ltd	6,000 Baht/time
	2. Wastewater Quality from the Process • Water quality online Monitoring - Temperature - pH - Conductivity	- Wastewater holding pond (**Figure 9-10**)	- Throughout operation period	- Installation of water quality online monitoring system	Gulf PD Co., Ltd	Included in total operation cost
	• Measurement by sampling - Temperature - pH - Total Dissolved Solids (TDS) - Suspended Solids (SS) - Oil & Grease - BOD_5	- Wastewater holding pond (**Figure 9-10**)	- monthly throughout the operation period	- Use methods identified in water quality standards of surface water sources in accordance with the notification of NEB, No. 8 (1994), and Standard Methods for the Examination of Water and Wastewater, regulated by APHA, AWWA and WEF, or methods identified by governmental agencies.	Gulf PD Co., Ltd	6,000 Baht/time
	• Annual Measurement All parameters follow's Industrial Estate Authority of Thailand Notification No. 76/2560 (B.E.2017) re: General Guidelines for Wastewater Drainage to the central wastewater treatment system of industrial estate.	- Wastewater Holding Pond (**Figure 9-10**)	- Once a year throughout the operation period	- Use methods identified in water quality standards of surface water sources in accordance with the notification of NEB, No. 8 (1994), and Standard Methods for the Examination of Water and Wastewater, regulated by APHA, AWWA and WEF, or methods identified by governmental agencies.	Gulf PD Co., Ltd	40,000 Baht/time
	3. Surface water quality Sampling time, cloud, air temperature, land use of both sides of the river, vegetable plants on both sides of the river, the river bed, etc. shall be recorded. If sampling is made at the overflow weir, the height of the overflow shall be recorded.	7 Station (**Figure 9-7**) - Station 1: Huai Phu Sai in the area before the outfall of Amata City Industrial Estate (Rayong), about 4 km from the outfall of Pluak Daeng Industrial Park. - Station 2: Huai Phu Sai, about 1 km before the outfall of the cooling water holding ponds of Plauk Daeng Power Plant. Effluent sample	- 3 times per year throughout the construction phase, i.e. 2 times in the dry season (December and February) and once in the rainy season (May)	- Use methods identified in water quality standards of surface water sources in accordance with the notification of NEB, No. 8 (1994), and Standard Methods for the Examination of Water and Wastewater, regulated by APHA, AWWA and WEF, or methods identified by governmental agencies.	Gulf PD Co., Ltd	140,000 Baht/time

TABLE 9-2 (CONT'D)

MONITORING PROGRAM FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DEANG DISTRICT, RAYONG PROVINCE

Performance Indicator and Purpose	Monitoring Parameters	Monitoring Locations	Frequency and duration	Methods of measurement and detection limits	Responsibilities	Equipment/ Laboratory Tests Cost Estimate
3. Surface water quality and groundwater quality (Cont'd)	- Depth - Flow rate - Temperature - pH - Total Dissolved Solids (TDS) - Suspended solids (SS) - BOD_5 - Dissolved Oxygen (DO) - Electrical conductivity (EC) - Chlorite (ClO_2^-) - Chlorophyll a (to monitor Eutrophication; According Water Quality Criteria for Aquatic Life of EPA, 1986, chlorophyll a that causes eutrophication ranges 8-25 mg/l) - Sodium (Na) (millimole/liter) (for SAR calculation) - Calcium (Ca) (millimole/liter) (for SAR calculation) - Magnesium (Mg) (millimole/liter) (for SAR calculation) $SAR = \frac{Na}{\sqrt{(ca + M\sigma)}}$	shall be collected at Wang Tan Mon Weir before the overflow weir crest. - Station 3: Huai Phu Sai at the outfall of the cooling water holding ponds of Plauk Daeng Power Plant. Effluent sample shall be collected at the overflow weir on the Ror Yor 2026 roadside before the overflow weir crest. - Station 4: Huai Phu Sai at the tail of weir crest about 1 km on the Ror Yor 2026 roadside - Station 5: Huai Phu Sai, downstream about 3 km behind the outfall of the cooling water holding ponds of Plauk Daeng Power Plant (in communities area) - Station 6: Dok Krai Reservoir, about 1 km from the entrance of Huai Phu Sai - Station 7: Dok Krai Reservoir, about 2 km from the entrance of Huai Phu Sai				
	4. Groundwater quality - Temperature - pH - BOD_5 - Total Dissolved Solid (TDS) - Suspended Solid (SS) - Dissolved Oxygen (DO) - Oil and Grease - Chlorite (ClO_2^-)	- Monitoring Well (Figure 9-8)	- 2 times per year in the dry season and the rainy season throughout the construction phase	- Use methods identified in Standard Methods for the Examination of Water and Wastewater	Gulf PD Co., Ltd	5,000 Baht/time/station
4. Transportation	Operation Phase - Daily record the number of type of vehicle and time to enter the project construction area - Daily Record the number of truck transporting material and equipment - Statistical record of accidents occurred from transportation including cause, location, time, and preventive measures for every accident.	Project area	- Everyday throughout the operation phase	- Record volume of daily traffic accident occurred during the project operation phase and produce a monthly report.	Gulf PD Co., Ltd	Included in total operation cost

TABLE 9-2 (CONT'D)

MONITORING PROGRAM FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DEANG DISTRICT, RAYONG PROVINCE

Performance Indicator and Purpose	Monitoring Parameters	Monitoring Locations	Frequency and duration	Methods of measurement and detection limits	Responsibilities	Equipment/ Laboratory Tests Cost Estimate
5 Water Use						
6. Solid Waste Management	Operation Phase - Type and volume of general garbage and waste from production process.	Project area	- Monthly throughout the operation period	- Survey and record	Gulf PD Co., Ltd	Included in total operation cost
7. Drainage and Flood Control	-					
8. Socio-economic	operation Phases - Public opinion	Representative of households within a 5 km radius of the project location cover 2 district and 4 sub-district in study area. (**Table 9-3** and **Figure 9-9**) - People living within 5 km radius of the project area - people living in the areas located by environmental monitoring stations - Community leaders, local leaders and involved government agencies	- Once a year throughout the operation phase	- Interview and questionnaire. The sample size is based on statistical calculations.	Gulf PD Co., Ltd	720,000 Baht/time
	- Record of complaints	Representative of households within a 5 km radius of the project location cover 2 district and 4 sub-district in study area. (**Table 9-3** and **Figure 9-9**)	- Every 6 months throughout the operation phase	- Complaints of communities relating to the project operation shall be recorded. Solution and the duration for problem solving shall also be recorded.	Gulf PD Co., Ltd	Included in total operation cost
9. Public Relations and Community Participation	Operation Phase - Record of activities with communities, business premises in Pluak Daeng Industrial Park and local involved government agencies.	- Communities within a 5 km radius of the project site - Business premises within Pluak Daeng Industrial Park - Local involved government agencies	- Throughout the operation period	- Record activities that the project arranges for local communities.	Gulf PD Co., Ltd. and Environmental Impacts Monitoring Committee	
	- Establish Environmental Impact Monitoring Committee		- Every 6 month, Record summary's activities of Environmental Impacts Monitoring Committee.			
10. Public Health/ Occupational Health and Safety	Operation Phase • Public Health - Morbidity statistics on people living within 5 km. radius of the project location	- Nearby communities	- Health status data of people shall be compiled from local public health facilities once a year	- Coordination with local public health facilities or involved agencies shall be made for health examination for local people - People living in the 5 km. radius of the project location and those living in the communities where environmental quality monitoring is conducted shall be interviewed once a year. - Health status data of people shall be compiled from local public health facilities for analysis and comparison.	Gulf PD Co., Ltd	Included in the annual budget of the project

