


Prepared For:

Inter-American Development Bank

ENVIRONMENTAL ASSESSMENT
LNG Re-gasification Plant Expansion
Woodbourne, St. Patrick Barbados

August 2016

Environmental Resources Management (ERM)
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LIST OF ACRONYMS

BNOCL	Barbados National Oil Company Limited
dB	Decibel
dBA	A-weighted decibels
EA	Environmental Assessment
ESHS	Environmental, Social, and Health and Safety
ESMP	Environmental and Social Management Plan
ESR	Environmental and Social Responsibility
Km	Kilometers
Leq	Equivalent continuous sound pressure level over a given period
LNG	Liquefied Natural Gas
m	Meters
Mcfpd	Thousand cubic feet per day
NPC	National Petroleum Corporation

EXECUTIVE SUMMARY

Introduction

The National Petroleum Corporation (NPC) and the Barbados National Oil Company Limited (BNOCL) are evaluating various strategies/options to manage the county shortfall in NG supply for the Christmas period in Barbados. The strategies being considered include the following phases:

- Phase I of the strategy includes the expansion/upgrade in the short-term of the BNOCL LNG regasification facility/plant located in Woodbourne, the upgrade of NG transmission line, and distribution infrastructure. This infrastructure development project will be financed by Inter-American Development Bank (IDB).

- Phase II of the strategy includes the construction and operation in the medium- and long-term of an LNG importation facility to supply NG to the power sector (LNG Public-Private Partnership [PPP] project). The IDB is planning to provide support to develop an environmental and social impact assessment for the Project.

This Environmental Assessment (EA) addresses the potential impacts associated with the implementation of Phase I. It also provides a brief comparison of alternative sites for the terminal and storage component of the Phase II project. An Environmental Assessment of the conceptual plan for the Phase II project will be prepared separately.

Project Description

The existing BNOCL LNG regasification facility/plant, commissioned in December 2015, is located near Woodbourne, Saint Philip, in the Parish of Christ Church, Barbados. The plant re-gasifies liquefied gas to NG and has the capacity to receive three iso-containers simultaneously. Iso-containers are 40 feet long, with the capacity to hold approximately 9,000 gallons of LNG and are delivered to the plant via trucks from ships landed at the Bridgetown Port facility. The plant, located approximately 30 kilometers (km) from the Port, was built to meet the National Fire Protection Association (NFPA) standard 59A (standard for the production, storage, and handling of LNG). At the plant, LNG is re-gasified and processed to NG using ambient air vaporizers. The NG is injected into NPC's existing distribution system. Currently, the plant can handle three iso-containers per week with a capacity up to 460 thousand cubic feet per day (mcfpd).

The proposed expansion of the existing LNG facility in Woodbourne includes the following upgrades. All of the proposed upgrades to the existing facility will be located within the existing plant footprint and no new land will be required or disturbed outside of the property.

- Expansion of the re-gasification facility to handle seven iso-containers per week;

- Expansion of the western parking bay to accommodate seven iso-containers trucks;
- Installation of two 50,000 gallons horizontal LNG storage tanks;
- Expansion of the secondary containment pit;
- Relocation of the existing flare gas line;
- Installation of new piping from the tanks to existing vaporizers; and
- Upgrade of existing NG transmission line (pipeline) from a regulation station in Woodbourne to a connection near the Grantley Adams International Airport.

Agency Meetings and Regulatory Requirements

ERM conducted meetings with pertinent regulatory agencies and governmental entities in Barbados to discuss the project and obtain their opinion on the potential project impacts and regulatory requirements. The capacity increase at the Woodbourne plant only requires a construction permit from the Town & Country Development Planning Office.

The Woodbourne LNG Plant Expansion triggers the following IDB environmental and social safeguard policies and directives, per IDB OP-703:

- B.2, Country Laws and Regulations: local requirements include only a development permit from Town and Country Planning Office. No EA or EIA is required.
- B.3, Screening and Classification. The project will have negligible to minor impacts and a small risk. It is classified as Category B.
- B.5, Environmental Assessment Requirements: This EA addresses the requirement for environmental assessment for the project.
- B.6, Consultations: NPC conducted a public consultation.
- B.7, Supervision and Compliance: A monitoring plan will be implemented for the project.
- B.10, Hazardous Materials: The project deals with small amounts of hazardous materials, such as fuels for truck operation. The environmental and social management plan (ESMP) for the project addresses the handling of these materials.
- B.11, Pollution Prevention: The project as a minimal risk of pollution, as it has minimal sources of pollution. The ESMP addresses the risk of pollution.

Environmental and Social Baseline

General Conditions at the Site and its Vicinity

The Woodbourne LNG Plant is located in a mixed-use area, where oil/gas wells, gathering lines, and a NG compressor station are embedded in a matrix of sugar cane parcels. BNOCL operates the oil/gas field and compressor facilities and owns the parcel where the plant is located. The nearest residential areas are located more than 400 meters to the southwest of the site.

Physical Environment

Barbados has a mild subtropical climate with average temperatures that range from 24 to 28 °C and humidity that ranges from 71 to 76 % (Evanson 2014). There is a dry season from January to June and a wet season that starts in late June and goes thru December.

The island of Barbados is the most eastern island of the English Caribbean chain of islands (Lesser Antilles) and topographically the island is relatively flat, composed of coral limestone, crossed with deep river-bed gullies that accommodate the movement of water during heavy rain.

The existing LNG facility in Woodbourne is located in a rural mixed land use area (industrial/commercial/residential). The nearest noise sensitive area is a resident located approximately 450 m southwest of the facility. The major source of ambient noise at the project area are the existing LNG re-gasification facility, compressor station, vehicle traffic on nearby roadways, and farm equipment operating in nearby fields.

Natural Hazards and Risks

The main natural hazard for Barbados is the occurrence of hurricanes. Approximately 12 hurricanes and several tropical storms have crossed the Island of Barbados from 1851 to 2010.

The main risks associated with the project are related to the handling of LNG. When LNG is spilled on land the gas it is initially denser than air and will form a vapor cloud close to the ground, as the gas is warmed and mixes with air it becomes less dense and rises and dissipates into the atmosphere. If a large volume of LNG is spilled in a short space of time the vapor cloud can serve to 'insulate' the LNG pooled on the ground allowing the LNG to remain for an extended period without totally evaporating. To mitigate the risks of an accidental LNG release from a LNG tank or iso-container, BNOCL has developed an emergency response plan to handle and mitigate any emergency at the plant or accident during the transportation of the iso-containers from the port to the plant. BNOCL has also conducted a fire risk analysis for the LNG plant to evaluate the risks of fires at the plant.

Biological Environment

Barbados is in the Windward Islands Xeric Scrub ecoregion and is included in the Caribbean Islands biodiversity hotspot. The biodiversity of Barbados has been influenced since the island was settled in 1627. Numerous species of plants and animals have been introduced, competing against indigenous species. In addition, habitats were altered and fragmented as the island was settled.

Socioeconomic Environment

Barbados is one of the mostly densely populated countries in the world, having a population density of 646 people per square kilometer at the most recent (2010) census. In 2010, the population of Barbados was 277,821, of which 47.9 % were male and 52.1 % female.

There was a general decline in the unemployment rate in Barbados from 1995 when it was 19.7 % until 2007 when it was 7.4 %. In 2010, the unemployment rate was 10.8 % and in 2015 it was estimated at 11.3 %. There has been a decline in employment in the agricultural and manufacturing sectors and a rise in employment in the services sector.

A survey conducted in 2010 indicated that 15 % of households and 19.3 % of individuals in Barbados were below the poverty line. The data indicate that the poverty gap (the extent to which the poor existed below the poverty line) and the severity of poverty compare favorably with those in Caribbean countries.

Impacts and Mitigation

The proposed construction (expansion and upgrades) and operation of the LNG plant will affect environmental and socioeconomic conditions in the project area. Project construction activities will be confined to inside the existing plant site, with no disturbance to new, undeveloped areas. Operation of the expanded facility will be of similar intensity as current operations. Traffic impacts will be minor, as the number of additional trips is minimal. The project is not expected to result in any major adverse impact and only two are considered minor impacts (i.e., vapor release from the potential rupture of the storage and iso-container tanks and fire hazard), the rest of the potential impacts are expected to be negligible.

The negligible to minor impacts of the project will be mitigated and managed with the application of industry-standard best practices. An Environmental and Social Management Plan prepared for the project summarizes these best practices. Any contractor or supplier that may be involved in the project will be required to incorporate the proposed mitigation measures and management controls within their own working procedures and plans.

Project Impact Category

The proposed Woodbourne LNG Plant Expansion will have negligible to minor impacts on the environment or the community. However, the handling of LNG involves minor potential

risks, which merits that the Project be classified as Category "B". In accordance with OP-703, Category B projects "are likely to cause mostly local and short-term negative" impacts, for which "effective mitigation measures are readily available".

1.0 INTRODUCTION

The National Petroleum Corporation (NPC) and the Barbados National Oil Company Limited (BNOCL) are evaluating various strategies/options to manage the country's shortfall in NG supply during the Christmas season— a critical period for the tourism sector. The main objective of the strategies being developed is to implement short, medium and long-term measures to resolve the current problem of shortage of NG and to ensure the security of supply to Barbadians. The strategies being considered include two phases:

- Phase I includes the expansion/upgrade of the BNOCL LNG regasification facility/plant located in Woodbourne and the upgrade of NG transmission line and distribution infrastructure. This infrastructure development project will be financed by Inter-American Development Bank (IDB).

- Phase II of the strategy includes the construction and operation of an LNG importation facility to supply NG to the power sector (LNG Public-Private Partnership [PPP] project). The IDB is planning to provide support to develop an environmental and social impact assessment for the Project.

This Environmental Assessment (EA) addresses the potential impacts associated with the implementation of the Phase I strategy. It also provides a brief comparison of alternative sites for the terminal and storage component of the Phase II project. An Environmental Impact Assessment of the Phase II project will be prepared separately.

2.0 PROJECT DESCRIPTION

2.1 PHASE I

2.1.1 Existing LNG Regasification Facility

The existing BNOCL LNG regasification facility/plant, commissioned in December 2015, is located near Woodbourne, Saint Philip, in the Parish of Christ Church, Barbados (see Figure 2-1). The plant re-gasifies liquefied gas to NG and has the capacity to receive three iso-containers simultaneously. Iso-containers are 40 feet long, with the capacity to hold approximately 9,000 gallons of LNG and are delivered to the plant via trucks from ships landed at the Bridgetown Port facility (see Figure 2-2). The plant, located approximately 30 kilometers (km) from the Port, was built to meet the National Fire Protection Association (NFPA) standard 59A (standard for the production, storage, and handling of LNG). At the plant, LNG is re-gasified and processed to NG using ambient air vaporizers. The NG is injected into NPC's existing distribution system. Currently, this plant can handle three iso-containers per week with a capacity up to 460 thousand cubic feet per day (mcfpd). The proposed expansion and upgrades of the existing uploading LNG facility will increase the reception capacity of LNG iso-containers to seven, with a total capacity of 1 million mcfpd. The upgrades of the facility also include the installation of two storage LNG tanks (50,000 gallons each) and the construction of a new gas pipeline (6 inches in diameter) approximately 4 km long from a regulator station in Woodbourne to a connection near the Grantley Adams International Airport.

The existing facility is comprised of two storage iso-containers spaces/bays operating at approximately 10 bar of pressure (see plant layout in Figure 2-2). The LNG in these tanks flows via 2-inch transfer hoses to two LNG vaporizers (see Figure 2-3). Figure 2-4 shows the flow diagram of the plant.

2.1.2 Transportation of Iso-containers

Incoming iso-containers are loaded at the Port onto trucks (Figure 2-5) and transported to the Woodbourne Plant. Drivers are trained on safety requirements, per US Department of Transportation guidelines (Code of Regulations Title 49 – Transportation). The training includes LNG Safety and Handling.

The main route between the Port and the Plant follows main roads, mostly along two-lane signalized primary roads. In case the main route is affected by any reason, drivers can take one of two alternative routes (see Figure 2-6).

FIGURE 2-1 APPROXIMATE LOCATION OF THE EXISTING LNG REGASIFICATION FACILITY

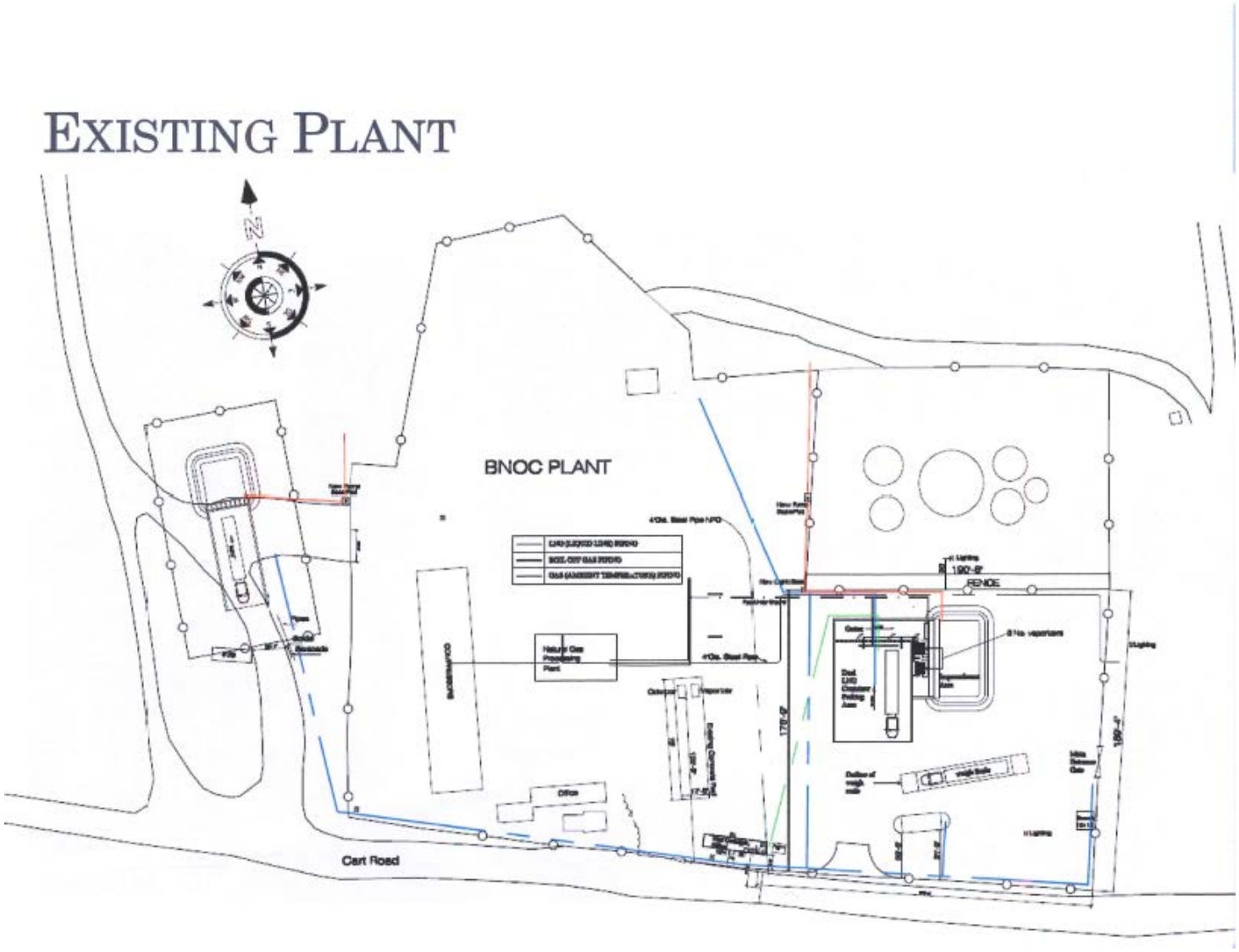
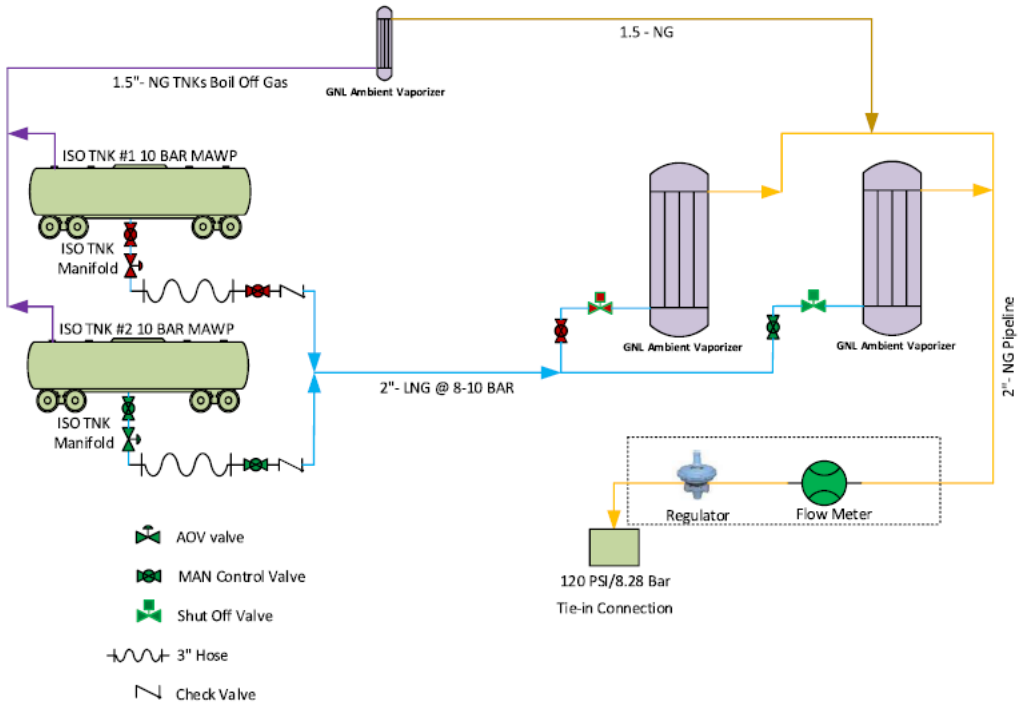


FIGURE 2-2 EXISTING LNG PLANT FACILITY

Source: BNOCL 20016.

FIGURE 2-3 ISO-CONTAINERS/TANKS UNLOADING PARKING AREA AND VAPORIZERS



Source: BNOCL 20016.