TABLE 9-2 (CONT'D)

MONITORING PROGRAM FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DEANG DISTRICT, RAYONG PROVINCE

Performance Indicator and Purpose	Monitoring Parameters	Monitoring Locations	Frequency and duration	Methods of measurement and detection limits	Responsibilities	Equipment/ Laboratory Tests Cost Estimate
10. Public Health/ Occupational Health and Safety (Cont'd)	• **Worker** - Accident, morbidity and injury statistics of staff, public health and staff health problems	- Project area	- A monthly summary report shall be made. Staff shall undergo annual physical examination once a year.	- Staff of the project shall have health examination.	Gulf PD Co., Ltd	Included in the annual budget of the project
	• Occupational Health and Safety - Statistical record of accidents	- Project area	- Operation period (Once a year)	- Keep a record of the accidents, specifying causes and characteristics of the accidents, impacts on health and the number of persons injured. Specify the method of correction of the problems and the suggestions. - Keep record accidents, causes, loss, corrective actions and methods to prevent recurrence	Gulf PD Co., Ltd	
	- Meeting of OHS Committees	- Project area	- Operation period	- Minutes of Meeting	Gulf PD Co., Ltd.	
	- Results of Emergency Plan	- Project area	- Operation period	- Evaluate the drills of the Emergency Plan in order to adjust the plan and the employees' working skills.	Gulf PD Co., Ltd.	
	- Noise in the workplace - Leq 8 hrs	Loud noise area i.e. - Cooling Tower area - Gas Compressor area - Boiler Feed Pump area - Gas Turbine area - Steam Turbine area	- 4 times a year	- International Organization for Standardization (ISO 1996) or method assigned by government offices	Gulf PD Co., Ltd.	10,000 Baht/time
	- Noise Mapping/Noise Contour in order to mark the areas of loud noise	- The production areas of loud noise	- The first year of operation and to carry on continuously every 3 years	- Integrated Sound Level or method assigned by governmental offices	Gulf PD Co., Ltd.	
	• **Heat** - Wet Bulb Globe Temperature: WBGT	- Condenser Exhaust Unit area - Steam pipeline area - Steam turbine area - Gas turbine area	- 4 times a year	- WBGT Method or method assigned by governmental offices	Gulf PD Co., Ltd.	5,000 Baht/time
	• **Light** - Light Intensive Level	- Electrical and Control Building - Administration Building - Workshop	- 4 times a year	- Lux Meter or method assigned by governmental offices	Gulf PD Co., Ltd.	10,000 Baht/time

TABLE 9-2 (CONT'D)

MONITORING PROGRAM FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DEANG DISTRICT, RAYONG PROVINCE

Performance Indicator and Purpose	Monitoring Parameters	Monitoring Locations	Frequency and duration	Methods of measurement and detection limits	Responsibilities	Equipment/ Laboratory Tests Cost Estimate
10. Public Health/ Occupational Health and Safety (Cont'd)	• Health - General health check-up for new workers o Physical check-up by physician o Chest x-ray o Complete blood count, blood type, immunity to Hepatitis B Virus infection	- New workers	- Prior to starting working for the Project within the duration of time required by law	- Physical exam - Lung X-ray - Blood test for complete blood count, blood group, Hepatitis B	Gulf PD Co., Ltd.	
	- General Health check-up for Full Time workers o Chest x-ray o eye and vision examination o Audiometric test o Physical examination by physician o Pulmonary function test o Complete blood count, blood type, immunity to Hepatitis B Virus infection	- Full Time workers	- Once a year	- Health check-up	Gulf PD Co., Ltd.	
11. Major Hazard	Operation Phase - Leak protection system for natural gas and diesel oil - Practices following emergency plan	- Project area	- As specified in the emergency plan	- Record examination of leak protection system for natural gas and diesel oil - Examine the practice following emergency plan	Gulf PD Co., Ltd.	
12. Green Area	-					
13. Heat Generated from the Power Plant	Operation Phase - Spot imagery, showing temperature data	- Covering the project construction site and air quality measurement stations	- Hot season (mid February – mid May), Rainy season (mid May – mid October) and cool season (mid October – mid February), the first year of operation and to carry on all season every 3 years (refer Meteorological Department of Thailand, www.tmd.go.th)	- Study and analysis of ground temperature based on data derived from the spot imagery, by Geo-Informatics and Space Technology Development Agency (Public Organization) (GISTDA) or capable agencies/ companies.	Gulf PD Co., Ltd.	

TABLE 9-2 (CONT'D)

MONITORING PROGRAM FOR SRIRACHA POWER PLANT OF GULF PD CO., LTD. PLUAK DEANG DISTRICT, RAYONG PROVINCE

Performance Indicator and Purpose	Monitoring Parameters	Monitoring Locations	Frequency and duration	Methods of measurement and detection limits	Responsibilities	Equipment/ Laboratory Tests Cost Estimate
14. pH of Rain Water and Sulfate Radicals in the Soil Monitoring	**Operation Phase** - pH of Rainwater	- Project area	- 2 times per year at the rainy season (during May and September)	- A pH meter shall be used for measurement through the method specified in Standard Methods for the Examination of Water and Wastewater. The pH meter shall be always calibrated by the agency registered with the government agency, at least once a year. The calibration details shall be attached to the environmental impact monitoring report every time the calibration is made.	Gulf PD Co., Ltd	
	Acid deposition (Soil depth 0-10 cm) - Soil pH - Sulphate radical in soil - Nitrate radical in soil - Organic Matter (OM) - Electrical conductivity (EC)	- Project area - Agriculture area near Khao Song Phi Nong Mountain, in the northwest of the project	- 2 times per year at the same time of sampling is performed	- Electrometric method - Leachate Extraction, Turbidimetric Method - Distillation and titrimetric Method - Wallkey-black Method - 1:5 Soil/Water Extract or method specified by the government agency	Gulf PD Co., Ltd	