FIGURE 2-4 EXISTING LNG PLANT RE-GASIFICATION PROCESS FLOW DIAGRAM

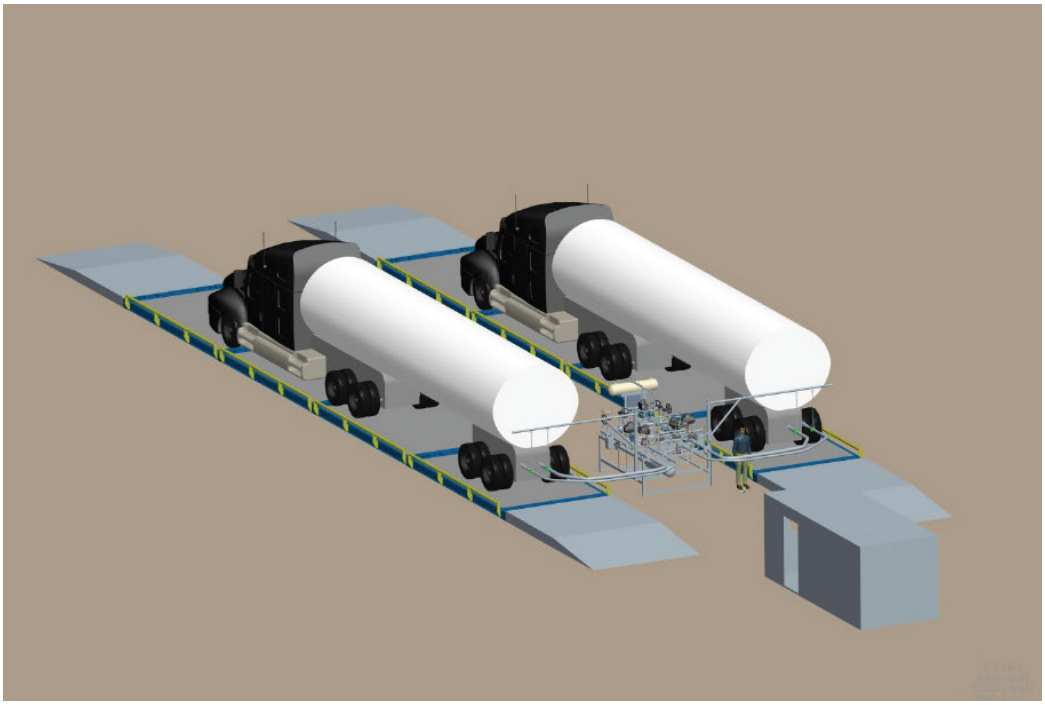


FIGURE 2-5 ISO-CONTAINERS/TANKS AND TRUCK UNLOADING

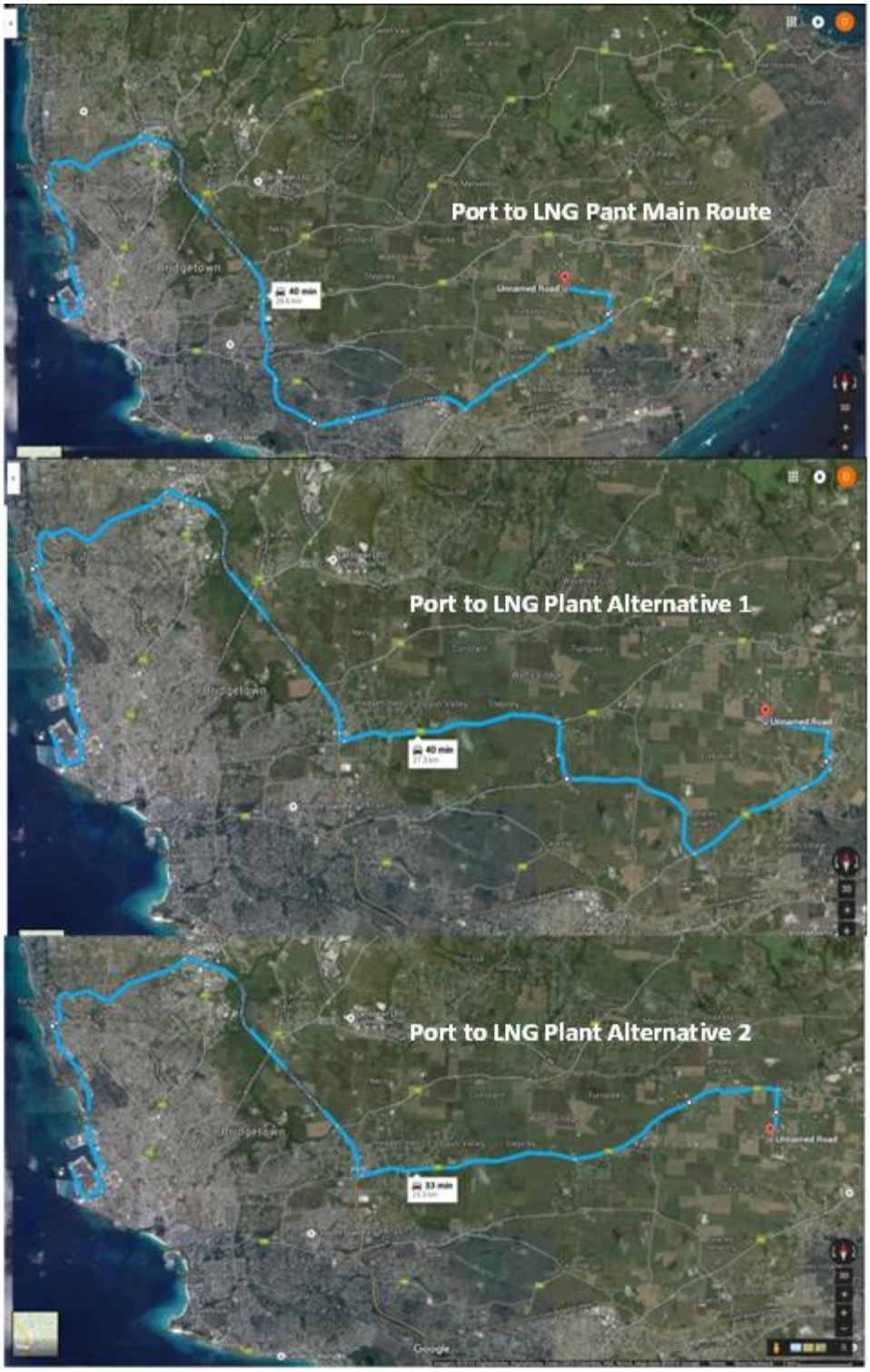


FIGURE 2.6 TRANSPORTATION ROUTES BETWEEN THE PORT AND THE WOODBOURNE PLANT

2.1.3 LNG Facility Expansion and Upgrades

The proposed expansion of the existing LNG facility in Woodbourne includes the following upgrades. All of the proposed upgrades to the existing facility will be located within the existing plant footprint and no new land will be required or disturbed outside of the property.

- Expansion of the re-gasification facility to handle seven iso-containers per week;
- Expansion of the western parking bay to accommodate seven iso-containers trucks;
- Installation of two 50,000 gallons horizontal LNG storage tanks;
- Expansion of the secondary containment pit;
- Relocation of the existing flare gas line;
- Installation of new piping from the tanks to existing vaporizers; and
- Upgrade of existing NG transmission line (pipeline) from a regulation station in Woodbourne to a connection near the Grantley Adams International Airport.

2.1.4 Storage Tanks and Iso-containers Parking Bay Location Alternatives

The main upgrades to the existing LNG plant include the construction of two storage tanks capable of holding 50,000 gallons of LNG each and expansion of the secondary containment pit. In addition to the construction of seven additional truck iso-containers LNG parking bays; one of the parking bays will be connected to the uploading regasification infrastructure, increasing the number of uploading bays from two to three.

Figures 2-7 to 2-9 show three design upgrade options considered for the location of the LNG storage tanks and iso-containers truck parking areas. Option 1 includes the installation of the two storage tanks next to the uploading bay facility (east side) and the construction and expansion of the western parking bay to accommodate six iso-containers trucks (see Figure 2-7). Option 2 includes the installation of the two storage tanks in the central portion of the facility, near the gas processing plant and the construction of four parking bays next to the uploading bay facility (see Figure 2-8). Similar to Option 1, Option 3 includes the construction and expansion of the western parking bay to accommodate six iso-containers trucks (see Figure 2-9); however, the two storage tanks will be installed north of the expanded parking bay area, next to a newly constructed

secondary containment pit. Option 3 was selected as the preferred design option.

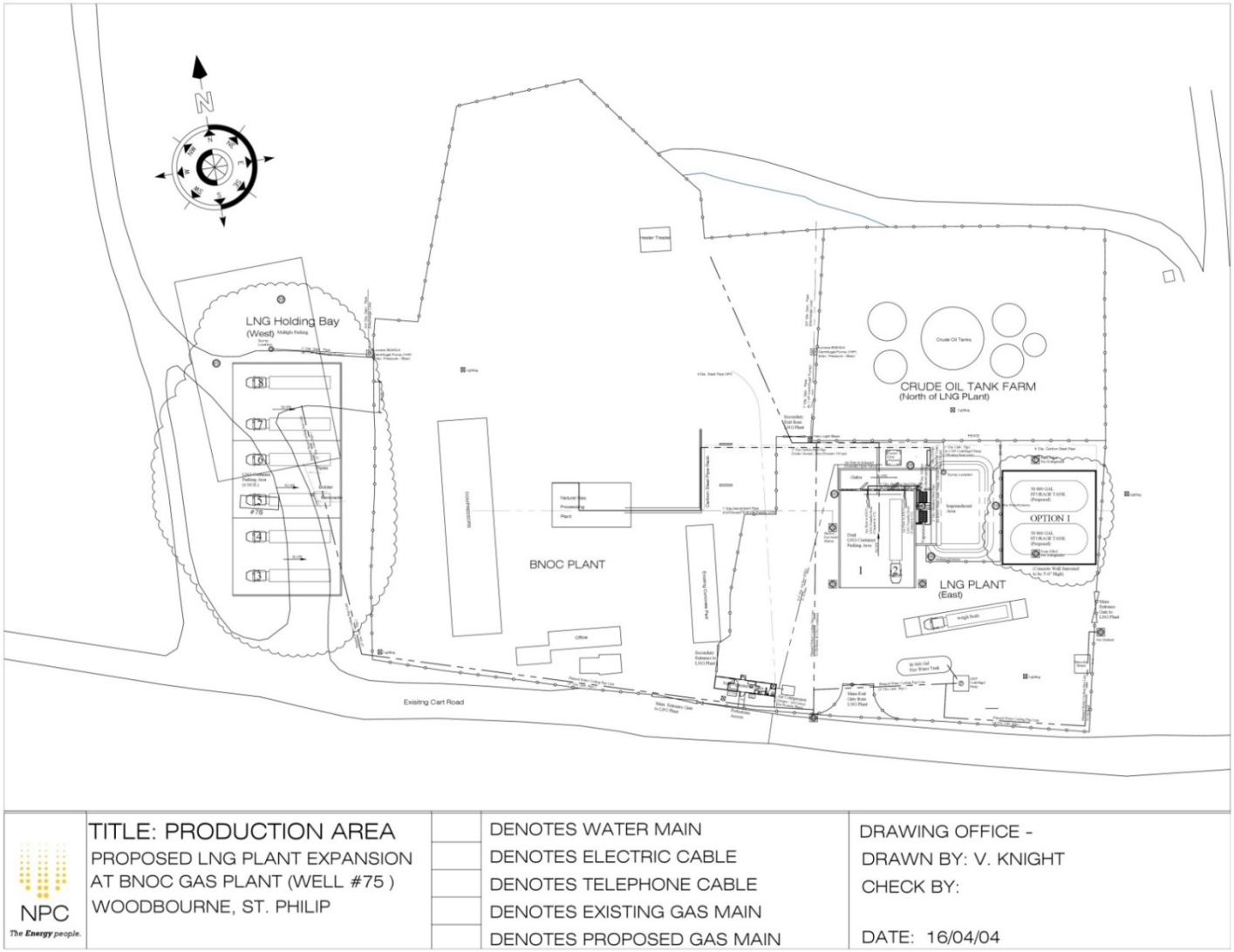


FIGURE 2-7 LNG PLANT LOCATION AND DISTRIBUTION OF ISO-CONTAINERS AND LNG STORAGE TANKS – DESIGN OPTION 1

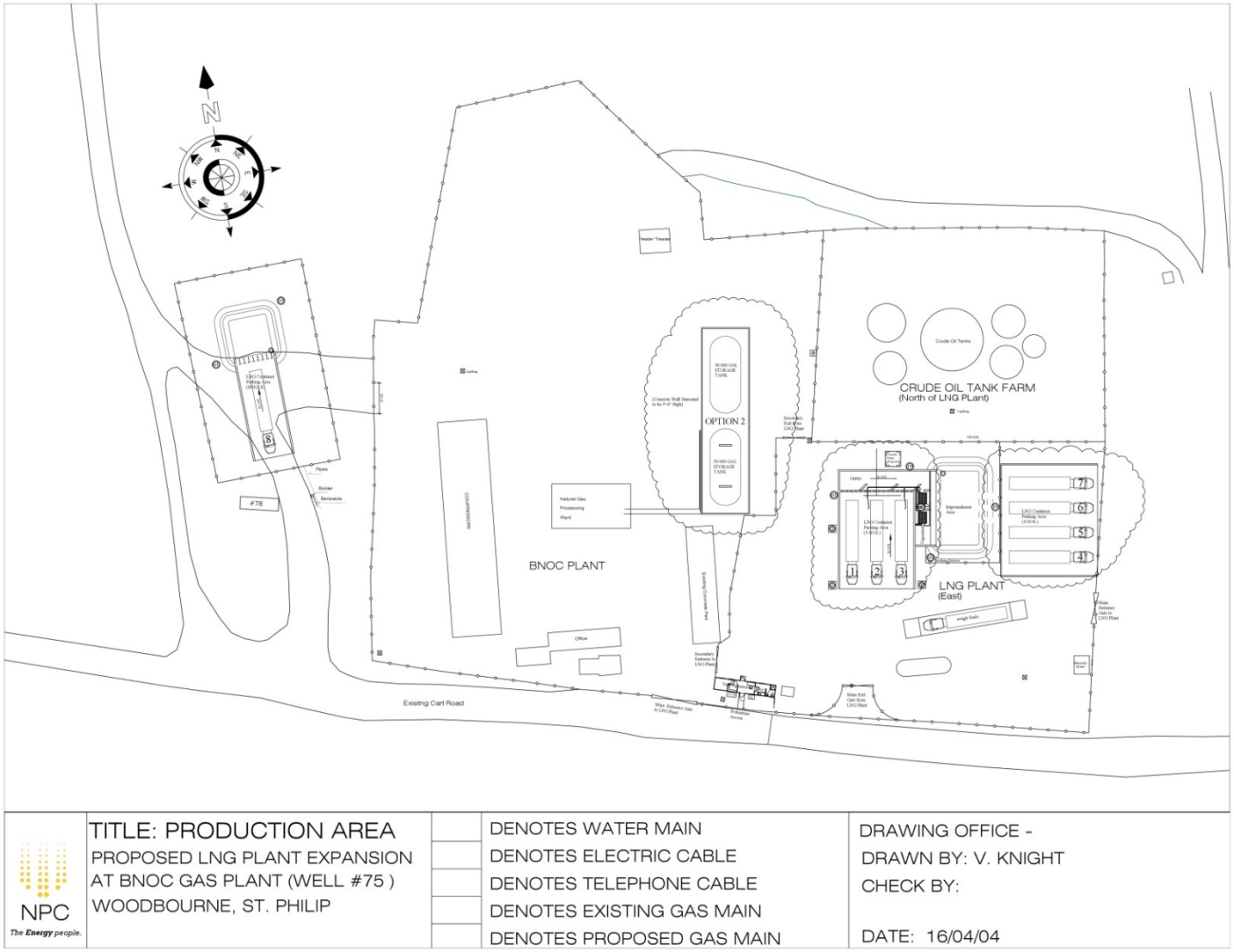


FIGURE 2-8 LNG PLANT LOCATION AND DISTRIBUTION OF ISO-CONTAINERS AND LNG STORAGE TANKS – DESIGN OPTION 2

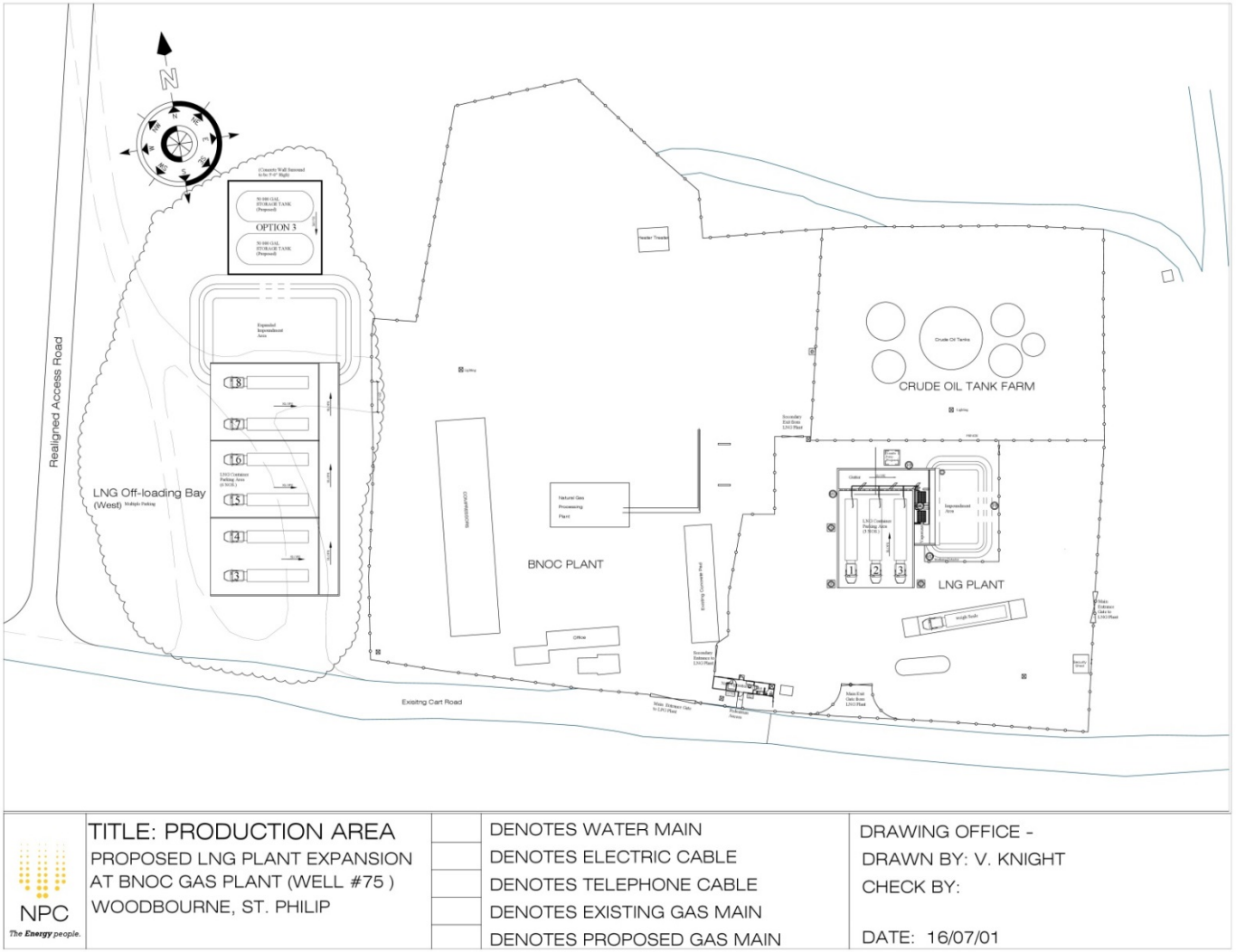


FIGURE 2-9 LNG PLANT LOCATION AND DISTRIBUTION OF ISO-CONTAINERS AND LNG STORAGE TANKS – DESIGN OPTION 3

2.1.5 Natural Gas Transmission Line Upgrade

The upgrade of the existing NG transmission line (gas pipeline) include the installation of a new pipeline of 6 inches in diameter to supply NG to the power plant adjacent to the Grantley Adams International Airport, which is located due south of the LNG plant (see Figure 2-10). The pipeline will be approximately 4.0 km long and it originates at the regulator station in Woodbourne.

The small diameter pipeline will be installed within an existing pipeline right-of-way corridor. The pipeline starts at the regulator station at Woodbourne and will run alongside an existing NG main for most of the route. Before joining the Walronds to Charnocks road, the pipeline traverses about 250 meters across an agricultural field, alongside the existing main. The route was ground-checked on August 24th and NPC line markers were identified showing the location on either side of the field. The route review indicated that there is an existing right-of-way agreement in place that will be updated to facilitate the upcoming work.