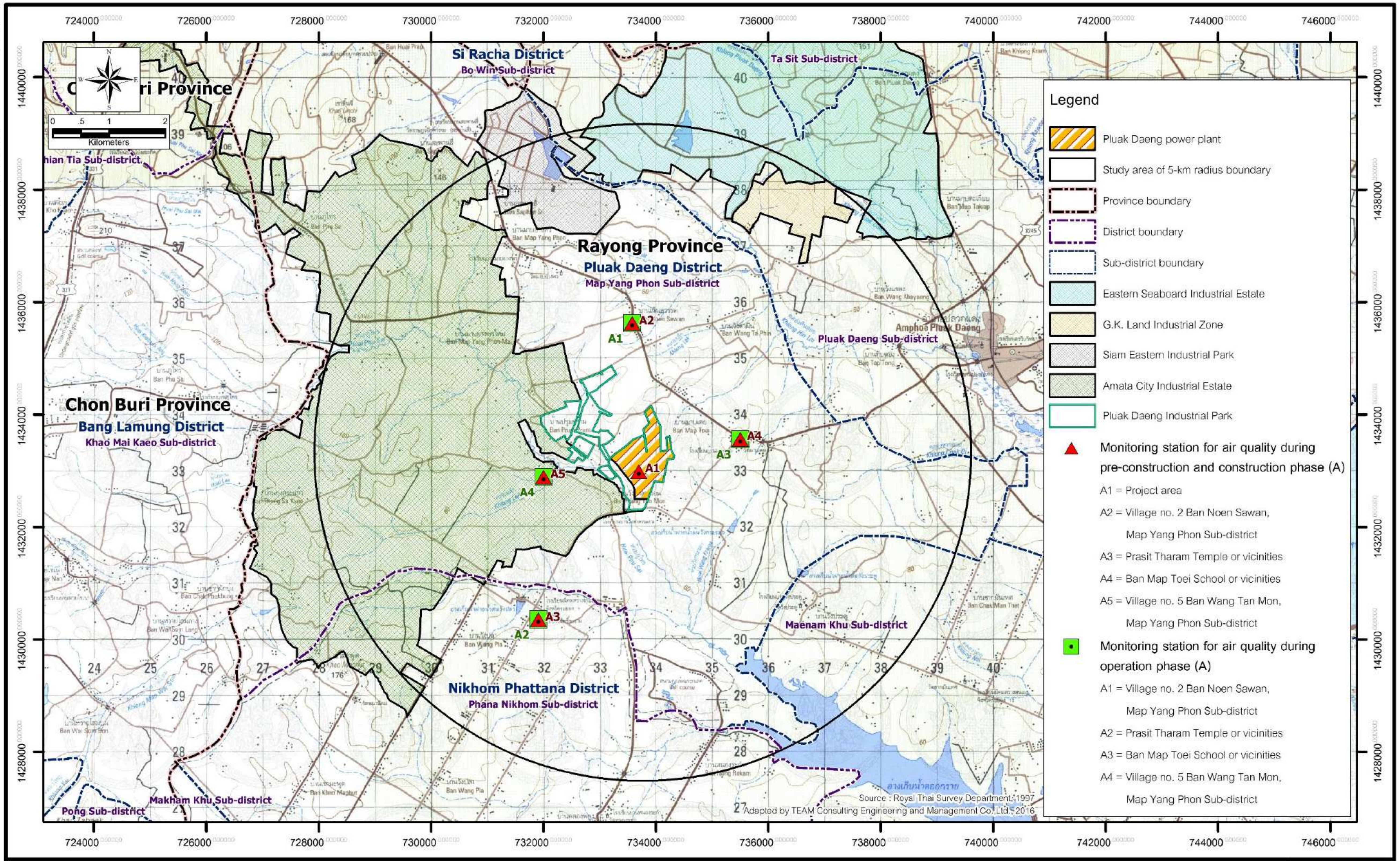


FIGURE 9-5 : AIR QUALITY MONITORING STATION

10P2809/Damrongsak.B/30-03-60/P2809-039 (English).mxd

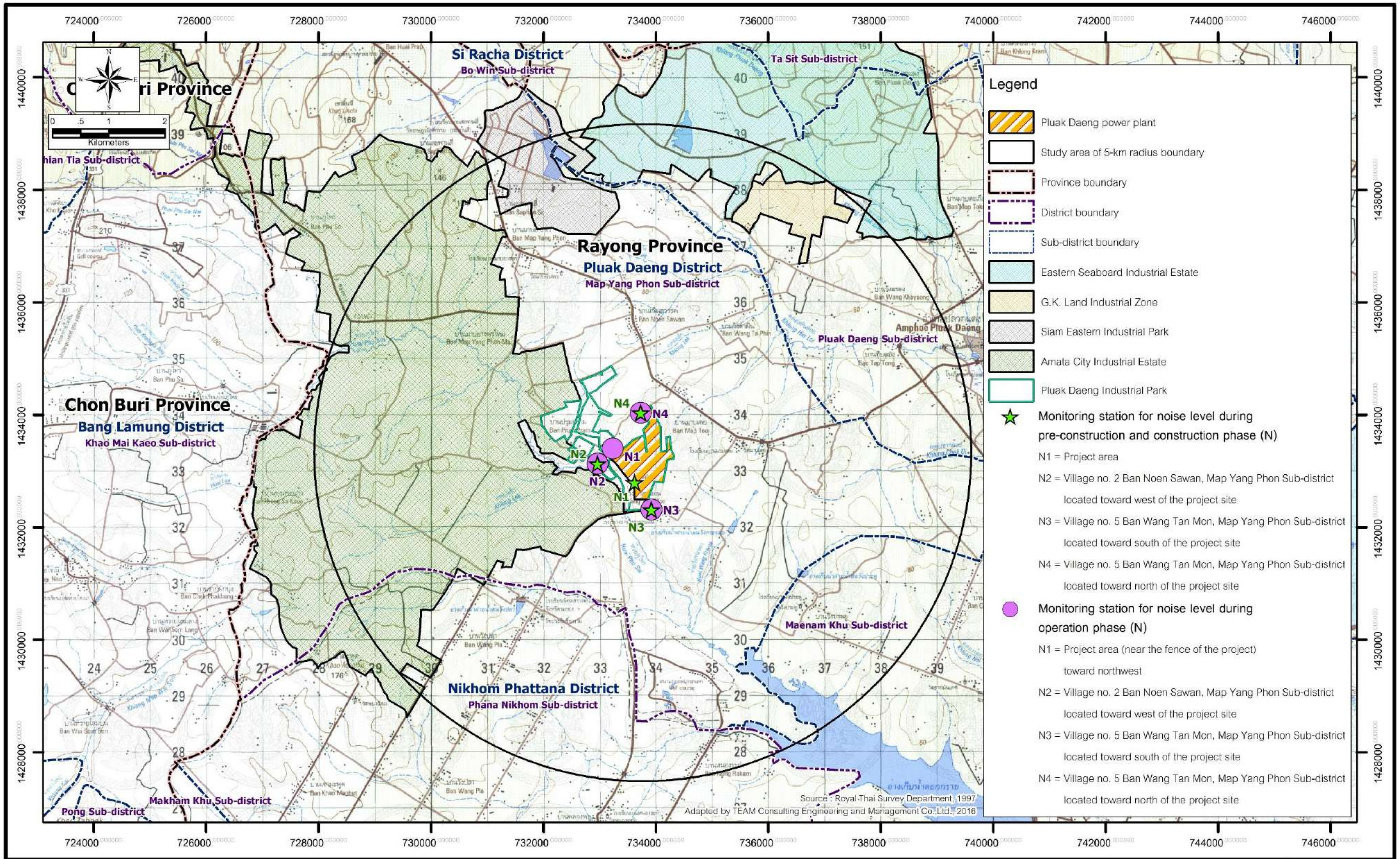


FIGURE 9-6 : THE PROJECT'S NOISE MONITORING STATION

TEAM

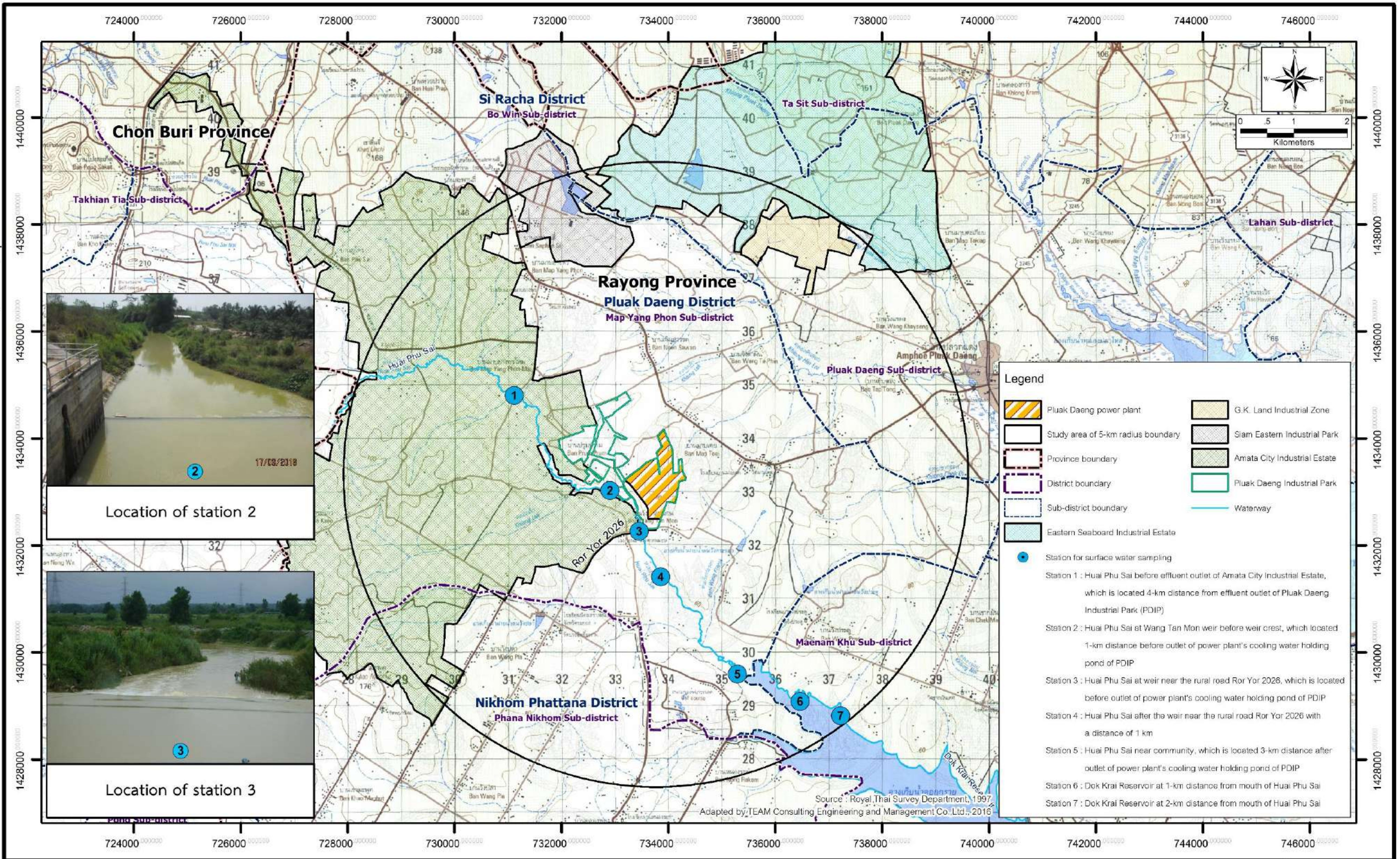


FIGURE 9-7 : SURFACE WATER QUALITY MONITORING STATIONS DURING PRE-CONSTRUCTION, CONSTRUCTION AND OPERATION PHASES

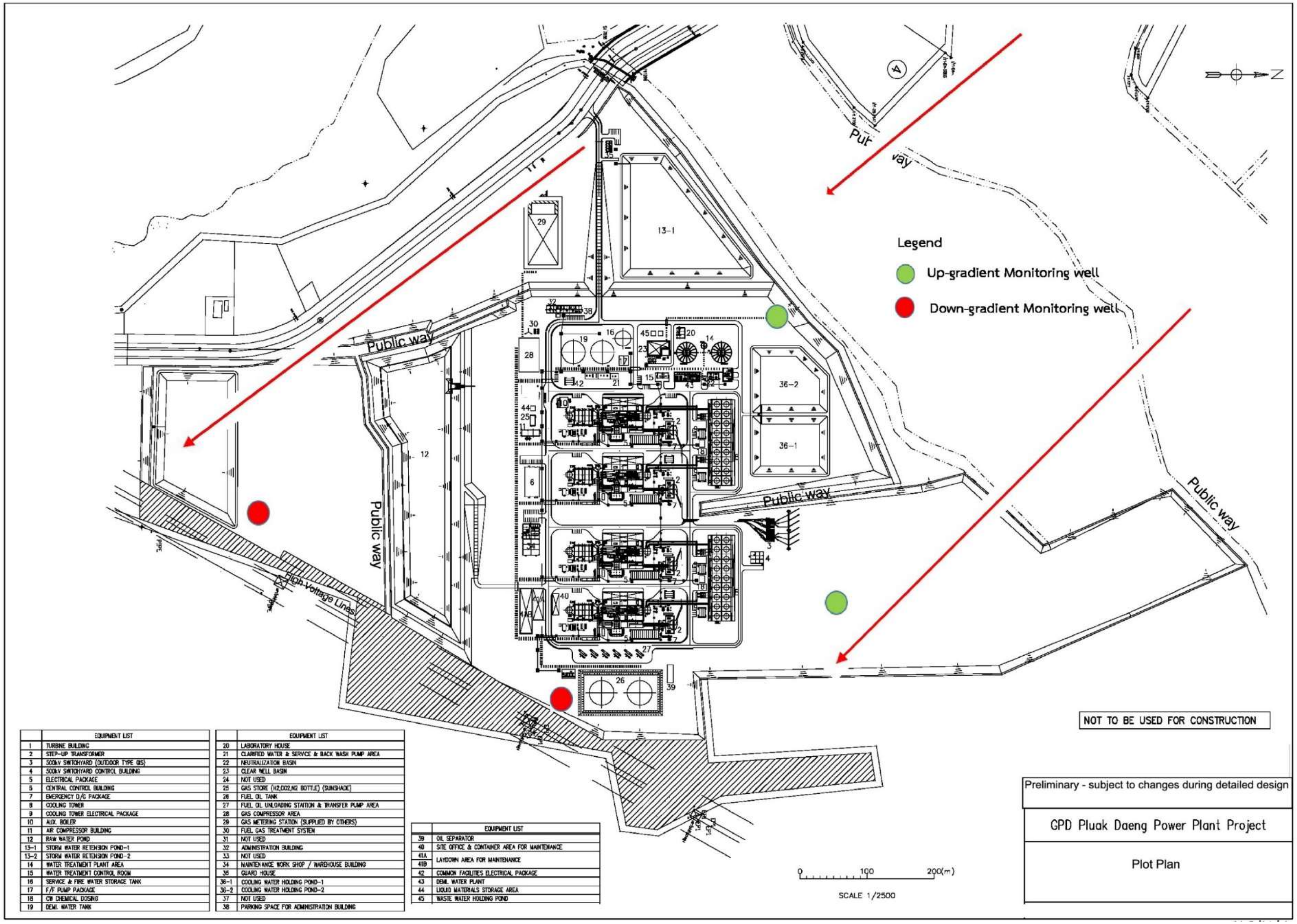


FIGURE 9-8 : LOCATIONS OF GROUNDWATER MONITORING WELLS OF PLUAK DAENG POWER PLANT PROJECT

TABLE 9-3

VILLAGES/COMMUNITIES WITHIN 5 KM RADIUS OF STUDY AREA WHICH ARE LIKELY TO BE AFFECTED BY PROJECT DEVELOPMENT

Province	District	Sub-District	Village no.
Rayong	Pluak Daeng	Map Yang Phon	Village no. 1 Ban Map Toei
			Village no. 2 Ban Nuen Sawan
			Village no. 3 BanMap Yang Phon
			Village no. 5 Ban Wang Tan Mon
			Village no. 6 Ban Map Yang Mai
			Village no. 7 Ban Chak Oi
		Pluak Daeng	Village no. 4 Ban Wang Ta Phin
			Village no. 6 Ban Thaptong
		Mae Nam Khu	Village no. 4 Ban Chak Munthet
			Village no. 7 Ban Wang Pradu
	Nikhom Phatthana	Phana Nikhom	Village no. 4 Ban Khao Maphut
			Village no. 5 Ban Khlong Phlu
			Village no. 6 Ban Nong Rakam
			Village no. 7 Ban Wang Pla
			Village no. 8 Ban Soi 13
1 province	**2 districts**	**4 sub-districts**	**15 villages**