From the open field, the route runs within the paved portion of existing roads to its terminus near the airport. No new rights-of-way will be necessary for this pipeline.

NPC is planning to subcontract the installation of the pipeline and has developed a set of technical specifications, including EHS, emergency, and traffic management guidelines. The technical specifications are detailed in Appendix D(a) of the ESMP attached to this report. In summary, the following guidelines and process will be followed during the installation and construction activities:

- The pipeline right-of-way is shared with other utility companies (e.g., electricity and communications), who are asked to conduct site visits and mark where any affected underground utilities are located.
- If road closures are necessary during the installation, the contractor will notify the media to alert the public of the intended closures.
- During construction, access to houses is not expected to be severely impacted; however, if there are access impacts, the owners will be notified in writing of the intended start date and estimated completion date.
- Traffic signs and wardens are placed to assist in managing traffic flow around the construction site.

- NPC Fitter's team is on site to inspect the trench to ensure its cross section meets NPC requirements for depth and width. Typical trench dimensions are 14"x 30".

- The bottom of the trench is covered in a layer of sand.

- If a portion of the trench is left open overnight, a security fence will be placed on either side with barrels or metal bars used as reinforcement to prevent pedestrians from falling into the trench. Amber flashing lights are placed at regular intervals along the trench to alert traffic users at night.

- When the pipeline is completed, it will be tested for structural integrity over a 24 hour period. The test is recorded using an analog chart box.

- The filled compacted trench will be tested for compaction levels by the Ministry of Transport and Works. If it passes the test, then the road is re-instated fully; if not, then compaction is conducted again.

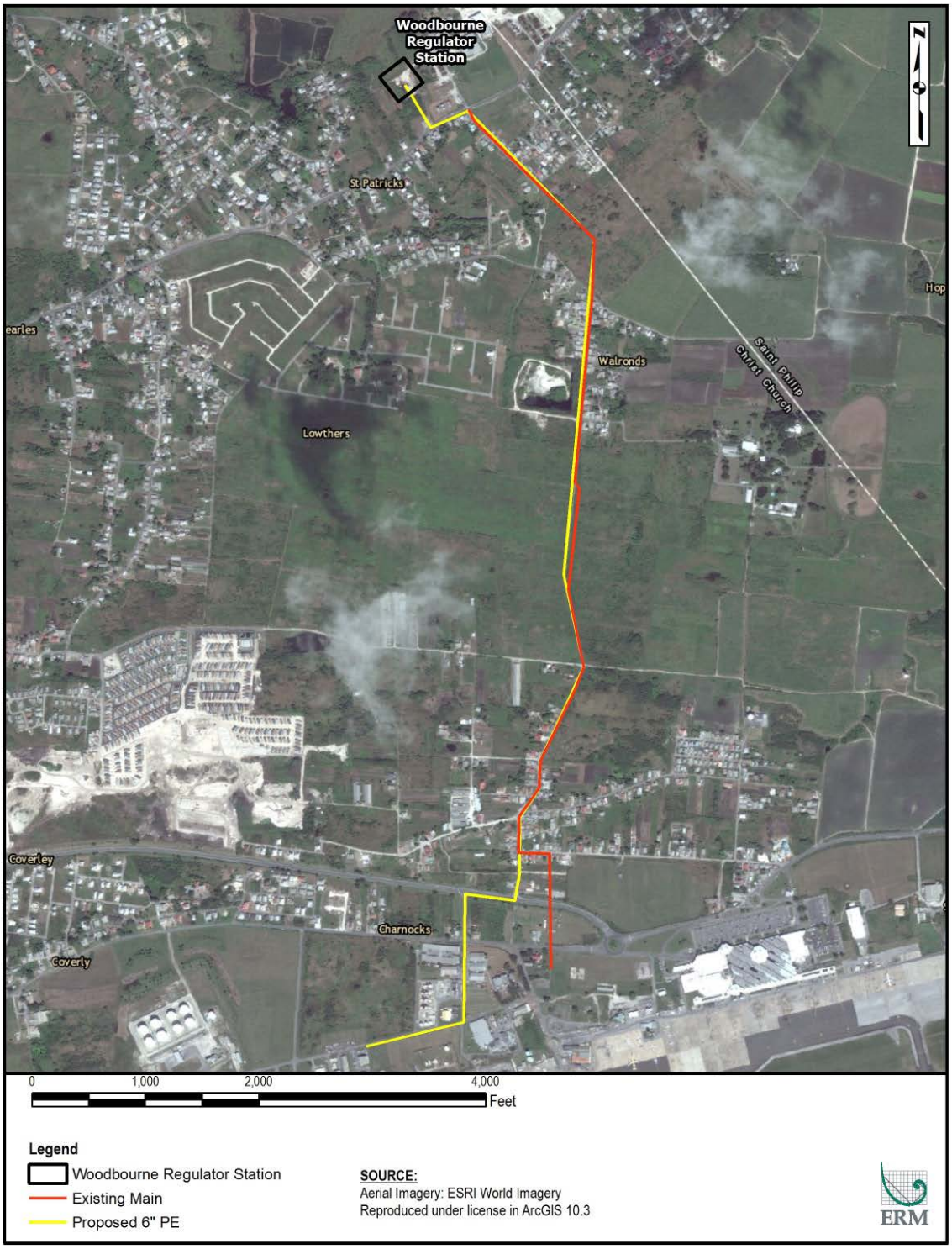


FIGURE 2-10 LOCATION OF THE UPGRADED PIPELINE

2.2 *PHASE II: BRIEF COMPARISON OF ALTERNATIVE SITES*

As described in *Section 1 – Introduction*, Phase II of the long-term strategy to resolve the shortage of NG in Barbados is the construction of an LNG importation facility (LNG Terminal) to supply NG to the power sector of Barbados. This phase of the project is proposed to be financed under a Public-Private Partnership (PPP). The main purpose for the construction of this facility is to satisfy demand from power plants, which are expected to have a fuel upgrade switching to NG fueling for power generation. Two alternative sites are being considered (Figure 2-11):

- Port of Bridgetown Site: The LNG terminal would be located in the Port of Bridgetown area at one of two potential locations in the north or south of the basin of the Bridgetown Harbor. Both locations are located within the existing port facility in an industrial brown field area, already disturbed and in operation.
- St. Lucy Site: This Alternative site is located in the St. Lucy area, in the northern tip section of the Island of Barbados, south and next to the Arawak Cement, Ltd facility. The parcel where the facility would be constructed is undeveloped and vegetated, and is adjacent to a residential development to the east and the community of Green Touch.

From an environmental and social standpoint, the Port of Bridgetown site appears as the preferred site, as it is already under industrial uses and requires minimal disturbance of undeveloped areas. Therefore, it minimizes impacts to flora, fauna, soils, and hydrology with respect to the St. Lucy site. Table 2-1 summarizes the comparison of potential impacts between the two sites.

TABLE 2-1 COMPARISON OF POTENTIAL IMPACTS OF ALTERNATIVE SITES FOR PHASE II FACILITIES

Environmental/Social Resource Potentially Impacted	Port of Bridgetown	St. Lucy	Comments
Climate and Air Quality	Yes	Yes	Both sites already have sources of emissions, including cement dust in St. Lucy.
Geology, Topography, and Soils	No	Yes	The Port site is already under industrial uses, on fill areas. The St. Lucy site is undeveloped, with rugged topography.
Hydrology	No	Yes	Port site is already graded. St. Lucy site is undeveloped and has rugged topography

Environmental/Social Resource Potentially Impacted	Port of Bridgetown	St. Lucy	Comments
Flora and Fauna	No	Yes	St. Lucy site is undeveloped and dominated by a mix of native vegetation.
Marine Environment	No	No	Both sites are active ports with sufficient depth (>9 meters [m]) and area for ship maneuvering. No dredging is anticipated at either site.
Near a Noise Receptor	No	Yes	Port site is surrounded by other industrial uses. St. Lucy site is adjacent a residential development.
Nearby Community	Yes	Yes	Port site is near industrial and urban areas; shortest distance to residential area is about 250 m. St. Lucy site is adjacent a residential, suburban area; shortest distance to residences is about 120 m. Site boundaries and layouts have not been established at either site. Site layout will have to accommodate appropriate safety criteria.

FIGURE 2-11 ALTERNATIVE SITES FOR PHASE II FACILITIES

2.3 SCOPING, REGULATORY REQUIREMENTS, AND PUBLIC CONSULTATION

2.3.1 Regulatory Requirements

Barbados is governed according to the 1966 Constitution of Barbados (as amended). Barbados legislation that encompass environmental protection for new and expanded developments includes several acts as well as the provisions of the Town and Country Planning Act (TCPA), which control and mitigate adverse effects on coastal and heritage resources and in sites of natural scenic beauty. The TPCA requires that new developments and changes to existing developments (i.e., addition of buildings), as well as specific criteria for air emissions and water discharges, be reviewed by the Chief Town Planner. During review of applications for developments, the Chief Town Planner may request an environmental impact assessment, which should follow the Environmental Impact Assessment Guidelines and Procedures for Barbados (1998) prepared by the Government of Barbados, Ministry of Health and the Environment.

There are several government policies that concern sustainable development and biological resources, including the Barbados Sustainable Development Policy, National Physical Development Plan, Coastal Zone Management Plan, and National Strategic Plan. The fourth goal of the National Strategy Plan 2005-2025 is to build of a green economy which requires advancement and protection of the environment, resources, infrastructure while advancing social and economic development.

In addition to national regulatory requirements, the Project and EA process will be consistent with all relevant international standards and requirements. These include international treaties and conventions to which Barbados is a signatory relating to environmental management and community rights (see Table 2-2). Furthermore, the Project and EA process will be guided by international best practices, notably IDB environmental and social safeguards.

TABLE 2-2 BARBADOS SIGNATORY INTERNATIONAL TREATIES AND CONVENTIONS

Agreement/Convention	Notes/Comments	Status
Climate Change/Air Quality		
Vienna Convention for the Protection of the Ozone Layer, 1985	Protection of the ozone layer.	Barbados acceded in 1992.
Montreal Protocol on Substance that Deplete the Ozone, 1989	Protection of the ozone layer.	Barbados acceded in 1992.
United Nations Framework	Control of greenhouse gas	Ratified by Barbados in

Agreement/Convention	Notes/Comments	Status
Convention on Climate Change (UNFCCC), 1992	emissions.	1994.
Kyoto Protocol, 1977	Greenhouse gas emissions targets.	Ratified by Barbados in 2000.
Biodiversity/Bio-safety, Traditional Knowledge		
International Plant Protection Convention, Rome, 1951	Prevention and control of non-native plants, plant products, pests, and diseases.	Adherence by Barbados in 1976.
United Nations Convention on Biological Diversity, 1992	Promotes development of national strategies for the conservation and sustainable use of biological diversity. Often seen as the key document regarding sustainable development.	Ratified by Barbados in 1993.
Cartagena Protocol on Bio-Safety	Protection of biodiversity from living modified organisms.	Barbados acceded in 2002.
Wildlife/Conservation		
Convention of International Trade in Endangered Species, 1972 (CITES)	To ensure that international trade in specimens of wild animals and plants does not threaten their survival and it accords varying degrees of protection to more than 33,000 species of animals and plants.	Barbados acceded in 1992.
Convention on Wetlands of International Importance especially as Waterfowl Habitats (RAMSAR), 1971	The conservation and sustainable utilization of wetlands, i.e. to stem progressive encroachment on and loss of wetlands now and in the future, recognizing the fundamental ecological functions of wetlands and their economic, cultural, scientific, and recreational value.	Ratified by Barbados in 2005.
Protocol Concerning Specially Protected Areas and Wildlife to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean, 1983	Protection of rare and fragile ecosystems and habitats.	Barbados acceded in 1992.
United Nations Convention to Combat Desertification, 1994	To combat desertification and mitigate the effects of drought through national action programs that incorporate long-term strategies supported by	Barbados acceded in 1997.

Agreement/Convention	Notes/Comments	Status
	international cooperation and partnership arrangements.	
Marine Protection and Safety		
Convention on the Protection and Development of the Marine Environment in the Wider Caribbean, 1983 (Cartagena Convention)	Protection and development of the marine environment.	Barbados acceded in 1985.
Protocol Concerning Cooperation in Combating Oil Spills in the Wider Caribbean, 1983	Protection of the marine environment from oil spills.	Barbados acceded in 1987.
United Nations Convention on the Law of the Sea, 1982	Protection of the marine environment.	Ratified by Barbados in 1993.

Source: ERM modified from UNEP 2010

2.3.2 *Agency Meetings and Regulatory Requirements*

ERM conducted meetings with pertinent regulatory agencies and other pertinent governmental entities in Barbados to discuss the project and obtain their opinion on the potential project impacts and regulatory requirements (Table 2-3).

The capacity increase in the Woodbourne plant only requires a construction permit from the Town & Country Development Planning Office. A copy of the application for permission to develop land submitted to the Town & Country Development Planning Office is provided in Appendix E.

TABLE 2-3 AGENCY AND OTHER PERTINENT ENTITIES MEETINGS

Entity	Meeting Date	Comments
Town & Country Development Planning Office	March 15, 2016 June 23, 2016	No EIA required. Construction permit required — NPC needs to submit a development application to the Town and Country Planning and Development Office. The development application includes a project description and measures to minimize project impacts.
Environmental Protection Department	March 15, 2016 June 23, 2016	No specific authorization required.
Fire Service	March 16, 2016	Discussed existing response plan for the Port.
Barbados Port	March 16, 2016	Confirmed the Port's operational and safety provisions for iso-container loading and unloading.
Coastal Zone Management	March 17,2016	No specific authorization required.

2.3.3 IDB Policies

The Woodbourne LNG Plant Expansion triggers the following IDB environmental and social safeguard policies and directives, per IDB OP-703:

- B.2, Country Laws and Regulations: local requirements include only a development permit from Town and Country Planning Office. No EA or EIA is required. The permit application is in preparation, pending details of the project elements.
- B.3, Screening and Classification: See Section 5 below.
- B.5, Environmental Assessment Requirements: This EA addresses the requirement for environmental assessment for the project.
- B.6, Consultations: NPC conducted a public consultation (see Section 2.3.4 below).
- B.7, Supervision and Compliance: A monitoring plan will be implemented for the project.
- B.10, Hazardous Materials: The project deals with small amounts of hazardous materials, such as fuels for truck operation. Management of hazardous materials is addressed in the ESMP.
- B.11, Pollution Prevention: The project as a minimal risk of pollution, as it has minimal sources of pollution. Pollution prevention is addressed in the ESMP.

2.3.4 Public Consultation

NPC conducted a public meeting on July 21, 2016 at 6:00 to 8:00 pm at the Auditorium of the BOCNL facility at Woodbourne. The public meeting was advertised in the local newspaper on July 17 and a presentation was prepared and delivered. Appendix A includes the newspaper announcement and sign-in sheet. The meeting was attended by 13 people.

2.4 INSTITUTIONAL FRAMEWORK AND EXECUTING AGENCY CAPACITY

The proposed LNG Regasification Plant expansion will be located within an existing BNOCL plant facility in Woodbourne that has been operating since December 2015 and as a result must follow the general environmental, health, and safety (EHS) guidelines put in place by BNOCL. To this end, the plant will be overseen by the health, safety, security, and environment (HSSE) Officer from BNOCL; however, because currently the plant is operated by NPC and the entire process is new to BNOCL, all of the procedures including emergency and EHS

were developed and implemented by the NPC HSSE Officer. The developed procedures are shared with BNOCL HSSEO and incorporated and/or adjusted to comply with the existing BNOCL guidelines to ensure everyone was operating on the same level.

The NPC's EHS officer, together with the LNG Supervisor and Operator has the responsibilities of managing the EHS activities at the plant.

3.0 ENVIRONMENTAL AND SOCIAL SETTING

This section discusses the existing physical, biological, and socieconomic environment within and in the vicinity of the LNG Plant and NG Transmission Line corridor areas (collectively the Project).

3.1 CONDITIONS AT THE SITE AND VICINITY

The Woodbourne LNG Plant is located in a mixed-use area, where oil/gas wells, gathering lines, and a NG compressor station are embedded in a matrix of sugar cane parcels (see Figure 3-1). BNOCL operates the oil/gas field and compressor facilities and owns the parcel where the plant is located. The nearest residential areas are located more than 400 meters to the southwest of the site.

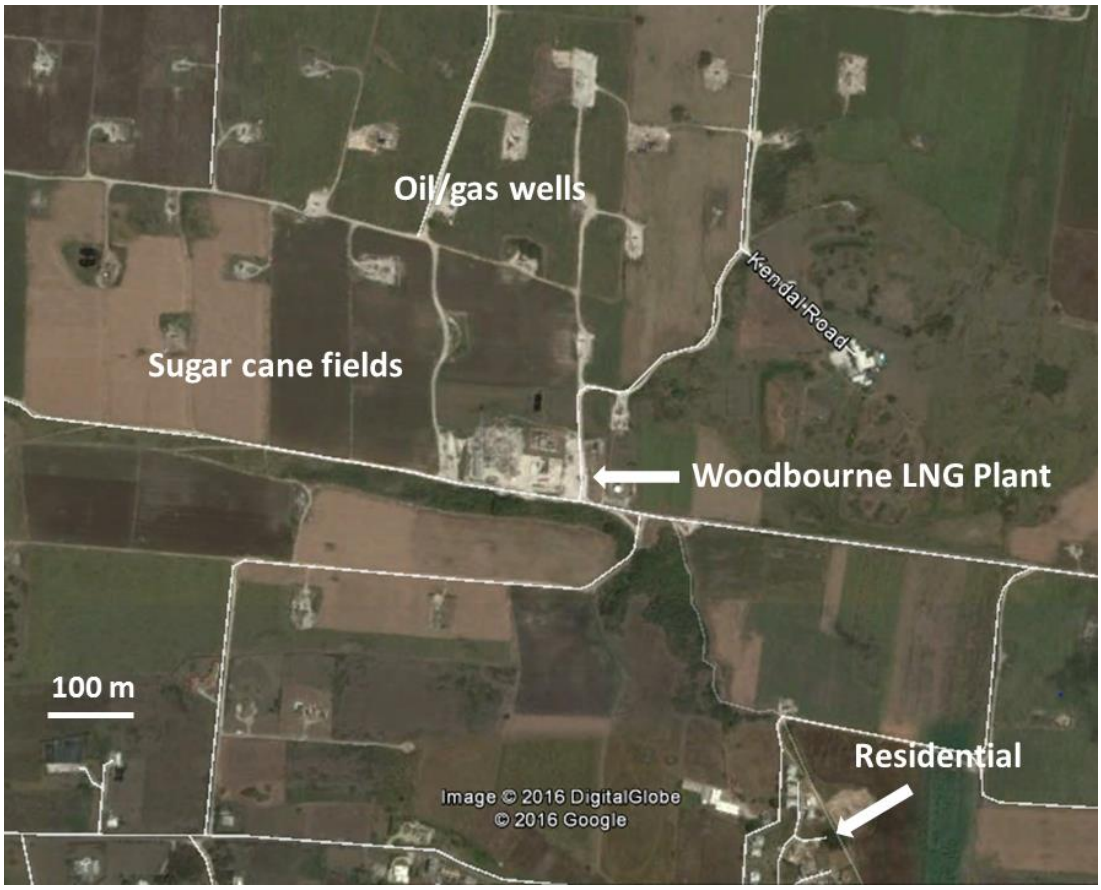


FIGURE 3-1 WOODBOURNE LNG PLANT AND VICINITY

3.2 CLIMATE AND AIR QUALITY

Barbados has a mild subtropical climate with average temperatures that range from 24 to 28 °C and humidity that ranges from 71 to 76 % (Evanson 2014). There is a dry season from January to June and a wet season that starts in late June and goes thru December. Barbados is on the southern edge of the West Indian hurricane zone and the hurricane season starts in late June and ends in November (The Commonwealth 2016; Government of Barbados 2002b). During this time period there is increased tropical storm activity and the island gets most of its rainfall.