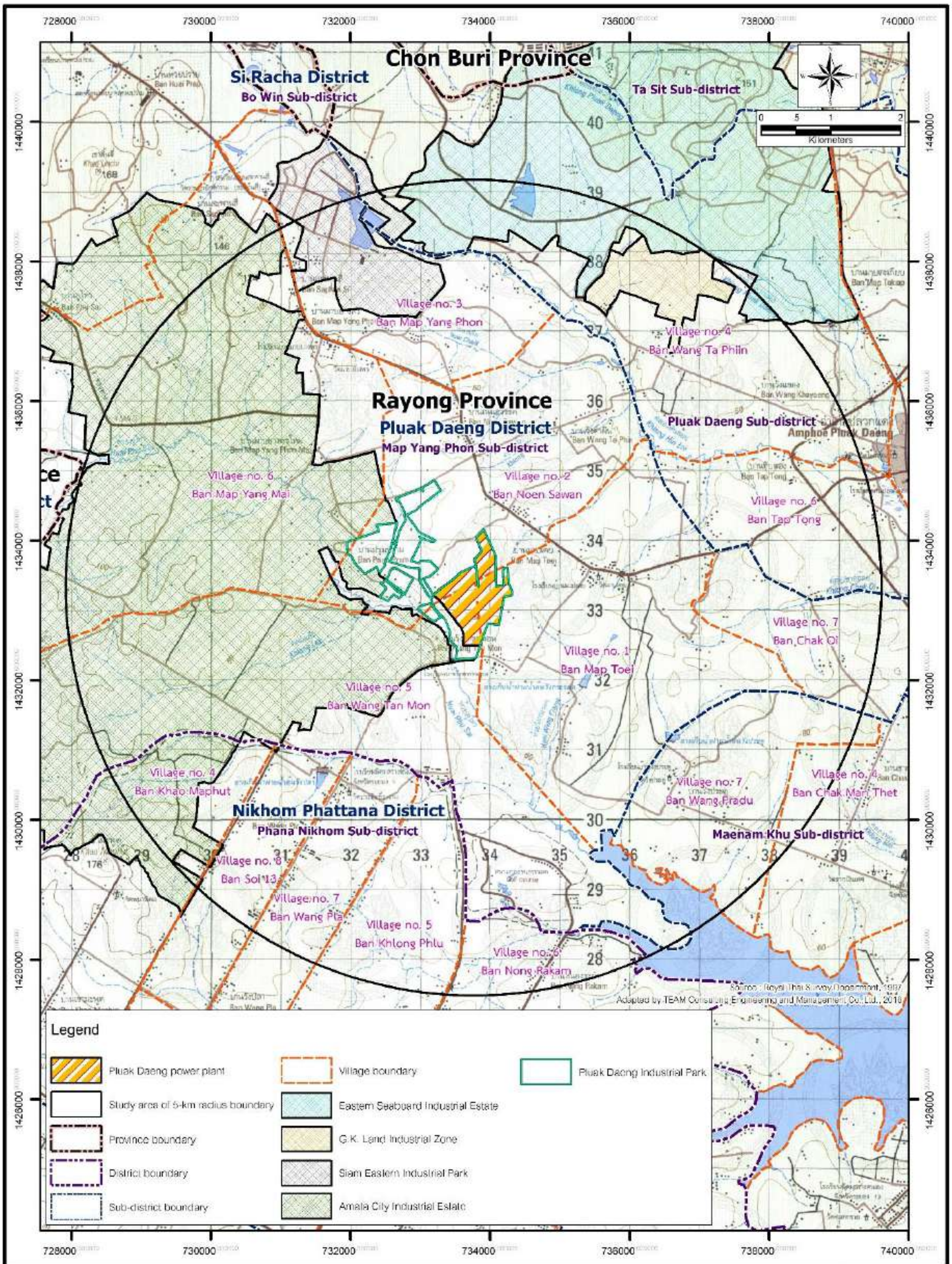


FIGURE 9-9 : STUDY AREA ACCORDING TO SOCIO-ECONOMICS MEASURE

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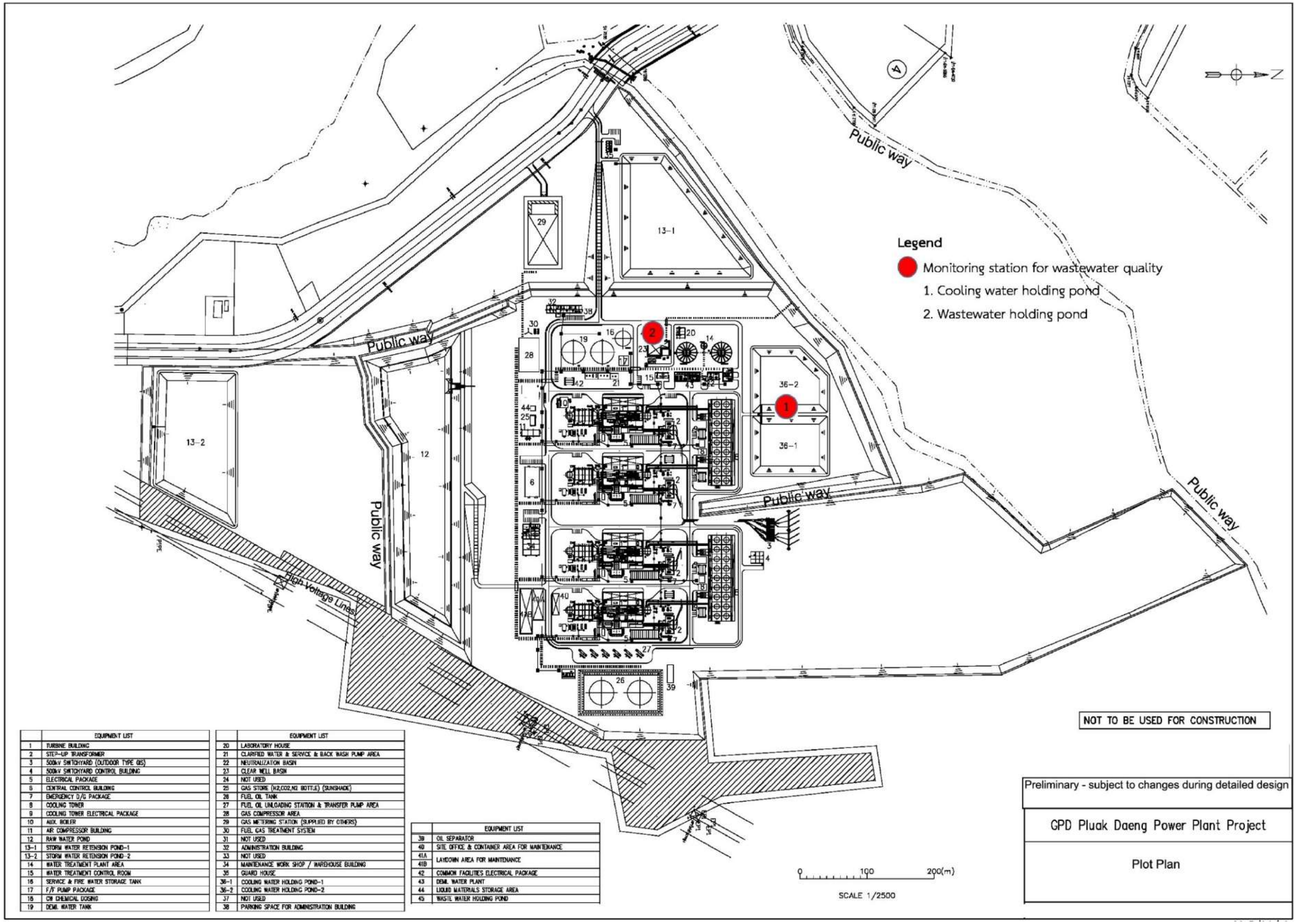

FIGURE 9-10 : WASTEWATER MONITORING STATIONS OF PROJECT

CHAPTER 10

CONCLUSION AND RECOMMENDATION

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CONCLUSION AND RECOMMENDATION

10.1 CONCLUSION FROM THE IMPACT ASSESSMENT

As the Pluak Deang Power Plant is located in the Pluak Daeng Industrial Park (Industrial Park), the potential impacts, therefore, are related to pollution from the project rather than from the project location and infrastructure of the project. The impacts related to the pollution from project operation are summarizied as follow;

10.1.1 Air Quality

The potential air quality impacts from the Pluak Deang Power Plant Project during the construction and operation phases will be from dust dispersion during the construction phase and stack emissions during the operation phase. The assessment of impact on air quality has conducted by using AERMOD model with the input data of meteorological data from the nearest meteorological station by Pollution Control Department and Thai Meteorological Department, and continuous air quality monitoring results of the year 2013-2015. With reference to the highest values in the monitoring of ambient air quality by Pluak Daeng District Public Health Office's Air Quality Monitoring Station, under the charge of the Pollution Control Department, which is about 6.6 kilometers away from the project location to the east-northeast (ENE), the levels of NO_2, SO_2, and PM-10 as measured in 2015 are within the established national standard levels. It can be concluded that the airshed is non-degraded. The considered sensitive receptors are the places where the occupants are more susceptible to the adverse effects of exposure to pollutants such as hospital and school. The assessment reults are as follows:

During the project construction, the main activities leading to the dispersion of suspended particulate are the activities in the preparation of the ground for foundation works and the building works. According to the forecast of the impacts from the project construction on 31 sensitive areas, the highest 24-hr average TSP is found at the construction area with the concentration of 185.54 $\mu g/m^3$. When it is added to the highest concentration measured from the field study (106 $\mu g/m^3$), the result was 291.54 $\mu g/m^3$. Nevertheless, the project