Meteorological data for the area are available from the weather station at Grantley Adams Airport in Christ Church. The airport is 12.9 km from the center of Bridgetown (see Figure 2-1). Table 3-1 shows the monthly and average air temperature and precipitation for the weather station. Precipitation averages approximately 1,270 millimeter (mm) annually (Miller 2012). Wind direction at the site is predominantly west-southwest.

TABLE 3-1 MONTHLY MEAN AIR TEMPERATURE AND PRECIPITATION AT GRANTLEY ADAMS AIRPORT (1981-2010)

Month	Mean Wind Speed (Knots)	Mean Relative Humidity (%)	Mean Temperature (°C)	Mean Rainfall (mm)	Mean Rain Days (Days)
January	11	77	25.8	70.1	11
February	11	77	25.7	41.3	8
March	11	75	26.2	37.4	8
April	11	77	26.8	60.8	8
May	12	78	27.6	79.0	8
June	12	80	27.7	103.0	11
July	11	81	27.6	132.9	15
August	9	81	27.8	141.9	15
September	8	81	27.7	157.6	14
October	9	82	27.5	185.1	16
November	9	83	27.0	171.6	14
December	9	79	26.4	89.6	12

Source: Miller 2012

There is limited air quality data available for Barbados. According to the Economic Commission for Latin America and the Caribbean (ECLAC) (ECLAC 2015), carbon dioxide (CO_2) emissions have generally increased since the 1990s (see Table 3-2).

TABLE 3-2 CARBON DIOXIDE EMISSIONS IN BARBADOS

Year	CO_2 Emissions (Thousands of tonnes)
1990	1074.4
1991	1206.4
1992	979.1
1993	1114.8
1994	748.1
1995	828.7
1996	850.7
1997	902.1
1998	1140.4
1999	1210.1
2000	1188.1
2001	1221.1
2002	1228.4
2003	1268.8
2004	1294.5
2005	1353.1
2006	1371.5
2007	1430.1
2008	1628.1
2009	1624.5
2010	1518.1
2011	1565.8

Source: ECLAC 2015

The World Health Organization (WHO) has guidelines for air quality that are designed to reduce the health impacts of air pollution. The guidelines relate to four common air pollutants including particulate matter (PM). The mean annual concentration of PM of less than 2.5 microns in diameters ($PM_{2.5}$) is a common measure of air pollution. The WHO guidelines state that mean concentrations of $PM_{2.5}$ should not exceed 10 microgram per cubic meter ($\mu g/m^3$) annually or 25 $\mu g/m^3$ in a 24-hour period. These are the lowest levels at which total, cardiopulmonary and lung cancer mortality have been shown to increase with more than 95 % confidence in response to long-term exposure to $PM_{2.5}$ (WHO 2005). In 2014, in Barbados the mean annual $PM_{2.5}$ concentration was 16.2 $\mu g/m^3$ (WHO 2014), which exceeds the WHO guideline value.

3.3 HYDROLOGY

Barbados has a network of ephemeral streams, which flow from the highest parts of the island towards the western coast. The streams are connected

through fractures in the carbonated rock, which covers the majority of the island, and in combination with surface runoff and infiltration into aquifers and underground caverns, they form the main hydrological system of the island (Evanson 2014). While aquifer recharge in Barbados is rapid (15 to 30 % of average rainfall) due to infiltration, it only takes places during the wettest 1-3 months of each year (Jones et al., 1998).

Approximately 99 % of the public supply of water in Barbados is groundwater extracted from large reservoirs within the aquifers (Evanson 2014). Generally, groundwater extraction wells in Barbados are located inland as far as possible, since ground water quality decreases rapidly to the seaward side of supply wells and the coastline also supports the greatest density of residential and tourism facilities. Barbados is one of the world's most water scarce countries (i.e., less than 1,000 cubic meters/person/year) and the Barbados Water Authority pumps near maximum capacity to meet demand (Evanson 2014; GOB, 2014).

3.4 GEOLOGY, TOPOGRAPHY, AND SOILS

The island of Barbados is the most eastern island of the English Caribbean chain of islands (Lesser Antilles) and topographically the island is a relatively flat. The island is the top of a seamount that rises 300 meters above sea level (masl) from the Barbados Ridge and was formed as an accreted wedge created by the movement eastwards of the Eastern Caribbean plate over the South American plate. The highest elevation point in the island is located in Mount Hillaby at approximately 340 masl in the Parish of Saint Andrew. The gradient at this location increases in a series of terraced tablelands until reaching the mount.

In the northeast region, the terrain is characterized as eroded and rocky with steep broken slopes; the rocks are sedimentary. In the rest of the island, the terrain is relatively flat composed of coral limestone, crossed with deep river-bed gullies that accommodate the movement of water during heavy rain. The coral limestone area composed of a series of gently sloping, step-like terraces. There are no permanent rivers in Barbados (Government of Barbados 2002a).

The coral limestone layer varies in thickness from approximately 10 to 100 meters (m) and consists of coral and coralline limestone bedrock with sporadic occurrences of sand deposits. Beneath the coral limestone layer are oceanic beds consisting of marl and ash covering the "Wedge Cover Unit" comprised of mudstones, sandstones and marls that weather to form silty clay to sandy clay soils. The most frequent soil type is fertile clay or clayey loam (Donovan 2005).

3.5 NOISE

The existing LNG facility in Woodbourne is located in a rural mixed land use area (industrial/commercial/residential). The nearest noise sensitive area (NSA) is a resident that is approximately 450 m southwest of the facility (see Figure 3-2). The baseline noise levels in the vicinity of the existing facility are not expected to be high. The major source of ambient noise at the project area are the existing LNG re-gasification facility, compressor station, vehicle traffic on nearby roadways, and farm equipment operating in nearby fields.

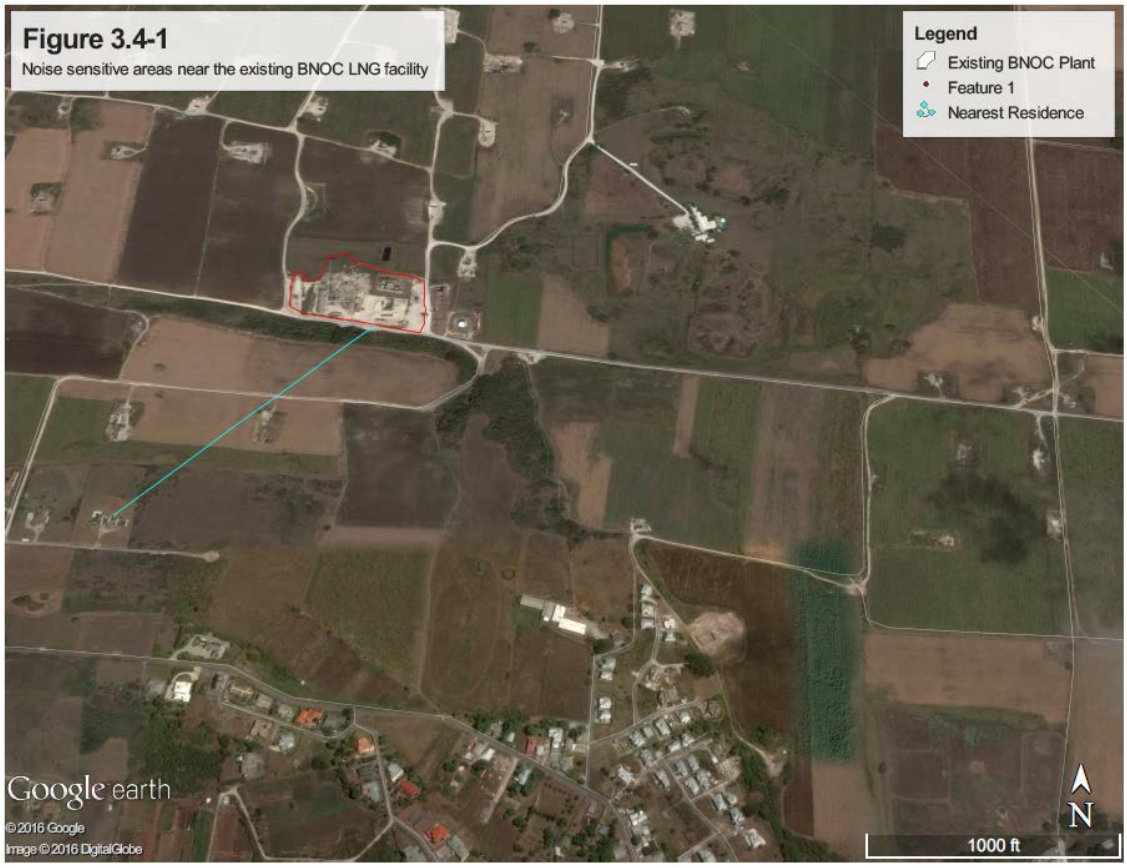


FIGURE 3-2 NOISE SENSITIVE AREAS NEAR THE EXISTING LNG PLANT

Typical outdoor sound level by land use category is presented in Table 3-3. Ambient day-night noise levels in areas with some commerce or industry are expected to range from 55 to 65 A-weighted decibel (dBA). Ambient day-night noise levels in rural and suburban towns with infrequent traffic are expected to range from 40 to 45 dBA.

TABLE 3-3 TYPICAL OUTDOOR SOUND LEVELS BY LAND USE CATEGORY

Land Use Category	L_d (dBA)[a]	L_n (dBA)[b]	L_{dn} (dBA)[c]
Wilderness areas	35	25	35
Rural and outer suburban areas with negligible traffic	40	30	40
General suburban areas with infrequent traffic	45	35	45
General suburban areas with medium density traffic or suburban areas with some commerce or industry	50	40	50
Urban areas with dense traffic or some commerce or industry	55	45	55
City or commercial areas or residences bordering industrial areas or very dense traffic	60	50	60
Predominantly industrial areas or extremely dense traffic	65	55	65

Source: Cavanaugh and Tocci 1998; Bies and Hansen 2009

dBA = A-weighted decibel

[a] L_d, or daytime L_{eq}, is the average equivalent sound level for daytime (7 a.m. to 10 p.m.).

[b] L_n, or nighttime L_{eq}, is the average equivalent sound level for nighttime (10 p.m. to 7 a.m.).

[c] L_{dn}, or day-night average sound level, is the average equivalent A-weighted sound level during a 24-hour time period with a 10-dB weighting applied to equivalent sound level during the nighttime hours of 10 p.m. to 7 a.m.

$$L_{dn} = 10log_{10}(\frac{15}{24}10^{L_d/10} + \frac{9}{24}10^{(L_n+10)/10})$$

The International Finance Corporation (IFC) recommends that noise levels in residential areas should not exceed 55 dBa during the daytime or 45 dBA during nighttime. In industrial/commercial areas, the World Bank recommends noise levels not exceed 70 dBA during daytime or nighttime (IFC 2007).

There is limited air noise data available for Barbados. The existing noise environment at properties in the Parish of Saint Lucy at the northern end of the island was characterized by sound level measurements taken for another project in May 2006 (AMEC 2006). Baseline noise measurements taken at four sites near the proposed wind farm location ranged from 45 to 60 dBA at residences during daytime hours and 37 to 55 dBa overnight. Measured sound levels at the four sites correspond to general suburban areas with medium density traffic or suburban areas with some commerce or industry (as presented in Table 3-3). Similar noise levels are likely found within the vicinity of the LNG plant.

3.6 NATURAL HAZARDS AND RISKS

3.6.1 Natural Hazards

In the Caribbean, there are three hurricane tracks. The Island of Barbados is located within the Eastern Caribbean track (Caribbean Hurricane Network 2016). The Eastern Caribbean track includes the Lesser Antilles. Approximately 12 hurricanes and several tropical storms have crossed the Island of Barbados from 1851 to 2010 (se Figure 3-3). Hurricane Janet, a category h3 (moderate to extreme), passed just south of Barbados with 121 miles per hour (mph) winds from east to southeast on 22 September 1955, impacting the southern of Barbados while Hurricane Allen, also a category h3, passed north of Barbados and made landfall with 127 mph winds on 4 August 1980. Allen heavily affected Barbados, causing $US 6 million in damages and destroying over 500 homes.

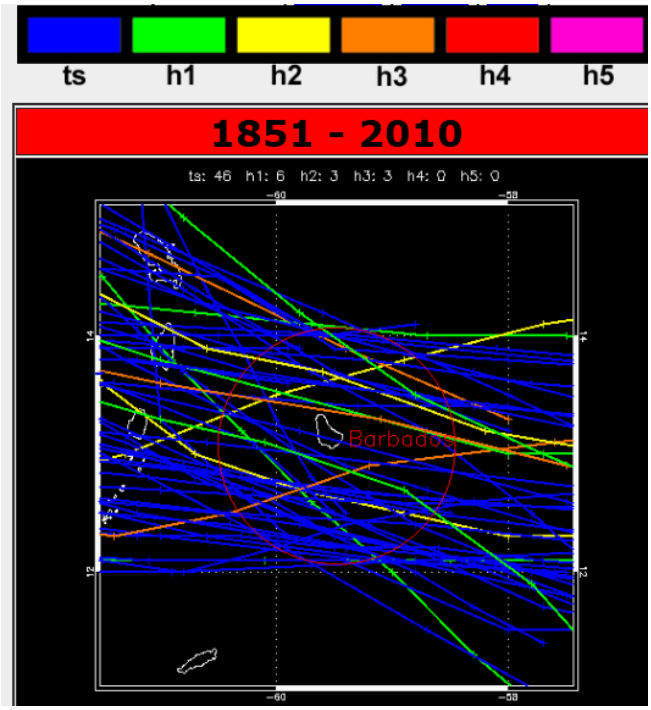


FIGURE 3-3 HURRICANES AND TROPICAL STORMS AFFECTING BARBADOS (1851-2010)

3.6.2 LNG Storage Tank and Transportation Container Failure and Fire Hazard Risks

LNG is composed of 97 to 99 % methane gas and at -162 °C liquefies. The liquefied liquid is a non-toxic, non-corrosive substance classified as a highly flammable substance (NEPA 59A). If LNG is accidentally released from a tank

rupture from a temperature-controlled container, it would likely contact warm surfaces and air that transfer heat into the liquid. The heat input begins to vaporize some of the liquid, returning the liquid to the gaseous phase. The relative proportions of liquid and gaseous phases immediately following a release depend on the release conditions. The liquid phase will form an LNG pool on the ground which will begin to "boil", due to heat input from the surrounding environment. A pool fire would likely occur an ignition source is present.

When LNG is spilled on land, the gas it is initially denser than air and will form a vapor cloud close to the ground, as the gas is warmed and mixes with air it becomes less dense and rises and dissipates into the atmosphere. If a large volume of LNG is spilled in a short space of time the vapor cloud can serve to 'insulate' the LNG pooled on the ground allowing the LNG to remain for an extended period without totally evaporating. To mitigate the risks of an accidental LNG release from a LNG tank or iso-container, BNOCL has developed an emergency response plan to handle and mitigate any emergency at the plant or accident during the transportation of the iso-containers from the port to the plant (see Appendix B). BNOCL has also conducted a fire risk analysis for the LNG plant to evaluate the risks of fires at the plant (see Appendix C). A vapor dispersion modeling will be conducted for the proposed plant expansion.

3.7 FLORA AND FAUNA

Barbados is in the Windward Islands Xeric Scrub ecoregion and is included in the Caribbean Islands biodiversity hotspot. The biodiversity of Barbados has been influenced since the island was settled in 1627. Numerous species of plants and animals have been introduced, competing against indigenous species. In addition, habitats were altered and fragmented as the island was settled. This section will briefly discuss the flora and fauna likely to be found within the vicinity of the project area.

3.7.1 Flora

In 1627, Barbados was mostly covered with tropical forests. Within 30 years of settlement, about 80 % of the forested area of Barbados was cleared for agriculture. Since the 1970s there has been a steady decline in sugarcane cultivation and in increase in the regeneration of natural vegetation (GOB 2002). Currently, an estimated 33 % of the land in Barbados is agricultural land and 15 % of the land area is forested (World Bank 2016). In rural areas, sugar cane and food crops are the predominant vegetation (The Commonwealth 2016).

There are about 700 species of tropical flowers and flowering trees in Barbados. Of those, only two endemic species have been identified: *Phyllanthus andersonii*, a gully shrub, and *Metastelma barbadense*, a slender climber usually found in dry woodland (GOB 2002; Sun Group 2015). Neither of these species are rare or endangered (GOB 2002), nor present at the project site.

There are four main types of vegetation communities that may occur in the vicinity of the project areas: coastal, sugarcane plantations, pastures, and roadside. Along the west (leeward) coast of Barbados, the beaches are relatively narrow. Where the land has not been cleared for coastal development, the beaches are backed by trees and shrubby undergrowth. The largest sugarcane plantations are found in the parish of St. Phillip, as well as the parishes of Christ Church, St. George, St. John, St. Peter, and St. Lucy. Eleven varieties of sugarcane are grown in these fields. There is also a number of invasive weeds. Where the soil was too shallow for crops, the land has been planted as pastures for fodder or direct grazing by animals. Roadside vegetation is often cutback or weeded by maintenance crews, but wayside gutters and trenches may have communities of herbs and shrubs (GOB 2002).

Gullies, which are steep clefts that provide a sheltered environment with more moisture than the other island habitats, are an important vegetation community in Barbados. They tend to have a large and mature collection of native vegetation, including ferns, climbers, shrubs, and trees. The major gullies in Barbados are found in the parishes of St. Peter, St. James, and St. Thomas, as well as in the ravines in the Scotland District. Gullies are not likely to be found in the vicinity of the Project site.

3.7.2 Fauna

Natural wildlife of Barbados has been largely displaced by sugarcane plantations. Most of the mammals found on Barbados, including the green monkey and mongoose, were introduced. The only remaining extant indigenous mammals of Barbados are six species of bats, about which very little is known (GOB 2002). The hare (*Lepus capensis*) is rare in Barbados, where it is found in grasslands and shrubs and is commonly associated with open habitats (Drew et al., 2008). There is no protective legislation for mammals in Barbados, either for the species themselves or their habitats.

There are 36 species of resident birds that are confirmed as nesting in Barbados, most of which are considered common. Of the 36 resident species, 8 species are exotics that have been deliberately introduced. Many of the resident avian species found on Barbados are protected under the Wild Birds Protection Act cap 398 (1985). Barbados lies on a migratory flyway that is used by eastern

North American shorebirds that over-winter in South America and over 150 species of migratory birds have been recorded in Barbados. In Barbados, migratory birds find foraging habitat in the western portion of Graeme Hall Swamp, Chancery Lane Swamp, Green Pond, and Long Pond, as well as several artificially maintained swamps. Regular winter resident bird species in Barbados include the osprey (*Pandion haliaetus*), purple gallinule (*Porhyrula martinica*), great blue heron (*Ardea herodias*) and little blue heron (*Florida caerula*) (GOB 2002).

There are several reptiles found in Barbados, including a worm snake (*Leptotyphlops bilineata*), tree lizard (*Anolis extremus*) and the leaf-toed gecko (*Phyllodactylus pulcher*), and the large teiid ground lizard (*Kentropyx borkiana*). In addition, the critically endangered hawksbill turtle (*Eretmochelys imbricate*) and the endangered leatherback turtle (*Dermochelys coriacea*) nest in Barbados. The hawksbill primarily nests on the west and south west coasts of Barbados, while the leatherback primarily nests between Morgan Lewis and Cattlewash. The hawksbill forages primarily on the bank reef along the west coast of Barbados and on south coast patch reefs while the leatherback leaves Barbados to forage in more temperate waters after nesting. In addition, the endangered green turtle (*Chelonia mydas*) reportedly forages an algae and sea grass nearshore Barbados (GOB 2002). None of these species are likely to occur on the LNG plant site.

Only two species of amphibians are found in Barbados. Both the cane toad (*Bufo marinus*) and the whistling frog (*Eleutherodactylus johnstonei*) are believed to have been introduced and the cane toad, which is abundant and widespread across the island, is considered to be an invasive species (GOB 2002). None of these species are likely to occur on the LNG plant site.

3.8 SOCIOECONOMICS

Barbados is one of the mostly densely populated countries in the world, having a population density of 646 people per square kilometer at the most recent (2010) census. In 2010, the population of Barbados was 277,821, of which 47.9 % were male and 52.1 % female. Bridgetown is located in the Parish of St, Michael, which has the highest population (88,529) of the parishes (see Table 3-4). St. Philip, where the existing LNG facility is located, has the third highest population (30,662) with 11 % of the population. Within the productive population (15 - 64 years) there are 187,095 persons, while there are 54,757 within the 0 - 14 age group and 35,969 at 65+ years. The median age is 38 years (Barbados Statistic Service 2013).

TABLE 3-4 POPULATION OF BARBADOS CENSUS (2010)

Parish	Population	Percent of Total (%)
St. Michael	88,529	31.9
Christ Church	54,336	19.6
St. George	19,767	7.1
St. Philip	30,662	11.0
St. John	8,963	3.2
St. James	28,498	10.3
St. Thomas	14,249	5.1
St. Joseph	6,620	2.4
St. Andrew	5,139	1.8
St. Peter	11,300	4.1
St. Lucy	9,758	3.5
Total Barbados	**277,821**	**100**

Source: Barbados Statistic Service 2013

For the past five decades Barbados has been able to control its rate of population growth through the successful implementation of an island-wide family planning program. This has contributed to the attainment of an average rate of population growth of 0.3 % between 1980 and 2008, which is comparable with that of most developed countries (GOB 2014).

The population of Barbados is predominantly black (92.4 %) or mixed (3.1 %) and 2.7 % of the population is white and 1.3 % is South Asian. The remaining population includes East Asians (0.1%) and Middle Easterners (0.1 %) (Barbados Statistic Service 2013).

There was a general decline in the unemployment rate in Barbados from 1995 when it was 19.7 % until 2007 when it was 7.4 %. In 2010, the unemployment rate was 10.8 % and in 2015 it was estimated at 11.3 % (CBD 2012; GOB 2012; BML 2016). There has been a decline in employment in the agricultural and manufacturing sectors and a rise in employment in the services sector. There has also been an improvement in the educational attainment of the labor force with a decline in the number of adults with no certification from 60 % in 1990 to 57 % in 2000 and an estimated 54 % in 2009. In Barbados there is universal primary and secondary education and the adult literacy rate is 99.7 % (CBD 2012; GOB 2012).

A survey conducted in 2010 (2,425 households and 6,973 individuals with 5,618 of them being adults 15 years and over) indicated that 15 % of households and 19.3 % of individuals in Barbados were below the poverty line of BDS$ 7,861 (annual). For all individuals reporting some form of income (employment and other sources), monthly income averaged BDS $2,496, with 50 % of the people surveyed having a monthly income of BDS $2,000 or less. The data indicate that

the poverty gap (the extent to which the poor existed below the poverty line) and the severity of poverty compare favorably with those in Caribbean countries that conducted poverty assessments around the same time. In general, over the 1995 to 2010 period living conditions in Barbados have improved with steady but moderate economic growth and a decreasing unemployment rate (CDB 012; GOB 2012).

Information on potential impacts generated from the required expansion and upgrades of the LNG plant were obtained from various sources, including consultation with NPC and BNOCL and local sources, discussions with pertinent local agencies, and environmental evaluations for similar projects worldwide, and literature review.

To assess impacts associated with or resulting from the proposed LNG expansion and upgrades, the project team used professional judgment, fieldwork, stakeholder meetings, and desktop analysis. The significance of potential impacts of the project was determined.

The proposed construction (expansion and upgrades) and operation of the LNG plant will affect environmental and socioeconomic conditions in the project area. Project effects on physical, biological, and socioeconomic resources are summarized in Table 4-1. The table provides the significance of potential project impacts on environmental and social resources, assuming that proposed and recommended mitigation measures, industry best management practices and embedded controls, and management plans are implemented.

Project construction activities will be confined to inside the existing plant site, with no disturbance to new, undeveloped areas. Operation of the expanded facility will be of similar intensity as current operations. Traffic impacts will be minor, as the number of additional trips is minimal. The pipeline will be installed inside an existing right-of-way.

The project is not expected to result in any major adverse impact and only two are considered minor impacts (i.e., vapor release from the potential rupture of the storage and iso-container tanks and fire hazard), the rest of the potential impacts are expected to be negligible. To further mitigate the risks of an accidental LNG release from a LNG tank or iso-container, BNOCL has developed an emergency response plan to handle and mitigate any emergency at the plant or accident during the transportation of the iso-containers from the port to the plant (see Appendix B). BNOCL has also conducted a fire risk analysis for the LNG plant to evaluate the risks of fires at the plant (see Appendix C). Vapor dispersion modeling will be completed before final design.

The negligible to minor impacts of the project will be mitigated and managed with the application of industry-standard best practices. Table 3-1 of the Environmental and Social Management Plan, prepared for the project and attached to this EA as Appendix D, summarizes these best practices. Any

contractor or supplier that may be involved in the project will be required to incorporate the proposed mitigation measures and management controls within their own working procedures and plans.

TABLE 4-1 SUMMARY OF PROJECT POTENTIAL IMPACTS AND RECOMMENDED MITIGATION/MANAGEMENT MEASURES

Resource	Source of the Impact and Existing Vulnerability	Recommended Mitigation/ Management Measure	Impact Significance After Mitigation
Physical			
Climate and Air Quality	• Wheel generated dust/surface disturbance during operation of diesel powered earth-moving construction equipment (e.g. bulldozers, graders, excavators, cranes, dump trucks) at the construction site. • Fuel combustion emissions from exhausts of iso-container trucks transporting LNG from the port to the LNG facility. • Construction workers commute vehicles (or company bus) to and from site.	• Reschedule earthwork activities during periods of high wind if visible dust is blowing off-site. • Provide dust suppression as needed. • Ensure that all construction equipment is maintained in accordance with manufacturer's specifications. • Stabilize disturbed areas as soon as possible.	**Negligible**
Geology, Topography, and Soils	• Landscape grading and recontouring required for installation of the new infrastructure to ensure proper drainage and stability. • Vegetation clearance and landscape grading.	• Implementation of soil erosion, storm water runoff, and sedimentation control measures.	**Negligible**
Hydrology	• Sedimentation from construction activities. • Contamination from accidental spills (e.g., fuel and lubricants if handled on site). • Pipeline construction/ replacement activities involving crossings of ephemeral streams or drainage structures.	• Implementation of improved and effective soil erosion, stormwater runoff, and sedimentation control measures. • Exercise controls for inspecting equipment and Implement a Spill Prevention and Countermeasures Plan (SPCC).	**Negligible**
Noise	• Operation of diesel powered earth-moving construction equipment such as bulldozers, front-end loaders, or dump trucks. • Vehicular traffic. • Operation of pumps and compressors.	• Ensure that all contractors on site undertake regular inspection and maintenance of all vehicles and construction equipment in accordance with manufacturer's specifications. • Ensure that all equipment operating at the facility (i.e., pump and compressor, ambient vaporizers, etc) are maintained and operate in accordance with manufactures' specifications. • Implement a monitoring program to monitor noise levels at the facility and nearby receptors. • Employ best available work practices on-site to minimize occupational noise levels.	**Negligible**

Resource	Source of the Impact and Existing Vulnerability	Recommended Mitigation/ Management Measure	Impact Significance After Mitigation
		• Select truck routes for construction traffic entering and leaving the site to ensure noise levels at noise sensitive receptors are kept to a minimum.	
LNG storage or iso-container tank failure risk	• Accidental spill of LNG from a tank rupture. • Accidental spill of LNG from an iso-container/tank accidental rupture from a traffic accident.	*LNG Tank Rupture* • Plant designed with embedded layers of protection: o **Sitting and design –** designed to meet international standards (e.g., NEPA 59A – distance requirements from LNG plant, materials resistant to the cryogenic temperatures, and equipment anchoring/grounding against high winds and electricity); o **Control and Monitoring –** detection equipment throughout the site (methane and flame detectors as well as various other sensors to detect any leaks and wind monitoring to determine the direction any potential vapors); o **Prevention –** audible and visual alarms as well as automatic emergency shutdown valves; o **Protection –** impoundment pit to contain any spilled LNG (fire response equipment and vapor control equipment – foam and water curtains); o **Plant emergency response –** trained operators to ensure rapid response; and o **Community emergency response –** emergency plan shared with the emergency services. • *Iso-containers Rupture* o All personnel hired to transport the containers have been trained to US Department of Transpiration standard for LNG drivers; o The route has been selected to ensure that	**Minor**

Resource	Source of the Impact and Existing Vulnerability	Recommended Mitigation/ Management Measure	Impact Significance After Mitigation
		only major roads that can handled the size and weight of the iso-containers are travelled; o The transport of the LNG containers from the Bridgetown Port to the LNG Terminal will occur in off-peak hours (between 23:00 and 05:00) as the vehicles are oversized. Each convoy will be escorted by an out-rider and the Royal Barbados Police Force shall be notified to facilitate road closures to ensure that no other road users can be impacted by the containers. o Iso-containers have built in safeguards to protect against roadside accidents (insulated and double walled, all valves are recessed within the confines of the container frame, valve cluster encased within a steel cabinet, and remote monitoring – pressure values can be monitored remotely to alert personnel to any issues prior to the container arrival).	
Fire hazard risk	• Accident release of LNG – LNG is classified as highly flammable gas.	• Distance requirements stipulated by NEPA 59A provide a buffer around the re-gasification facility where no ignition sources are present (no ignition sources within 100 feet of storage tanks, e.g., liquid fuel storage, motors, highways, and unrated electrical appliances). • Large wheeled dry powder fire extinguisher units (350 pounds) stationed around the transfer bay. • Fire water system (30,000 gallons tank and pump) used to cool surrounding infrastructure in the event of a fire. • Foam blocks in the impoundment pits to provide constant passive response (does not require operator intervention.	**Minor**

Resource	Source of the Impact and Existing Vulnerability	Recommended Mitigation/ Management Measure	Impact Significance After Mitigation
Natural Disasters	• Hurricanes and natural fires	• Storage tanks will be built to withstand hurricane force winds and earthquakes. • Natural vegetation fires (flame detectors also detect fires external to the plant and result in a shutdown of operation).	**Negligible**
Biological			
Flora and Fauna	• Ground clearing and grading for the emplacement of infrastructure. • Increase noise from construction and operation activities.	• To avoid potential collisions with fauna, limit speeds on roads. • Provide dust suppression as needed. • Implementation of improved and effective soil erosion, storm water runoff, and sedimentation control measures. • Site has no vegetation, so no vegetation loss is anticipated.	**Negligible**
Human Resources			
Construction-related effects on the public	• Temporal increase of noise and dust from construction activities.	• Ensure that all contractors on site undertake regular inspection and maintenance of all vehicles and construction equipment in accordance with manufacturer's specifications. • Ensure that all equipment operating at the facility (i.e., pump and compressor, ambient vaporizers, etc) are maintained and operate in accordance with manufactures' specifications. • Employ best available work practices on-site to minimize occupational noise levels. • Reschedule earthwork activities during periods of high wind if visible dust is blowing off-site. • Provide dust suppression as needed. • Stabilize disturbed areas as soon as possible.	**Negligible**
Socioeconomic	• Project induced economic activity will result from contracting of materials and services during the construction and operations phases including mechanical equipment, piping, building materials, civil construction works; telecommunications equipment, and other materials.	No additional mitigation measures are proposed.	**Positive**

Resource	Source of the Impact and Existing Vulnerability	Recommended Mitigation/ Management Measure	Impact Significance After Mitigation
	• Increase availability of natural gas for economic development. • Increase employment.		

5.0 PROJECT IMPACT CATEGORY

The proposed Woodbourne LNG Plant Expansion will have negligible to minor impacts on the environment or the community. However, the handling of LNG involves a minor potential risks, which merits that the Project be classified as Category "B". In accordance with OP-703, Category B projects "are likely to cause mostly local and short-term negative" impacts, for which "effective mitigation measures are readily available". Appendix D presents the Environmental and Social Management Plan of the Project.

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APPENDIX A PUBLIC CONSULTATION: NEWSPAPER ANNOUNCEMENT AND SIGN-IN SHEET

FAZEER MOHAMMED

A test of patience and consistency

West Indies cricket is preparing for the examination that has consistently proved to be the most daunting.

THIS FEELS like grappling with GCE A Levels all over again. If the orals don't get you and you scrape through the multiple-choice, that unavoidable essay question has the potential to obliterate any prospect of an overall passing grade.

Phenomenal success for the Under-19s in Bangladesh and at the **World Twenty20** in India has been followed by an encouraging effort in getting to the final of the tri-nation One-Day International series here at home. Now though, West Indies cricket is preparing for the examination that has consistently proved to be the most daunting and so often the most dispiriting over the past 20 years.

Benchmark

As much as the public has been attracted in droves to the compact excitement of the sport's shortest format and are still more likely to turn up for a One-Day International (ODI), Test cricket is still held as the benchmark, the water line at which successive teams and successive players of abilities great and small have occasionally been splashing and thrashing around to stay afloat. Maybe that will change in time as T20 takes an ever-greater hold on the Caribbean consciousness, fuelled obviously by the success enjoyed and the spirited environment that surrounds it.

In stark contrast, Thursday's scheduled first day's play in the four-Test series against India at the **Vivian Richards Stadium** in Antigua will probably be like any visit to a place of worship outside of the festive season when only the few diehards are to be found.

Struggle

Yet even those disenchanted masses will occasionally pass by a television set or a radio tuned into the cricket and inquire as to the score. Yes indeed, Test cricket still matters to the audience out there, even if they don't turn up in person. And if the majority of players are to be believed, it is still the format of the game at which they yearn to excel, to be compared favourably with the legends of their parents' and grandparents' lifetimes.

Putting aside the many parochial and insular matters – an analytical piece by S. Rajesh at **www.espncricinfo.com** provides telling detail on both Denesh Ramdin and Shane Dowrich – the hosts are likely to struggle throughout much of the series against opponents who have shown far more effective adaptability across the different formats of the game and, most importantly, now reflect the confidence, the aggression and even the arrogance of a nation that has become comfortable with the role of being the dominant economic force in cricket.

There is frankly no need to occupy space extolling the virtues of the likes of captain Virat Kohli, spinner Ravichandran Ashwin, pacer Ishant Sharma and the other key players among the visitors simply because their credentials are so very well established on the international stage.

Progress

Of course, the same cannot be said of many of their West Indian counterparts, whose numbers range from the encouraging to the ordinary. Still, it is an opportunity once again to at least attempt to confound the critics, to show that the progress made earlier in the year can be transferred to Test level and that coach Phil Simmons has actually been able to build a squad around young captain Jason Holder – in the face of considerable adversity – that can actually hold its own.

On the face of it, though, that will be considerably easier said than done, especially with a bowling line-up lacking in experience, consistency and proven potency, not to mention the inevitable concerns about front-line members of the attack staying in active duty for the duration of the contest.

Front-line bowlers

West Indies are likely to find themselves in a situation of having to rely on two men, Holder and Carlos Brathwaite, who are not yet front-line bowlers in their own right, yet are considered invaluable for their general cricketing acumen and for the runs they can contribute lower down the order in a batting line-up that remains a combination of the unproven and the inconsistent.

Miguel Cummins should have played his first Test between the showers in Sydney in January but is now likely to get the burgundy cap and a heavy workload, especially if Shannon Gabriel remains injury-prone and Devendra Bishoo's worn spinning finger succumbs to the rigours of protracted spells.

Don't be surprised if all five make the final 11 and opener Rajendra Chandrika and the uncapped Roston Chase are the ones who miss out from the squad, given the expectation that Holder and Brathwaite, at seven and eight, can be expected to make significant contributions.

Look, whichever way you approach it, this is going to be a tough examination. It is best then to buckle down for the long haul and show the sort of Kraigg Brathwaite-type concentration and determination that will allow the flash and flair of Darren Bravo and Marlon Samuels room for expression.

Like most exams, though, it's easier said than done.

Fazeer Mohammed is a regional cricket journalist and broadcaster who has been covering the game at all levels since 1987.

NOTICE

INVITATION FOR THE PUBLIC TO ATTEND
AN
INFORMATION SESSION AND
STAKEHOLDER CONSULTATION

ON

PROPOSED EXPANSION TO THE BARBADOS NATIONAL OIL COMPANY'S LNG RE-GASIFICATION FACILTY

Date: JULY 21ST

Time: 6 - 8:00PM

Location: BNOCL PAVILION

SIGNUP REGISTER FOR BNOCL OPEN CONSULTATION

DATE: JULY 21, 2016

PRINT NAME	ORGANIZATION	PHONE NUMBER	EMAIL ADDRESS
Mervyn GORDON	BNOCL	[redacted]	[redacted]
PEDRO BUSHELLE	BNOCL	[redacted]	[redacted]
WESLEY CARTER	BNOCL	[redacted]	[redacted]
FWD PATRICK	BNOCL	[redacted]	[redacted]
PATRICK WELCH	BNOCL	[redacted]	[redacted]
NOEL GREENIDGE	NPC		
KEN LINTON	NPC		
Ricardo Calvo	ERM		[redacted]
LAWSON BERNARD	GOL	[redacted]	[redacted]
JAMES BROWNE	NPC	[redacted]	[redacted]
Shyrelle Haward-Gittens	~~Government~~ Public	[redacted]	
DAMIEN CATLYN	NPC	[redacted]	[redacted]
PAULA GITTENS	NPC	[redacted]	[redacted]

APPENDIX B EMERGENY RESPONSE PLAN

2016

Emergency Response Plan

LNG Re-Gasification Plant Woodbourne, St. Philip

Barbados National Oil Company Ltd.

6/27/2016

Code:	
Version:	0.2
Created by:	Damien Catlyn
Approved by:	
Date of version:	27-Jun-2016
Signature:	

Distribution List

Copy No.	Distributed to	Date	Signature	Returned	
				Date	Signature

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TABLE OF CONTENTS

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1 GENERAL INFORMATION

1.1 SCOPE

This plan covers the Emergency Response Procedures for the Liquefied Natural Gas Re-gasification facility at:

Barbados National Oil Company Limited
Woodbourne,
St. Phillip

1.2 GENERAL

This system is designed to utilize current technology, safety, and control devices. However, emergency conditions can develop. Causes for emergencies may include such things as judgment errors by facility or truck operators, equipment failure, natural disasters or sabotage. Therefore it is important for personnel to be prepared to respond quickly, safely, and properly to an emergency to reduce injury or property and equipment damage. The equipment is designed with safety features included. The methane sensors and flame detectors at this facility provide continuous real-time monitoring. In cases where an emergency is eminent, the control system can activate the emergency shutdown (ESD) system. In addition, where the activation of emergency shutdowns can result in significant pressure accumulation, pressure relief devices are provided to relieve predetermined pressures safely and automatically.