has established environmental impact mitigation and preventive measures on air quality during the construction phase by spraying water in the construction area, the soil mounds or where project construction activities causes the dispersion of suspended particulate, such as the road, the area undergoing filling and grading, etc. to reduce the dispersion of the suspended particulate, at least two times/day (morning and afternoon). When the weather is hot, dry or windy, it is estimated that the sprayed area getting dried and there is a tendency to caused dust dispersion the project will consider to increase frequency on spraying water at the area; and Install shading nets or fences with the height of 3 meters from the ground around the project. Those mitigation measures could reduce the total suspended particulate (TSP) to 92.77 $\mu g/m^3$. When this is added to the highest concentration measured from the field study (106 $\mu g/m^3$), the result was 198.77 $\mu g/m^3$ or 60.23 % of the standard level. The maximum incremental TSP is 92.77 $\mu g/m^3$ at the construction site over 25 percent of national ambient air standard (330 $\mu g/m^3$), it takes place at the project area. In addition, the incremental TSP at the sensitive receptors are 0.29-4.50 $\mu g/m^3$ approximately 0.09-1.368 percent of national standard.

During the operation period, the air quality impact will be from the use of natural gas as main fuel and diesel oil as backup fuel to generate the electricity. The combustion of these fuels will generate major air pollutants including primary oxides of nitrogen (NO_x), sulfur dioxide (SO_2), and particulate matters (PM). However, there will be small amount of SO_2 emission and PM because of the composition of selected fuel of the project. Results from forecating model showed that the operation of 100% load produces the incremental concentration of nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and total suspended particulate (TSP) in the atmosphere at the sensitive receptors below 25 percent of WHO ambient air quality guidelines and national ambient air quality standard.

There is only the maximum 1-hour average concentrations of NO_2 taking place at the Jom Hae and Jom Hae Mountain with distance of about 13-15 kilometers from the project site. Comparing those maximum concentrations with WHO guidelines for the effects of NO_2 on vegetation (critical level), they are far below the critical level. Accordingingly, the potential impact is considered to be not significant.