The fire block valves are the most effective forms of emergency control since they limit the quantity of gas that can contribute to a potential emergency. In the event of shutdown due to methane detection, the source should be identified immediately. Proper operation of the facility cannot be initiated until the problem is corrected. A manual ESD can be initiated by the operator.

Manual fire fighting systems will be provided to allow operators and responding authorities various options in controlling the emergency situation. With these systems, site personnel have at their disposal the necessary equipment to control most any emergency condition that could arise. Since there is a varied possibility of situations and conditions during an emergency, "cookbook" approaches are not always a realistic approach to rectifying the situation. Therefore the purpose of this manual is educating the operator(s) with the various systems that

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are present; provide ideas for controlling specific emergencies and list guidelines on specific procedures

1.3 DEFINITIONS

Controllable Emergency	An emergency condition in which the hazard is limited to within the immediate vicinity of the Facility
Uncontrollable Emergency	An emergency condition in which constitutes a hazard to persons and/or property outside of the immediate vicinity of the Facility

1.4 EMERGENCY PREVENTION

All personnel shall identify and report to BNOCL any suggested improvements to equipment and/or procedures which would aid in the prevention of unsafe conditions that could cause an emergency

1.5 TRAINING

All personnel working on the Re-gasification Facility shall receive training on how to identify unsafe conditions and how to respond to emergency situations. Wherever possible, contractors and National Emergency Responders shall also be trained on the emergency procedures for the Facility.

1.6 EMERGENCY COMMUNICATION

The fire alarm system at the LNG Re-gasification facility shall be connected directly to the Barbados Fire Service as well to ensure timely notification in the event of a major incident. BNOCL is also a member of the national 'Astro radio' network and so has a direct communications link with the Department of Emergency Management (DEM) as well as Royal Barbados Police Force (RBPF) in the event of a major incident.

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2 RESPONSIBILITIES

The safety of persons is the primary consideration in an emergency. All actions taken must take into account the preservation of life as their primary focus.

2.1 LNG OPERATOR

- Inform all Visitors and Contractors of the evacuation routes and location of the muster point
- The Operator on duty shall be determine the immediate response to any emergency
- He/she shall take the safety of site personnel (including him/herself) and the immediate public as the priority
- Account for all visitors and contractors on the site and direct them to the muster point
- The LNG Operator may initiate the Emergency Shutdown Device (ESD); notify local authorities (Fire Service/RBPF); and order a site evacuation

2.2 LPG OPERATOR

- Report to and assist the LNG Operator in whatever response the LNG Operator has chosen
- Initiate the ESD for the LPG plant if required

2.3 HSSE OFFICER

- Ensure all personnel are trained in the emergency response procedures
- Ensure all safety equipment is inspected, tested and calibrated according to the manufacturer's recommendations
- Obtain information and brief the Fire Service when they arrive

2.4 VISITORS AND CONTRACTORS

- Know the emergency procedure as it relates to them and the evacuation routes and muster point location
- Wait at the muster point and verify your presence with whoever BNOCL staff member is conducting a head count
- Obey the orders of all BNOCL staff and Fire Service personnel in the event of an emergency

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3 IDENTIFICATION OF POTENTIAL EMERGENCIES

3.1 LIST OF POTENTIAL HAZARDS

1. Major Leak
2. Spill
3. Fire
4. Fire outside Plant Perimeter
5. Natural Disaster
6. Frost Spots on Container Wall
7. Total Container Failure

3.2 VERIFICATION OF ALARMS

3.2.1 Methane Gas Detectors (MGD)

MGDs are used for early detection in potential accident locations. They are located strategically around the Facility to provide coverage for areas with a higher risk of leaking. An Emergency Shutdown (ESD) will be triggered if the MGD detects any methane in an area, after the shutdown a visual verification followed by a swift repair will generally prevent an emergency situation from being initiated.

Most ESDs are triggered by minute amounts of methane and are fixed by tightening a nut/bolt or connection. However, there is always a chance that something greater may occur therefore the shutdown is always triggered.

3.2.2 Flame Detectors

Flame detectors are used to detect any flames that may occur within the potential accident locations before they become major incidents. Similar to MGDs the flame detectors have been strategically placed to cover high risk areas.

The flame detector will trigger an ESD and send an automatic alert to the Barbados Fire Service. Immediately after the shutdown: a visual verification by the LNG Operator followed by extinguishment of the flames (if the fire is small and easily managed).

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3.3 VISUAL ESD LIGHT

There is a red light in the control panel and room which activates in the event of an ESD. No other operations can be continued until the methane source has been identified and corrected.

3.4 CONTROLLABLE INCIDENTS

If an emergency occurs the personnel shall determine whether:

- It can be managed and rectified by the personnel on site with no assistance from national emergency entities or
- that will not affect the public outside of the immediate vicinity of the plant

If both criteria are met then all applicable emergency procedures (e.g. isolation and ESD) will be initiated and followed.

3.5 UNCONTROLLABLE EMERGENCIES

In the event a verified emergency condition exists where a hazard could develop to persons or property outside the site radius, evacuation procedures should be executed immediately.

The following conditions may constitute an uncontrollable emergency:

- Total Failure of an LNG container
- Large fire within the facility
- Large scale spill of LNG

3.6 MEDICAL INCIDENTS

In the event of a medical emergency, the BNOCL first aid procedures shall be followed.

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4 EMERGENCY RESPONSE – CONTROLLABLE INCIDENTS

4.1 ISOLATION PROCESS AND ESD PROCEDURES

In most emergency conditions (e.g. natural disaster, uncontrolled venting of gas, fire) it is necessary to isolate all sources of LNG. The isolation of the LNG will remove the fuel source from a fire and facilitate its extinguishment or allow it is burn itself out. After the fire is extinguished recovery operations may begin.

Under normal conditions, the ESD will initiate automatically and close the fire block valves.

4.1.1 Emergency Shutdown:

On detecting a leak, the system shall perform an ESD automatically. When this occurs, isolation procedures shall be initiated as outlined below:

1. Control Panel ESD switch triggered (OR)
2. ESD switch triggered – located in control building
3. Isolate LNG in containers by closing liquid line valves
    a. Note: this is a back-up step as the ESD will already have closed the fire block valves on the containers
4. Isolate the power sources – electric circuit breaker

4.1.2 LNG Trailer

The LNG containers are equipped with manual fire block valves located on the left side and left rear of the container. Should the automatic ESD fail for some reason the fire block valves may be closed manually (Figure…)

1. Pull on the handles or anywhere along the silver cable running down the left side of the container

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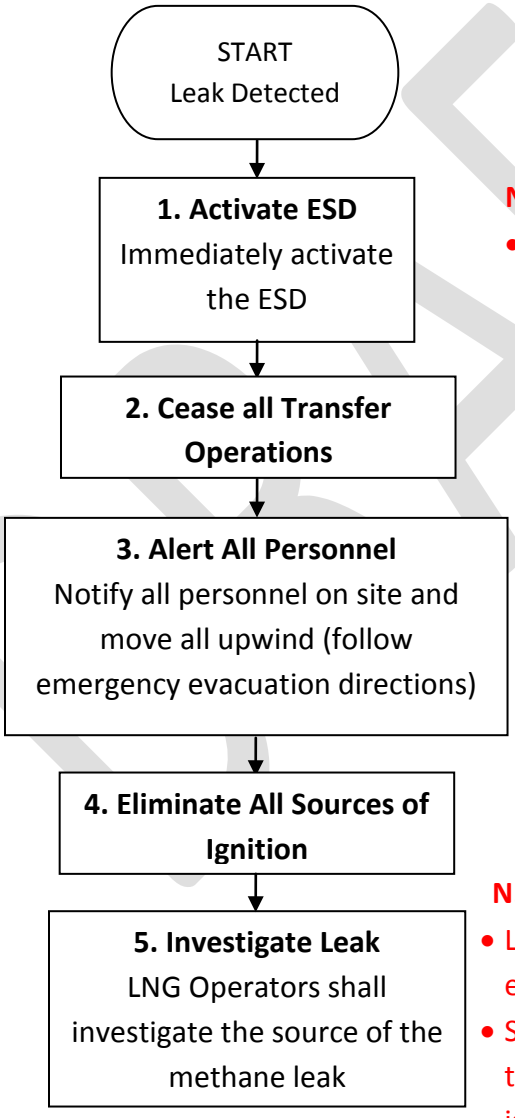
4.2 LNG LEAK, SPILL

N.B.

Research has indicated that with LNG spills, the flammable limits of the vapour cloud are near the visible limits of the cloud. The lower the humidity the farther the flammable limit extends past the visible cloud.

There is no permanent LNG storage on site so all LNG related spills are expected to involve the LNG containers, LNG Liquid lines or the vaporizers.

For all leaks the following steps are to be taken:



N.B.

- New Fortress LNG containers do not have ESD capability so LNG Operators shall manually close the LNG supply line on the container (or pull the firebreak line)

N.B.

- LNG Operator shall not enter any vapour cloud
- Shall not enter any area that his personal gas tester is O_2 deficient

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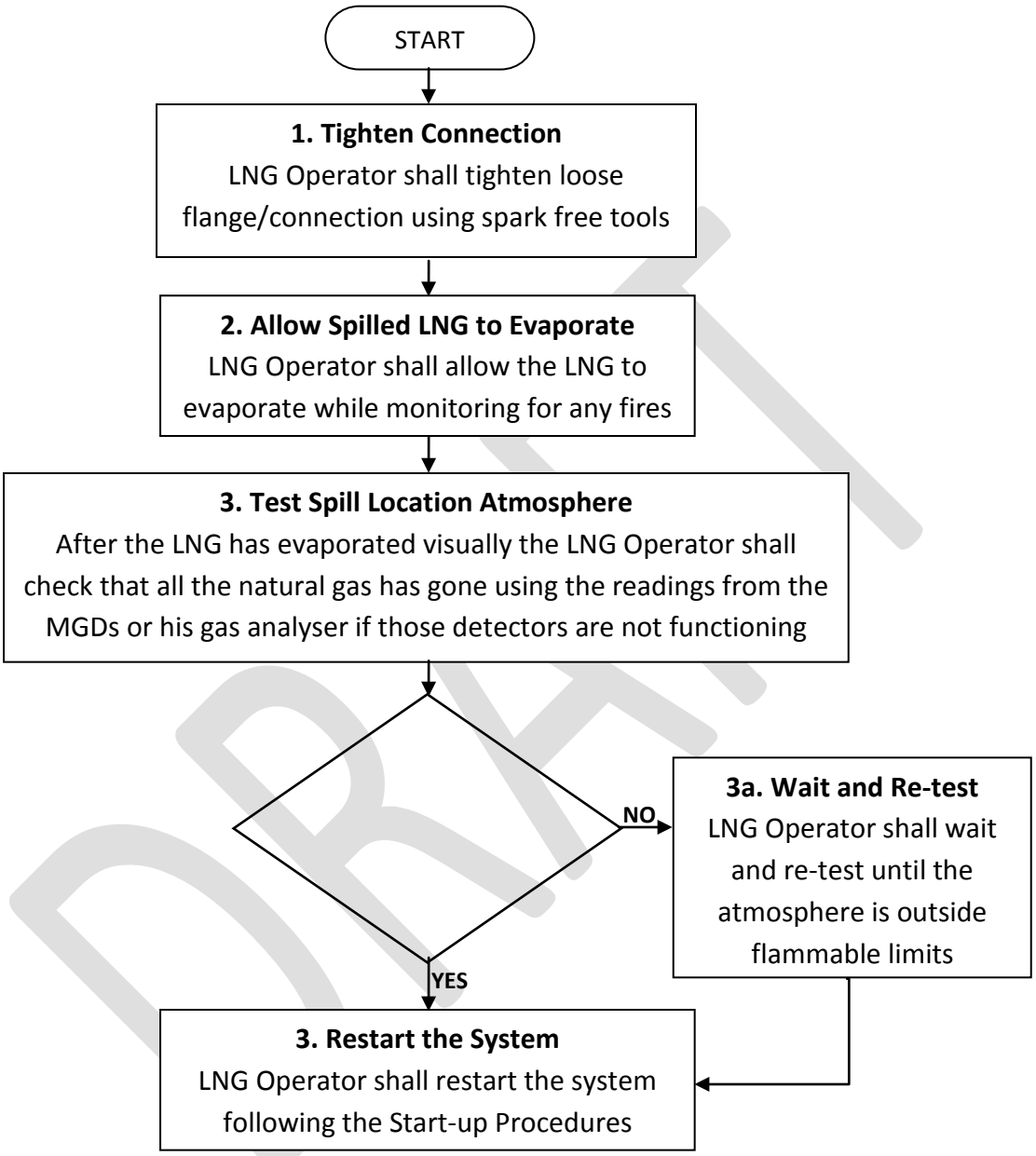
4.2.1 Small Leak at Hose/Pipe Connection

If there is no fire and the leak is found to be due to a loose connection, the LNG Operator shall:

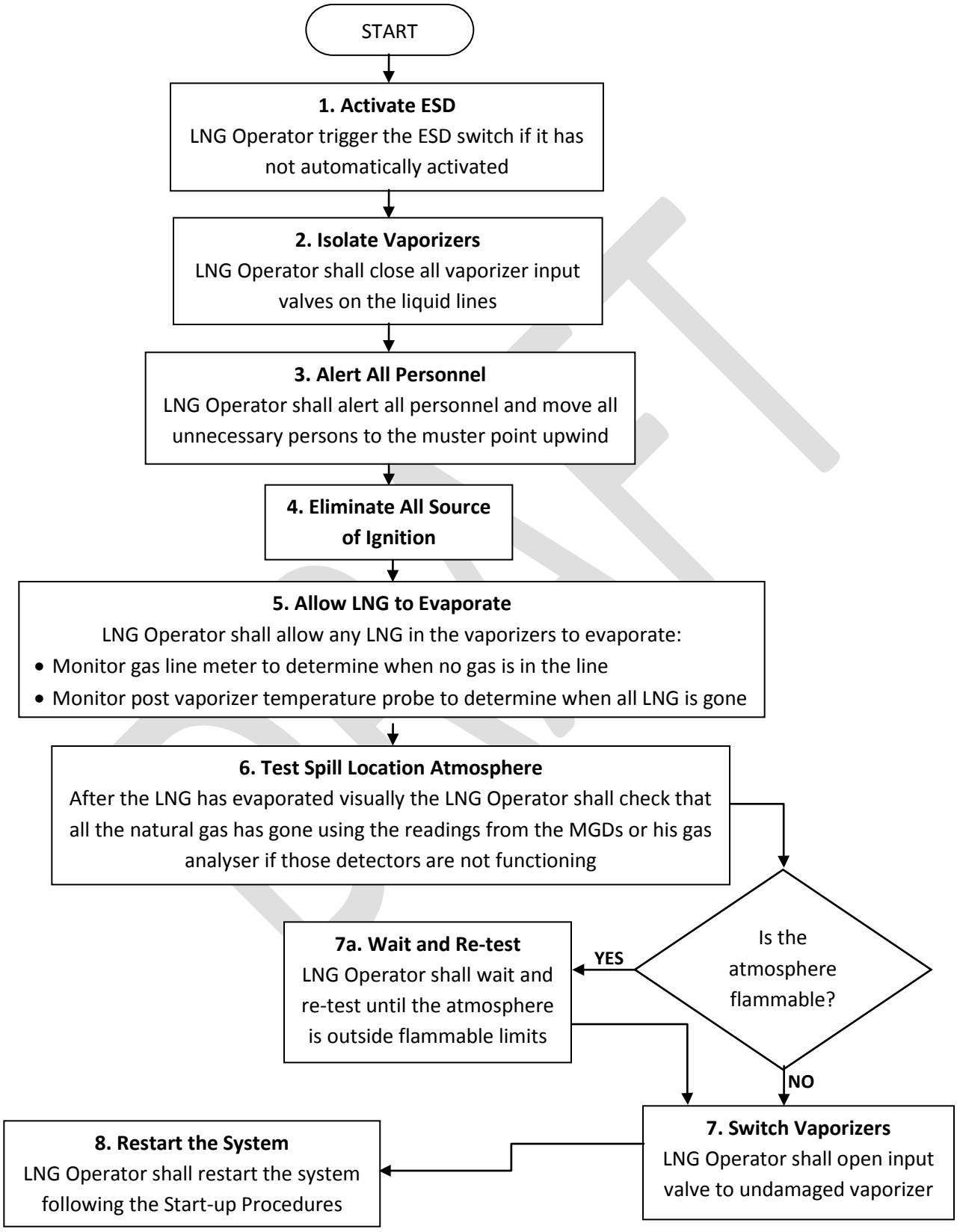


N.B.

- If a fire occurs as a result of any leak or spill then the Operator shall follow procedure in Section 4.3
- After any fire related incident the plant shall **not be restarted** until the affected equipment has been **fixed/replaced and all equipment inspected** and deemed suitable for operation.