10.1.2 Noise Level

The construction activity causing the highest level of noise is the foundation work. During that activity, the predicted 1-hour equivalent sound pressure level (L_{eq} 1 hr) at the three Sensitive areas; west of the project (Village no. 2, Map Yang Phon sub-district), south of the project (Village no. 5, Map Yang Phon sub-distric), and north of the project (Village no. 2, Map Yang Phon sub-district) is increase in background below 3 dB(A). As for disturbed noise, all three sensitive receptors have higher level of disturbed noise than the standard level. Therefore, the project set up measure to reduce that disturbed noise by installing temporary noise barrier at the site of the foundation piling in the west, south and north sides. The noise barrier is made from 1.27-mm metal materials (steel 18 ga) or thicker having sound transmission loss (TL) of 25 dB(A). The height of the noise barrier is approximately 5 m which will bring the specific noise to a level lower than the standard. It is anticipated that the noise from the project's construction activities will have temporary and low impact on the everyday life of the nearby receptors.

During the operation period, the major noise source will be an electricity generator. The standard engineering design specifies that the noise level at 1 m away from the generator and 1.2 m above the ground (level of hearing) must not exceed 85 dB(A). Regarding the project's design, equipment generating loud noise will be installed in buildings that are equipped with acoustic walls to absorb noise. Silencers will be installed to reduce the noise level during operations of equipment that may generate loud noise, such as safety valves and start up vent valves. The Project will control general noise level at the Project's fence areas not to exceed 70 dB(A). Forecast results of Leq 24 hr and noise annoyance during the operation phase in communities in the west, the south and the north of the project: Leq 24 hr meets the standard while noise annoyance is higher than the standard. However, a combined noise level from the project activities and the currently measured noise level equals to the currently measured noise level. This indicates that noise level from the project activities will not increasingly affect the communities. Hence, noise impact during the operation phase is at a low level. Also, the noise level monitoring at the vicinity will be monitored entire the project lifetime.

10.1.3 Surface Water Quality

The Project's primary source of wastewater during the construction period comes from workers' wash rooms and toilets. The rest is wastewater from construction activities. The uncontaminated volume is sent to wastewater holding ponds for quality checking according to the requirements of Pluak Daeng Industrial Park (Industrial Park) prior to discharging into Pluak Daeng IndustrialPark's central wastewater treatment system. Wastewater from wash rooms and toilets is drained into the septic tanks. During the construction period, it is estimated that there will be 234.2 m^3 of wastewater per day. With this regard, the Project requires that the contractors provide bathrooms and toilets to their workers and staff with the ratio of 15 persons to one room. As for the hydrostatic test water discharge of about 250 m^3 will be measured for pH, temperature, and volume of suspended solids, oil and grease to ensure that the values of these indices are within Pluak Daeng Industrial Park's specified criteria prior to discharging into Pluak Daeng Industrial Park's central wastewater treatment system. In terms of rainwater, it is likely to be contaminated with deposits of soil, sand or debris from the construction so it will be drained into temporary sedimentation pond for soil or sand sedimentation before draining clear water into rain gutter drainage system of Pluak Daeng Industrial Park later. As a result, the impact level on surface hydrology during the construction period of the project is low while there is no impact on surface water quality.

During the operation period, discharged water will come from two sources: 1) the electricity generating process and 2) the cooling system. The wastewater discharged from the process consists of wastewater from the water treatment system, the operation room and the office building at the maximum volume of 48 m^3/day. This discharged water will be initially treated before sending to the project's wastewater holding pond which has the capacity to retain the discharged water for at least one day. The pond will be equipped with online monitoring of water quality to check the temperature, pH and conductivity (to find Total Dissolved Solid) in accordance with the requirement of the industrial estate before sending it for treatment in Pluak Daeng Industrial Park's central wastewater treatment system.

Water discharged from the cooling tower of 12,232 m^3/day maximum is uncontaminated and free from substances from the production process, and it will be retained at the project's two cooling water holding ponds with the holding capacity of 19,000 m^3 each. Each pond can retain the water for at least one day. While one of the ponds is being used, the other pond will serve as the emergency pond. The discharged water is retained here before being released into the cooling water holding pond of Pluak Daeng Industrial Park which can take in the water for another one day. The project has installed a water quality online monitoring system to check temperature, pH and conductivity (for the purpose of the detection of the total dissolved solid (TDS)) in the cooling water holding pond in accordance with Ministry of Industry's Quality Standards of Discharged Water where the level of total dissolved solid must be within the standards of the Royal Irrigation Department on the quality of discharged water in the waterways and temperature not exceeding 34 ^{o}C. The cooling water is finally drained into Huai Phu Sai canal flowing through Pluak Daeng Industrial Park. The difference between temperature of mixing water (drained cooling water and water in Huai Phu Sai and that of Huai Phu Sai canal is lower than 3 ^{o}C.

Moreover, the water quality in Huai Phu Sai, and Dok Krai reservoir, which connect to each other, was forecasted to evaluate the impact from the cooling water drained from the cooling water holding pond of Pluak Daeng Industrial Park into Huai Phu Sai. The water quality forecast was conducted by calculation of SAR, and BOD and TDS concentration in (1) Huai Phu Sai after receiving the cooling water, and (2) Dok Krai reservoir after receiving water from Huai Phu Sai. The quality of the cooling water was taken from that of Kaeng Khoi power plant 2 which is IPP power plant of Gulf Group and currently operating. The results show that SAR, and BOD and TDS concentration in Huai Phu Sai (during wet season) and Dok Krai reservoir do not change significantly. However, the water in those water resources after receiving the project's cooling water still could be used for water use for agriculture and production of tap water.

Therefore, the impacts from the discharged cooling water on Huai Phu Sai, and Dok Krai reservoir are low. Nevertheless, to monitor the water quality in the water sources adjacent to the project and Pluak Daeng Industrial Park, the project will continue with examination of the level of SAR and Chlorophyll A to monitor the environmental impacts throughout the duration of the project.

10.1.4 Aquatic Ecology

During the construction period the Project will produce scraps that can be washed out of the Project site and affecting the ecology of water resources in the surrounding areas. The Project, thus, has established mitigation measures, such as washing tire of the trucks leaving the construction area or construction-related areas to prevent dirt and sand from potential stains on the roads both inside and outside of the Project area. This will eventually avert the dirt and debris from various construction projects, from being washed directly into the public waterways. Storm water within the construction site will be collected in the rain gutter drainage system and drained into temporary sedimentation pond for retention and sedimentation inside the Project site. The solid sediments are separated from the rainwater and the clear water is recirculated for use to spray roads to reduce suspended particulate levels in the Project site. The remaining volume will be drained into Pluak Daeng Industrial Park's rain gutter drainage system. Therefore, it can be estimated that the construction activities of the Project will have low impact on an aquatic ecology in the areas surrounding the Project site.

During operation period, the impact assessment on aquatic ecology is not only considered wastewater treatment of the project and Pluak Daeng Industrial Park, but also considered the use of chemical substances in the process. The chemical substances are considered to affect the aquatic ecology, namely, chlorine dioxide (ClO_2), ammonia (NH_3) and phosphate (PO_4^{3-}).

The project has selected the ClO_2, the substance that will not generate Trihalomethane (THMs), or other compounds that have been studied or confirmed not to cause any environmental impact, to dispose biofilms and microorganisms in the cooling blowdown. However, there may be some impacts on aquatic ecology that may affect aquatic lives because ClO_2 will change to chlorite (ClO_2^-). From the calculation showed that Huai Phu Sai, and Dok Krai reservoir after receiving the cooling water from the project, which yields the concentration of chlorite of less than 1 mg/l, will have chlorite with concentration of 0.2 mg/l. This concentration of chlorite is too low to cause the impact on fish, mysid shrimp and phytoplankton as relevant reference document.