4.2.2 Leak in a Vaporizer

Any leak occurring in a vaporizer shall result in:



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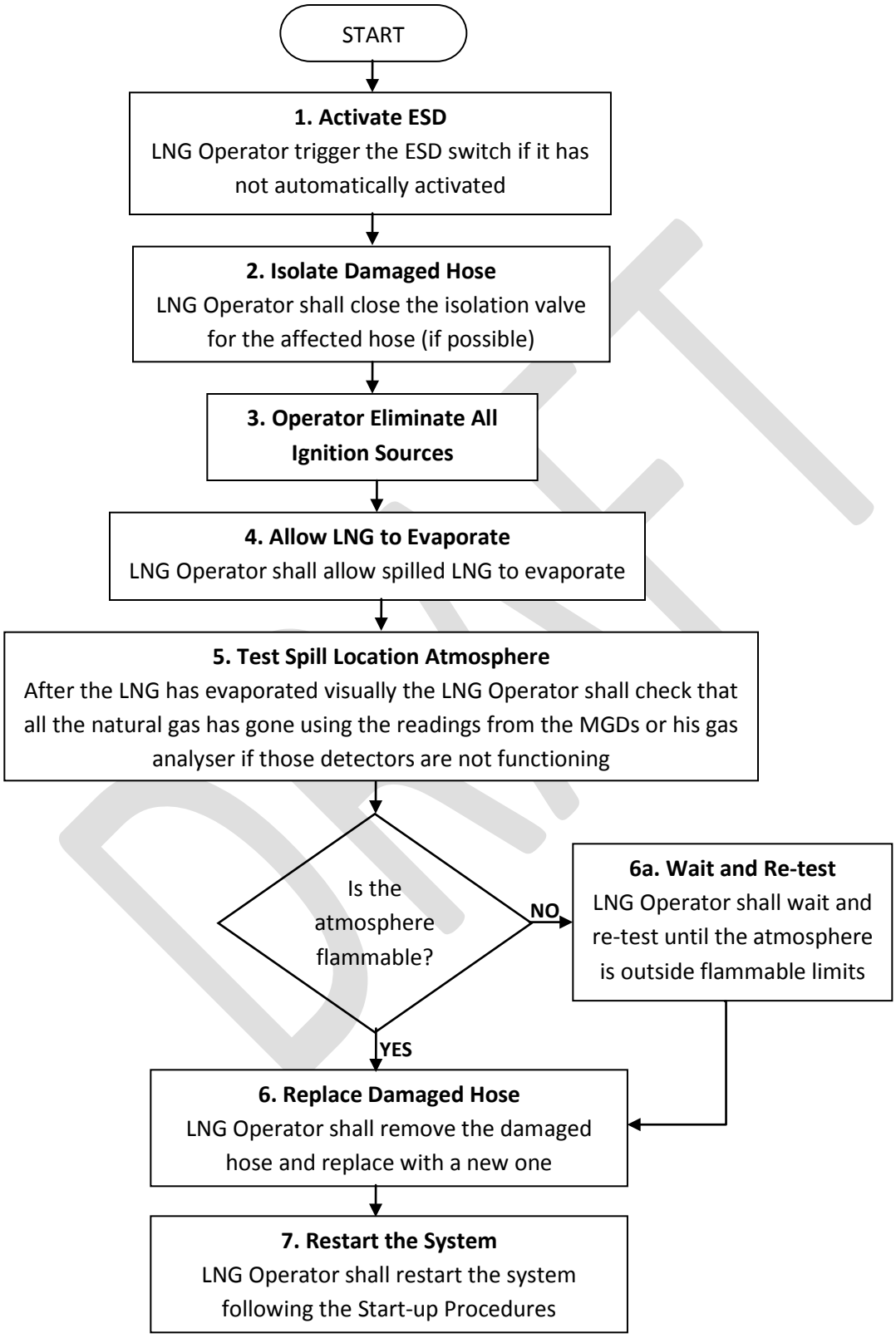
4.2.3 Leak in Transfer Hose



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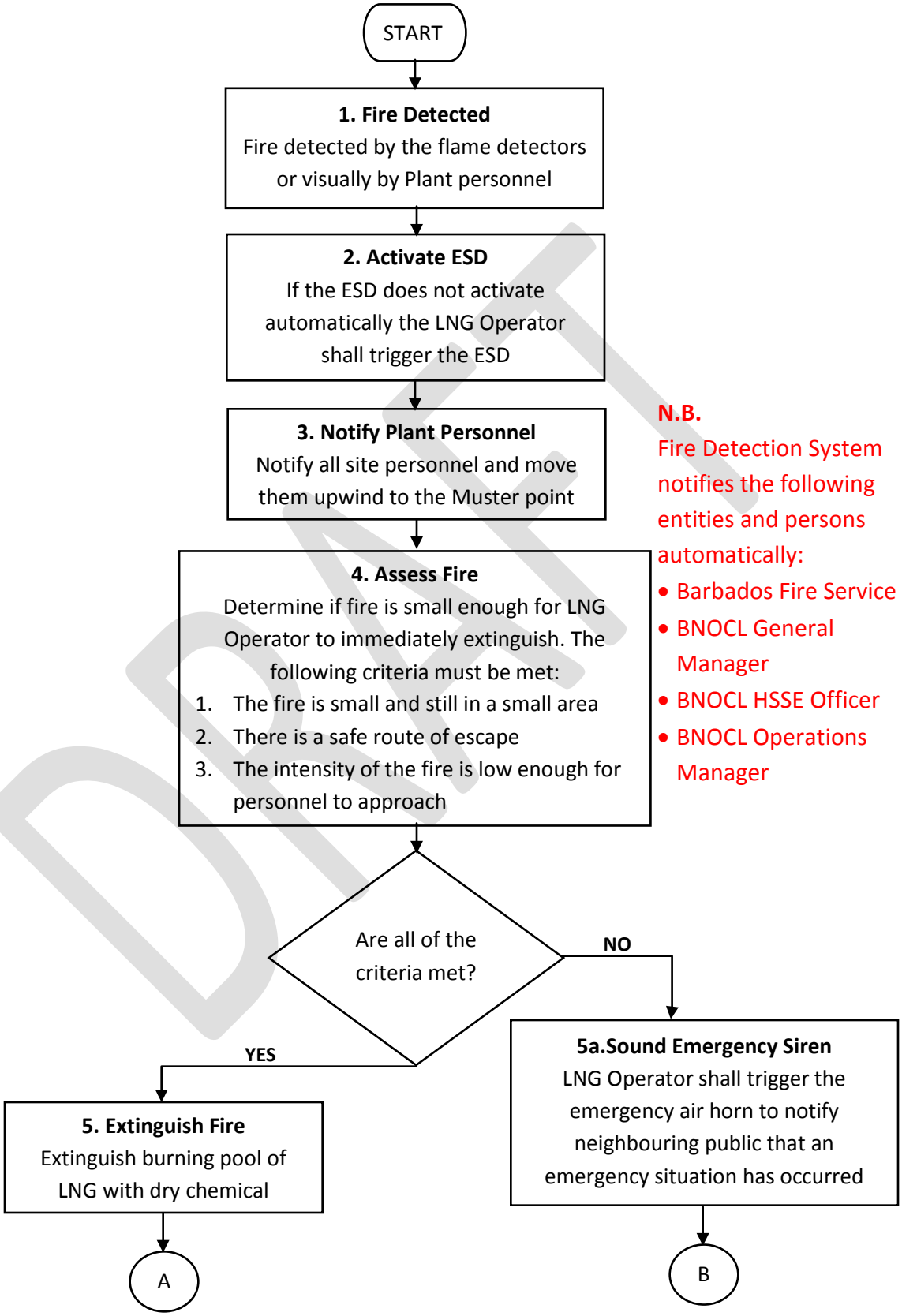
4.3 FIRE INCIDENT INSIDE PLANT



N.B.

Fire Detection System notifies the following entities and persons automatically:

- Barbados Fire Service
- BNOCL General Manager
- BNOCL HSSE Officer
- BNOCL Operations Manager

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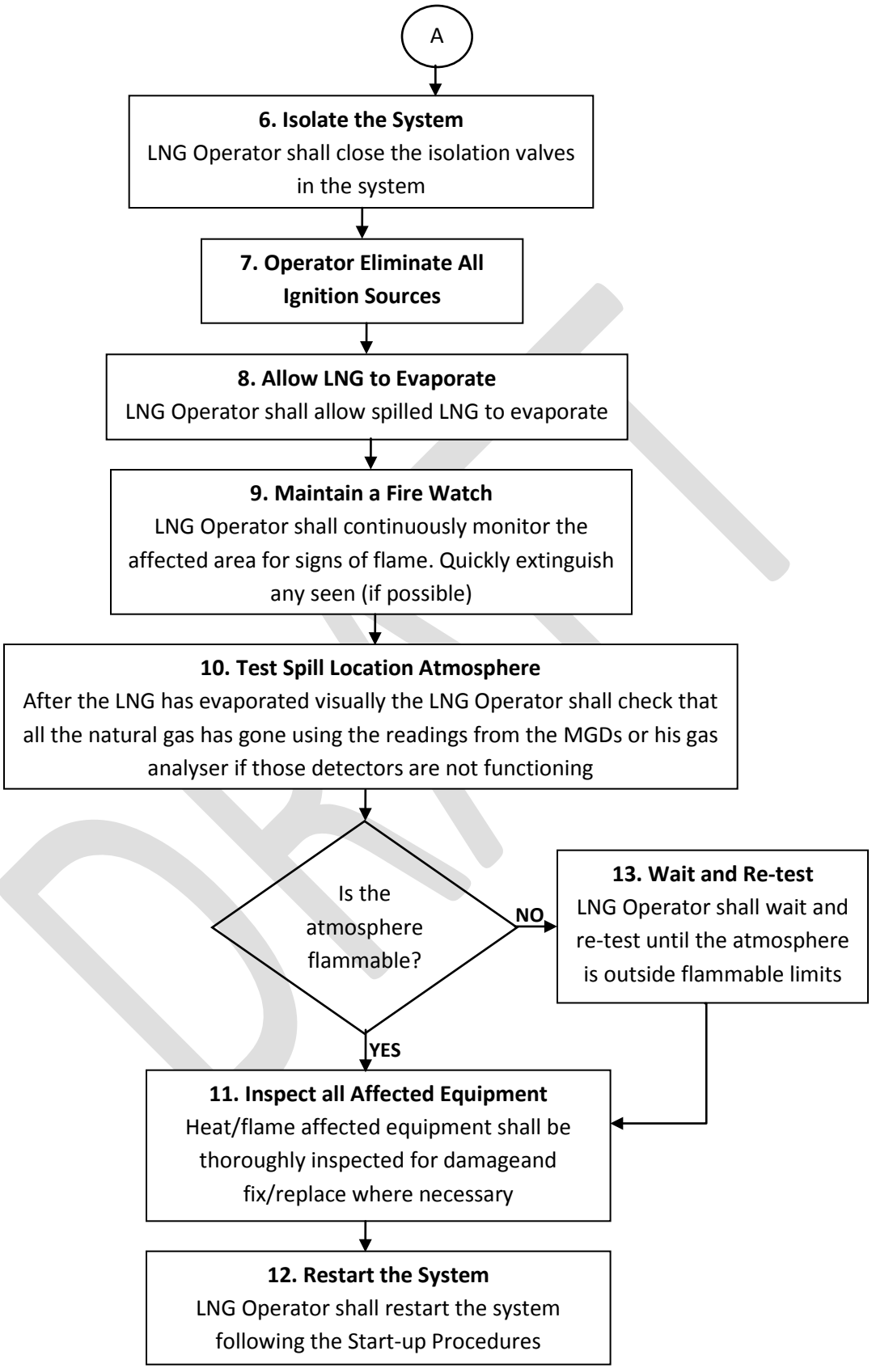
A
6. Isolate the System
LNG Operator shall close the isolation valves in the system
7. Operator Eliminate All Ignition Sources
8. Allow LNG to Evaporate
LNG Operator shall allow spilled LNG to evaporate
9. Maintain a Fire Watch
LNG Operator shall continuously monitor the affected area for signs of flame. Quickly extinguish any seen (if possible)
10. Test Spill Location Atmosphere
After the LNG has evaporated visually the LNG Operator shall check that all the natural gas has gone using the readings from the MGDs or his gas analyser if those detectors are not functioning
Is the atmosphere flammable?
NO
13. Wait and Re-test
LNG Operator shall wait and re-test until the atmosphere is outside flammable limits
YES
11. Inspect all Affected Equipment
Heat/flame affected equipment shall be thoroughly inspected for damageand fix/replace where necessary
12. Restart the System
LNG Operator shall restart the system following the Start-up Procedures

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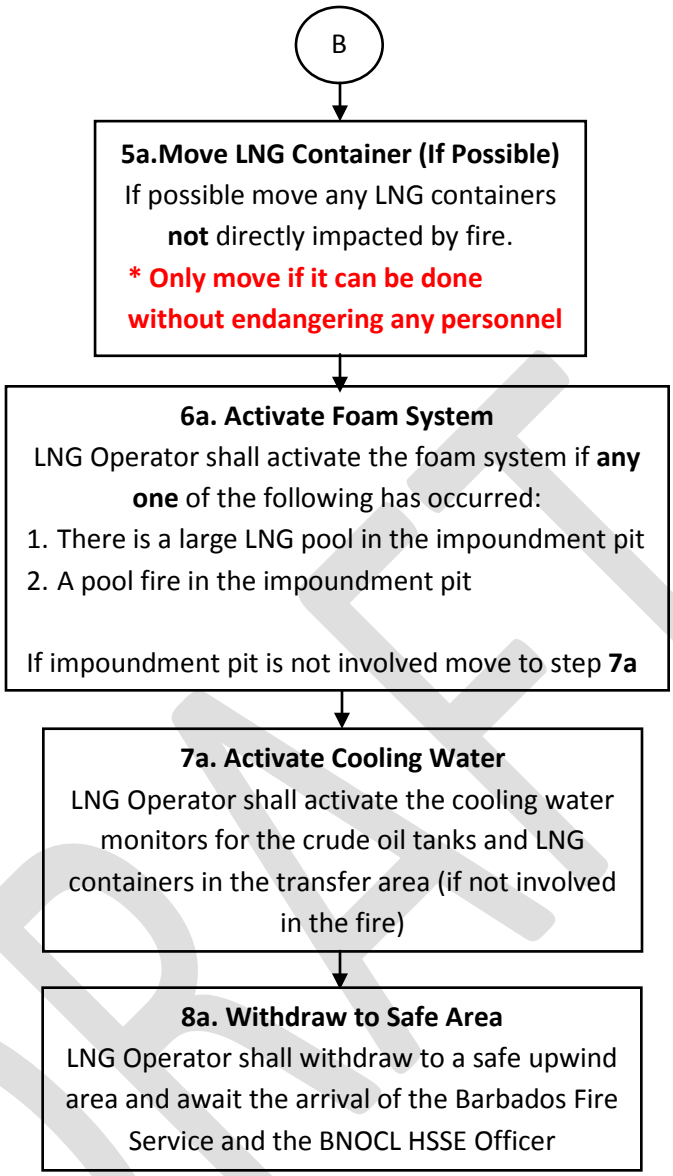
B
5a.Move LNG Container (If Possible)
If possible move any LNG containers not directly impacted by fire.
* Only move if it can be done without endangering any personnel
6a. Activate Foam System
LNG Operator shall activate the foam system if any one of the following has occurred:
1. There is a large LNG pool in the impoundment pit
2. A pool fire in the impoundment pit
If impoundment pit is not involved move to step 7a
7a. Activate Cooling Water
LNG Operator shall activate the cooling water monitors for the crude oil tanks and LNG containers in the transfer area (if not involved in the fire)
8a. Withdraw to Safe Area
LNG Operator shall withdraw to a safe upwind area and await the arrival of the Barbados Fire Service and the BNOCL HSSE Officer

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4.4 NATURAL PHENOMENON

4.4.1 Severe Electrical Storm

Due to the increased probability of an electrical power surge, the ESD should be initiated to ensure the continued integrity of all the electrical components of the system.

4.4.2 Earthquake

Low magnitude tremors are becoming more common. The vaporizers, saddles, and their foundations are built to withstand that type of seismic zone activity.

Although no seismic occurrences should be taken lightly, after tremors that measure greater than or equal to 5.0 on the Richter scaleall piping connections, pipe supports, vaporizers, and foundations shall be visually inspected. If movement has occurred pressure tests shall be conducted on all associated piping and equipment.

4.4.3 Hurricane

Due to the probability of damage from flying objects and flooding from heavy rainfall. The plant shall be shut down for all hurricanes registering greater than category 2 on the Saffir-Simpson scale.

All piping connections, pipe supports, vaporizers and equipment shall be visually inspected after the operational all clear has been given. If damage has occurred, pressure tests shall be conducted on all associated piping and equipment.

4.5 FIRE OUTSIDE FACILITY PERIMETER

Any fire outside the site area which is visible to the operator should be reported to the fire department immediately.

If there is a cane field/grass fire that is approaching the plant, the LNG Operator shall activate the ESD, if the flame detectors have not already done so.

The operator should be aware of any blowing embers that might come inside the radius area.

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5 EMERGENCY RESPONSE – UNCONTROLLABLE INCIDENTS

5.1 LARGE LNG SPILL

A catastrophic failure of an LNG container could result in a vapour cloud that leaves the plant boundary and affect the nearest residence approximately 900m away. The distance the vapour cloud travels is dependent on:

- Wind velocity
- Terrain
- Atmospheric conditions

Studies indicate that LNG is rapidly dissipated by high winds, however low wind speeds keep the vapour cloud close to the source.

Worst Case: Container failure with wind speeds are below 8 mph (~13 km/h). Under these conditions if the vapour cloud comes into contact with an ignition source, it will burn back to the spill source (**will not explode but it will ignite**).

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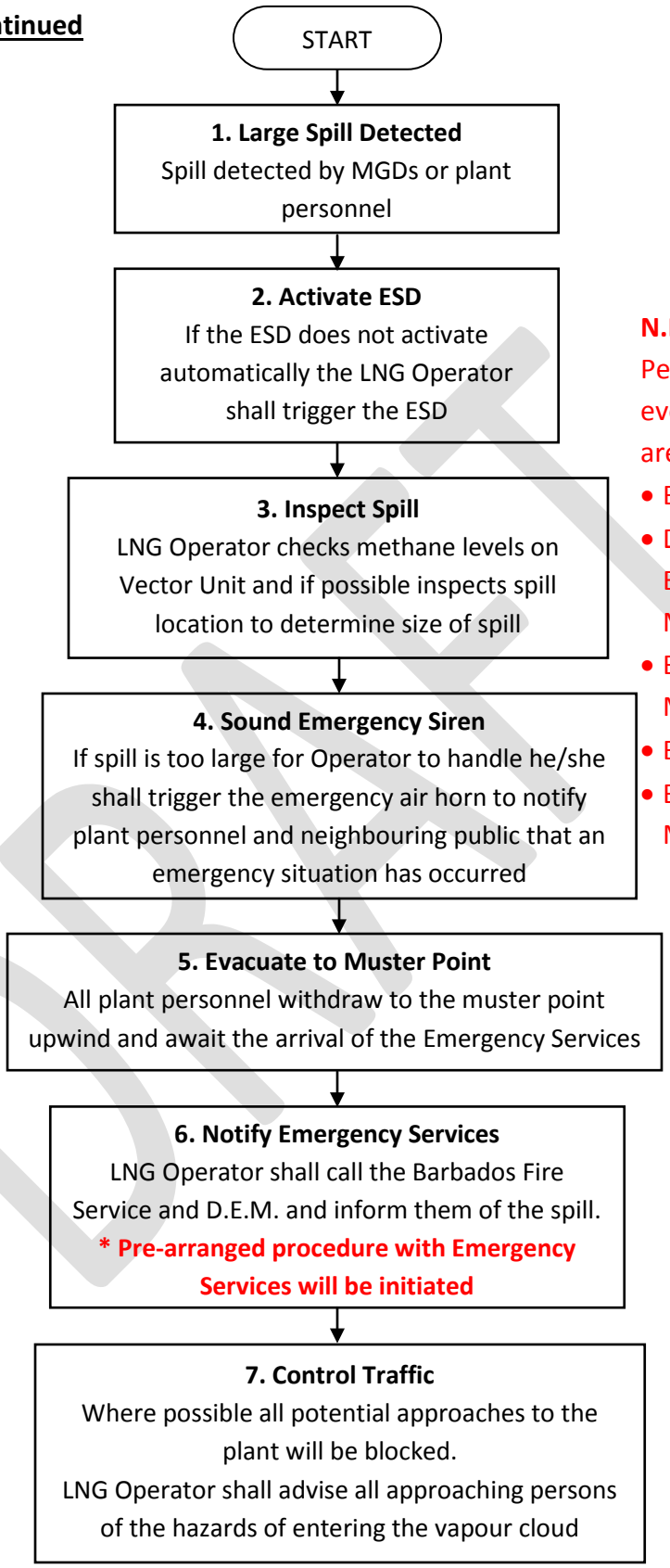
Large LNG Spill Continued



N.B.