Pluak Deang Power Plant uses trisodium phosphate (Na_3PO_4) in its boilers to prevent slag formation. The remaining water in the boilers will be blowdown and mix with the cooling blowdown. Regarding the rate of phosphate use of the 10 % concentration substrate, the annual use is 30 m^3. If phosphate dissolution from the heat does not occur, the boiler blowdown when mixing with the cooling blowdown will produce phosphate of the concentration of 0.38 mg/l to be discharged into the canal. The concentration of phosphate will be diluted when mixing with Huai Phu Sai, and flows into Dok Krai reservoir. Whereas the concentration of phosphate that will cause eutrophication is 0.29 mg/l with the nitrogen (TKN) concentration in water of about 0.2 mg/l. As the result, the assessment of phosphate can be concluded that the concentration of phosphate and nitrogen were not at the levels that may pose a problem of eutrophication.

Ammonia used in the project is to (1) control nitrogen oxides produced by the fuel firing and (2) control water quality in the boilers/boiler pipeline system, which later will be the blowdown mixing with the cooling blowdown. From calculation ammonia concentration in the cooling blowdown of Pluak Deang Power Plants will be equal to 0.49 mg/l. After cooling blowdown from Pluak Deang Power Plant is discharged into Huai Phu Sai the average of ammonia concentration in Huai Phu Sai will be 0.18 mg/l. According to surface water quality standards from the Announcement of the National Environment Board, No.8 (November, B.E. 2537), the ammonia level in water bodies, Class 1, Class 2 and Class 3, which are clean water bodies suitable for living things, shall not exceed 0.5 mg/l Therefore, when the effluent from the cooling system is discharged into Huai Phu Sai, the total ammonia in Huai Phu Sai will still meet the standards. This will not affect aquatic ecology. As ammonia evaporates from water body, ammonia level will reduce. Aditionally, ammonia will not accumulate in Dok Krai Reservoir as water is pumped from the reservoir and ammonia can evaporate from water.

10.1.5 Infomration Disclosure, Public Consulations and Participations

Public consultations were held two times. The participants consist of agencies at provincial, district and sub-district level, community leaders, local people, representatives of local educational institutes and environmental NGOs, local mass media, fisherman group utilizing the Dok Krai Reservoir, and interested general public with the total of 582 and 711 in the first and the second public consultation, respectively.

The concerns and recommendations expressed in the public consultations can be categorized into main 7 aspects: cumulative impact from air pollution on long term agricultural sector and people’s health, impact on water quality in Huai Phu Sai and Dok Krai Reservoir, traffic accident and inconvenient transportation, safety system of the project, water use, fishery, benefit to the community and public participation to monitor the project implementation. All of the concerned were considered and incorporated in the project's environmental impact mitigation measures.

In addition, power plant visit was arranged to create the learning process from a direct personal experience of the public target group and to create the understanding with one another which would be beneficial to the coexistence between the community and the Project. The participants were community headmen and local people within the study area. For this reason, a power plant visit was arranged for the public in the vicinity of the Project and within the study area with the objective of creating knowledge and understanding about the operation of power plant. A group of 402 participants were taken to visit Kaeng Khoi Power Plant 2, Kaeng Khoi District, Saraburi Province.

To ensure the representatives of communities receive sufficient knowledge from the field trip, Gulf PD Co., Ltd. arranged activities during the visit to the power plant and the natural gas pipeline system within the power plant. The participants viewed a video presentation and listened to briefing from the personnel of the Kaeng Khoi Power Plant 2. The briefing included the information on background of Kaeng Koi Power Plant 2, the power generating process, the pollutant and water controls followed the generating process, the policy on the supervision of the environment and the conduct of the community relations activity. Additionally, stage was opened for participants to ask questions and the representatives of the Project including environment unit, community relations unit, personnel of Kaeng Khoi Power Plant 2 jointly answered all questions.

10.1.6 Public Health

The health impact assessment was conducted within the concentration on local people in sensitive receptors within 5 km radius around the project site, including the project staff and workers. The study was conducted in accordance with Guidelines for HIA in Thailand's EIA Report and Thailand's EIA Manual by Environmental Impact Evaluation Bureau, Office of Natural Resources and Environmental Policy and Planning (ONEP), Ministry of Natural Resources and Environment (June 2008) and carried out according to the notification of Ministry of Natural Resources and Environment prescribing rule, method, regulations and EIA guideline for project may cause severe impact to communities, environmental quality and health B.E.2552 (2009), 29 December 2009).

According to the public health personnel survey from 9 medical centers in the study area, 8 8 . 9 % of the interviewees stated the inadequacy of medical personnel and medical devices. 66.7% of local public health personnel viewed that the existing environment causing health impact to people comprised air quality, water quality, chemicals, etc.

According to the opinion survey, 55.6% stated that during the construction period, the project would bring about advantages in socio-economic aspect to the study area. The remaining interviewees viewed that the project would cause problems to the study area, such as dust, traffic congestion, migrant and foreign workers, etc. Besides, nearly all public health personnel (88.9%) expressed their concerns about air quality (dust), noise from construction material and equipment transportation, blockage of drainage channel, increased number of workers, contagious diseases from workers, increased number of patients, accident at work, and accident during construction materials and equipment transportation. Furthermore, they were concerned about additional responsibilities during the project construction period.

10.1.7 Major Hazard Assessment

The simulation of any leak and flammable of chemical substances such as natural gas, diesel oil and aqueous ammonia by BREEZE HAZ model, consideration is taken on leak characters (instantaneously or slowly) and ignition characters (instantaneous ignition or delay ignition). For the studied results of impacts to be occurred to adjacent areas including natural gas transmission pipeline system, diesel transportation pipeline system, and diesel storage tank, consideration was taken on areas with any leakages and ignition.

It is found that when natural gas/diesel oil is assumed to be leaked and ignited, the radius of heat radiation is mostly in the power plant site. From risk probability, it is found that the project risk is at a low level.

For the chemicals and boiler explosion hazard, it is found that the probability is at a low level. In addition, the project has prepared safety management measure from the design period through installation to operation and annual examination for maximum safety benefit will be regularly conducted.

Although the risk analysis indicated that the project has low level risk, the project development will strictly follow international standards for the design, construction, operation and maintenance. In addition, the project has prepared emergency plans and training program to be able to handle the emergency situation at all time.

10.2 RECOMMENDATIONS

Based on the results of the EIA study, the necessary recommendations can be emphasized as follows:

(1) The project shall be under all conditions, strictly enforce the implementation of the proposed environmental measures designed for the construction and operation phases in order to avoid or minimize both environmental and social impacts on the surrounding communities and general public.

(2) The project shall always conduct an environmental study for any modification of the project design and/or the environmental action plan to find out the environmental feasibility before making the decision.

(3) The public praticipations are the ongoing activities throughout the project implementation. The comments, concerns and suggestions from concerned stakeholders shall be considered and incorporated into the project environmental management plan as appropriate.