Persons to contact in the event of an Emergency are:

- Barbados Fire Service
- Department of Emergency Management (D.E.M.)
- BNOCL General Manager
- BNOCL HSSE Officer
- BNOCL Operations Manager

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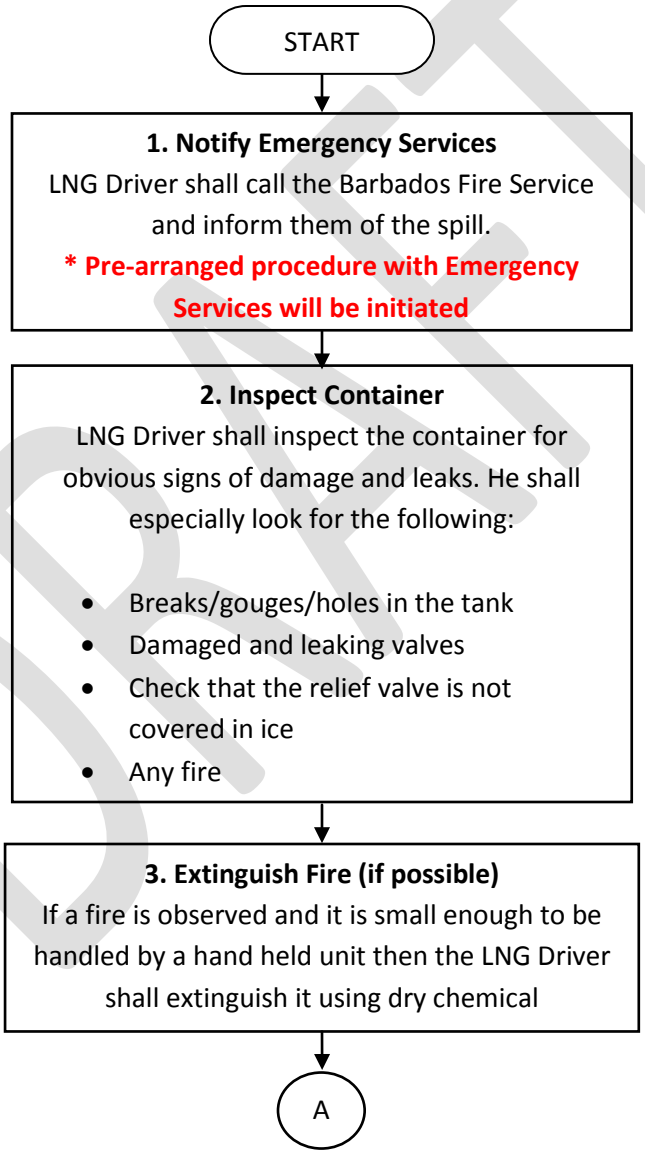
5.2 LNG CONTAINER ROLLOVER

A serious vehicular accident involving an LNG container in which the tank is damaged or the container has rolled over on its side could result in an unconfined LNG spill on the public roads and become a fire or even explosive hazard.

Worst Case: Container rolls on its side and the LNG comes into contact with the relief valve causing it to freeze shut. This would result in the pressure building inside the tank and could result in a Boiling Liquid Expanding Vapour Explosion (BLEVE).



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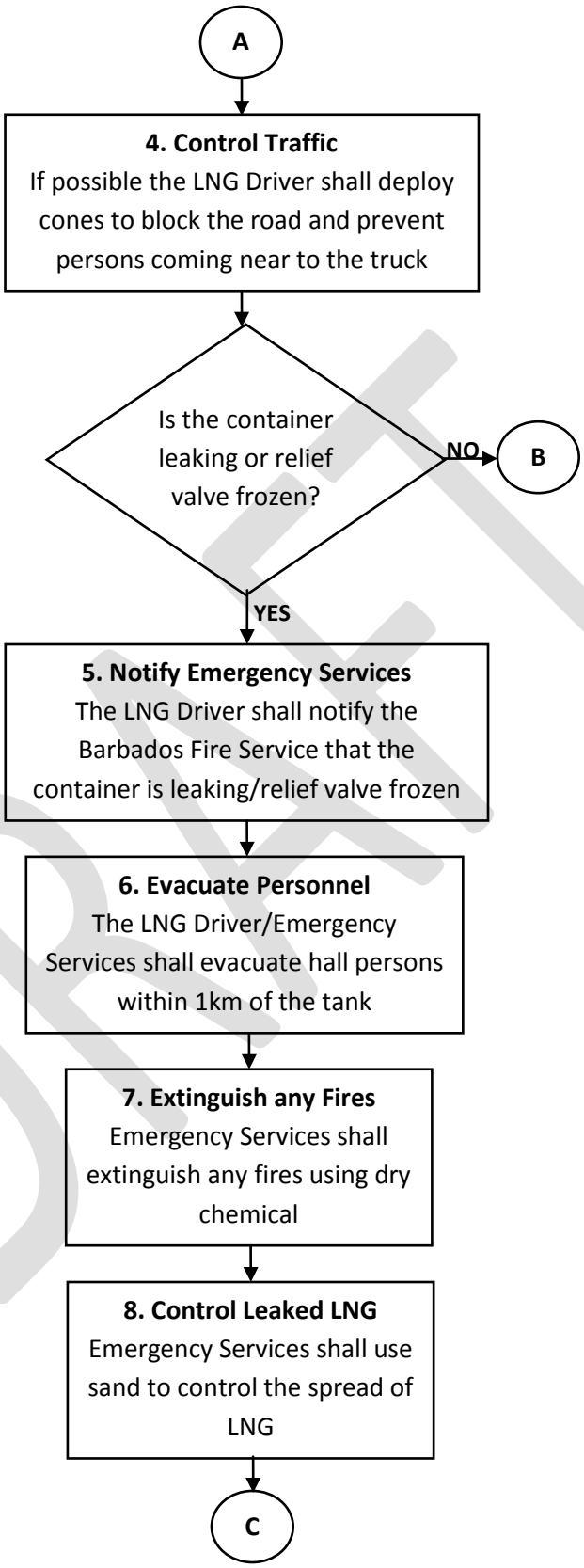
A
4. Control Traffic
If possible the LNG Driver shall deploy cones to block the road and prevent persons coming near to the truck
Is the container leaking or relief valve frozen?
NO
B
YES
5. Notify Emergency Services
The LNG Driver shall notify the Barbados Fire Service that the container is leaking/relief valve frozen
6. Evacuate Personnel
The LNG Driver/Emergency Services shall evacuate hall persons within 1km of the tank
7. Extinguish any Fires
Emergency Services shall extinguish any fires using dry chemical
8. Control Leaked LNG
Emergency Services shall use sand to control the spread of LNG
C

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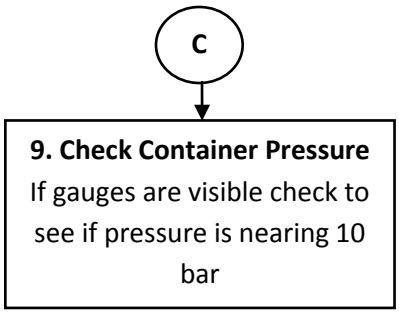
C
9. Check Container Pressure
If gauges are visible check to see if pressure is nearing 10 bar

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6 INTERNAL NOTIFICATION AND COORDINATION

6.1 GENERAL

The Emergency Coordinator shall be the communication link between the LNG Operator and any outside assistance until the emergency situation has been rectified.

An **Emergency Call List** (Appendix...) shall be kept up to date and shall be made available at the site Headquarters, Control Room and any other place deemed necessary.

6.2 EMERGENCY CALL-OUT

In some instances it may be necessary to have additional personnel report to the site to provide assistance. The Emergency Coordinator shall authorise additional help as needed.

6.3 CONTROLLABLE EMERGENCY

Upon verification of an accident condition, the operator shall notify the Emergency Coordinator. Communications between the coordinator and the operator will be maintained as much as possible without hindering the emergency response efforts.

6.4 UNCONTROLLABLE EMERGENCY

In the event of an uncontrollable emergency the Emergency Coordinator will notify the proper authorities.

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7 EXTERNAL COMMUNICATION AND COORDINATION

7.1 GENERAL

Before the beginning of operation of the LNG facility, local officials shall be made aware of all types, quantity, and locations of all fire control equipment.

Local officials shall also be given copies of this Emergency Response Plan (and any updates) to show what potential hazards are at the Facility, communication and emergency control capabilities, and the facility's status of each emergency. A map of the area showing all potential entrances by the public shall be provided to the Department of Emergency Management and Royal Barbados Police Force for their use in cordoning off the LNG facility in the event of an emergency.

7.2 FIRE SERVICE

The fire detection system shall be programmed to notify the Fire Service automatically in the event of a fire or explosion within or adjacent to the site.

The Worthing Fire Station is the responsible entity. Contact details are:

- Worthing Station: **311** if not call

The Fire Service does not utilise dry chemical and so shall require the dry chemical equipment already staged at the LNG Facility. Coordinated training session to familiarise the Fore Service staff with the fire response equipment on the LNG facility shall be conducted regularly.

7.3 ROYAL BARBADOS POLICE FORCE

In the event of a security threat, major controllable incident or uncontrollable incidents the RBPF shall be contacted. Contact details are:

- RBPF: **211**

7.4 MEDICAL EMERGENCY

In the event of a medical emergency, the BNOCL first aid procedure shall be followed and .....shall be contacted.

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7.5 MEDIA COMMUNICATION

DRAFT

8 EVACUATION

8.1 CONTROLLABLE INCIDENTS

In the event of a *controllable emergency* all persons within the immediate location of the emergency shall exit the area avoiding any vapours that may be emitted from the incident.

In the event that visitors or contractors are present on site, they shall be accounted for and directed off the company property.

When leaving the area, avoid congregating on the access roads where responding emergency vehicles or personnel may traverse.

Evacuation will preclude the persons from removing their tools, equipment or vehicles from within the plant boundaries. Remove any sources of ignition.

In the event of a vapour cloud, direct persons opposite and up wind of the occurrence.

Due to the remote location of the LNG Facility, the only evacuation seen to be needed, will be those personnel actually in the facility. In the case of a controllable emergency where there will be cause for an evacuation, all personnel will exit through the exit gate, which will be open. And personnel will move to the east of the facility to the area of the T-junction leading to the access road to Yorkshire (Figure 1.).

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Figure 1: Site Map showing the location of the Re-gasification Facility Muster Point

To be in cooperation with local officials, the LNG Facility has established contact with surrounding local law enforcement and fire departments. Both entrance and exit gates will be opened and all LNG personnel will offer full support to all external agencies

8.2 UNCONTROLLABLE INCIDENTS

In the event of an *uncontrollable emergency* execute the evacuation plan for persons within the site area described in the above section.

After activation of the ESD, all persons must leave the area. All personnel will exit through the exit gate, which will be open. The emergency horn shall be sounded in a continuous blast to alert all members of the public in the fields surrounding the LNG facility that there is an emergency situation that requires their evacuation. Both entrance and exit gates will be opened and all LNG personnel will offer full support to all external agencies

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9 EMRGENCY TERMINATION

9.1 ALL CLEAR NOTIFICATION

The Emergency Coordinator shall issue the all clear when the emergency has been determined to be over. That determination will be performed by the main Emergency Coordinator for controllable incidents and by the external Incident Commander for uncontrollable incidents.

9.2 DAMAGE ASSESSMENT

The Emergency Coordinator shall determine the extent of the damage, materials required and estimate time for repair. This procedure will be done in cooperation with LNG and Gas Plant Managers and Supervisors.

9.3 EMERGENCY EQUIPMENT RECHARGE

BNOCL shall recharge all expended fire extinguishers and replace them if deemed necessary.

9.4 HAZARD REMOVAL

When an investigation is required by the regulatory agency, *BNOCL or its representatives* shall not remove any component involved until the investigation is complete or is given permission by that agency. One exception to this rule is the necessity to move these components to maintain or restore service or safety. In the event of components being removed for operational or safety reasons, they must remain on site. They must also be kept intact, as much as possible, until the investigation is complete or the agency's authorization is given to do otherwise

9.5 SERVICE RESTORATION

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11 APPENDIX – EMERGENCY CALL LIST

NAME	TITLE	NUMBERS
PATRICK WELCH	HSSE OFFICER	CELL: HOME:
ROBERT COX		
FLOYD PATRICK		
WINSTON BAILEY		

DRAFT

APPENDIX C FIRE RISK ASSESSMENT (FRA) FOR BARBADOS NATIONAL OIL COMPANY LIMITED (BNOCL) LNG SATELLITE PLANT

APPROVED
By Federico A. Martinez at 8:42 am, Apr 22, 2016

REVIEWED
By Agramonte at 8:31 am, Apr 22, 2016

GasEner
ENGINEERING | PROCUREMENT | CONSTRUCTION

BNOCL

Fire Risk Assessment (FRA) for Barbados National Oil Company Limited (BNOCL) LNG Satellite Plant

Tittle:	Fire Risk Assessment (FRA)
Emission for:	Review and Approval
Doc. No.:	BNOCL-FRA-201603-1001
Revision:	4
Date:	April 21, 2016

Made	Review	Approved
JRA	FM	FM

TRACKS CHANGES

Rev.	**Date**	**Description**	**Prepared**	**Checked**	**Approved**	**Rev. Date**
0	2016.02.20	Initial document	JRA	FM	FM	2016.02.24
1	2016.03.05	Team discussion	JRA	FM	FM	2016.03.08
2	2016.03.08	Report for client review	JRA	FM	FM	2016.03.15
3	2016.03.29	Report for client review	JRA	FM	FM	2016.03.31
4	2016.04.21	Final Report	JRA	FM	FM	2016.04.22

DISCLAIMER

This Report and the contents hereof (collectively, this "Report") are being provided pursuant to and in accordance with the TECHNICAL PROPOSAL FOR FIRE RISK ASSESSMENT (FRA) FOR BARBADOS NATIONAL OIL COMPANY LIMITED (BNOCL), dated December 3rd, 2015 between of NPC and GasEner, SRL.

Except as otherwise explicitly stated in the Service Contract, the provisions of the Service Contract are for the sole protection and legal benefit of the parties thereto, and their permitted successors and assigns, and no other person or entity shall be a direct or indirect beneficiary of, or have any direct or indirect cause of action or claim against, any party arising from the Service Agreement or the publication, disclosure or distribution of this Report.

This Report does not constitute the provision of final engineering or design services or advice and should not be utilized or relied on by any person or entity as final engineering or design services or advice. For the avoidance of doubt, neither GasEner, SRL nor their affiliates shall be liable to any third party for any harm or loss associated with utilization of or reliance on this Report.

The present Fire Risk Assessment covers the necessary, but not the detailed requirement to identify and protect the LNG Satellite regasification facility located in Woodbourne, St. Philip, Barbados with GPS location: 13.108461°N, 59.506437°W. All the considerations herein are intended for review or further considerations, as a wide and detailed engineering study is needed before any other action takes place.

Contents

ABBREVIATIONS

ALARP	As Low As Reasonably Practicable
BNOCL	Barbados National Oil Company
CM	Consequence Modeling
ETA	Event Tree Analysis
F	Frequency
F&G	Fire and Gas
FL	Flame Length
F/N	Frequency / Number of Fatality
HSE	Health, Safety and Environment
IPS	Isolated Process Segment
IRPA	Individual Risk per Annum
JFS	Jet Fireproofing Study
LFI	Leak Frequency Integrator
LFL	Lower Flammable Limit
LSIR	Location Specific Individual Risk
PHAST	Process Hazard Analysis Software
PLL	Potential for Loss of Life
QRA	Quantitative Risk Assessment
SR	Societal Risk
LNG	Liquefied Natural Gas
NFPA 59A	Standard for the Production, Storage and Handling of Liquefied Natural Gas, 2013 Edit.
NFPA 13	Standard for the Installation of Sprinkler System, 2010 Edit.

EXECUTIVE SUMMARY

The present study stablishes the Fire Risk Analysis for the operational phase of the BNOCL LNG Plant. The base for this study is a Quantitative Risk Assessment (QRA), which was performed using PHAST RISK; a Process Hazard Analysis software from Det Norske Veritas (DNV).

BNOCL project consists of an installation to produce NG from LNG using ISO containers and ambient vaporizers at nearly 8.27 BARG (120 PSIG) and 17°C. BNOCL foresees to bring the ISO containers from overseas and transport them to site by mean of trailers.

The objective of the present study is to identify and evaluate possible risks scenarios that could be present during the operational phase of the LNG Satellite plant. Irrespective of some process and operational issue being recommended, Fire Risk Assessment is the main topic of the entire study.

During the risk analysis the following primary proposed scenarios were identified:

- LNG leak in the reception area
- LNG leak in the temporary storage (ISO TANKs)
- LNG leak in the transfer area
- LNG leak in the process areas
- NG leakage at vaporizers outlet, metering and regulation station

As a result, five (5) different nodes of the system were evaluated as leakage scenarios; which were analyzed via the Events Tree technique. Each event frequency was determined from a triggering event. In addition, ignition sources around the facility and fires events in the containment areas were analyzed as stated in NFPA 59A, Chapter 5.

Based on the described process above, an evaluation of risks before treatment was made. All plausible risks sources were evaluated, warning indicators and planned controls, as well as protection and preventive measures were adopted.

Among these measures the following were identified:

A. Preventive Measures

- Smoking is not allowed at any time inside the perimeter of the BNOCL LNG Plant.
- Activities of open fire and naked light are prohibited
- Facility entrance with portable cell phones, cameras and other none approved electronics devices is not permitted. Any of the above mentioned equipment entering the site have to be listed as intrinsically safe or explosion proof.
- No other vehicle but the truck-tractor will be permitted to operate in the perimeter during ISO tanks maneuvering operation.

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- Operational manuals have to be present at all the time in the plant control room.
- Personnel should be trained in the storage, use, and handling of LNG and entire operation of the LNG facility.
- Suitable Personal Protective Equipment (PPEs) have to be available for all the personnel involved in the plant operation.

B. Preventive System

The recommended prevention systems as considered based on this study are the following:

- Besides the LNG Satellite Plant operation control room; a remote monitoring and/or control point with a redundant communication system is usually recommended.
- The control, communication, F&G and the fire protection system shall be equipped with two power sources. In the case of the water based fire protection, a single listed UL/FM fire pump may be enough.
- The electrical system has to be designed according to areas classification.
- Each vaporizer or group of vaporizer has to be equipped with a remote activated Shut Off Valve (ESDV).
- A manual or automatic pump to remove rain water from the dike containment has to be installed.
- Consideration to furnished the operation control room with positive pressure and the provision of an elevated air intake with a gas sensor is recommended.
- The system control Programmable Logic Controller (PLC) has to be listed UL/FM. Taking into consideration the size of the facility; an instrumented independent PLC for the Safety Instrumented System (SIS) may not be necessary.
- A grounding system in the LNG transfer area need to be installed. An interlock system may be provided to stop cargo transfer if the grounding system fail/disconnect.
- A low temperature indicator/interlock is recommended at the vaporizers out let. Downstream gas metering piping is not usually suited for cryogenic loads, it means that under certain value, the system should alarm and stop gas send out if the temperature limit setting is reached.
- Overflow protection by mean of pressure setting is necessary at vaporizer outlet. After the plant is set to normal operation; the overflow protection indicates that an open flange or piping section is present.
- Vaporizers inlet line has to be furnished with Pressure Safety Valves (PSV)

- A piping arrangement system for hoses draining is mandatory. It will allow for hoses safety connection/disconnection.

C. Protection Measure

In case of a sinister, the protection measures were classified and listed as follow:

C.1 Passive Protection

- LNG primary and secondary containment areas. All containment areas are supposed to be designed according to NFPA 59A, Art. 5.3.2.
- If concrete is used, it should be capable to withstand the effects of the LNG low temperatures due to spills, and the effects of high temperatures due to fires.
- Fire wall between tanks is not mandatory, for the LNG Satellite Plant was considered as an entire compact system. Even though, it is management option to build this extra level of protection if so wished.
- Lightning protection as part of the electrical system is required
- Fire and Gas (F&G) system with visual and audible alarms with the possibility to detect heat, cold temperature and gas leak are mandatory to be in place as per NFPA 59A, Art. 12.4.

C.2 Active Protection

- Water spray protection according to Density/Area Curves of NFPA 13 based on *"Hazard Locations".* For LNG, taking into consideration its vapor pressure, flashpoint, and specific gravity; the density may vary between 0.2 gpm/ft^2 and 0.5 gpm/ft^2 (8.1 to 20.4 L/min/m^2). NFPA 15, *"Standard for Water Spray Fixed System for Fire Protection"* should be consulted for more details on required distribution densities.
- For exposure protection of vessels, a density of 0.25 gpm/ft^2 (10.2 L/min/m^2) should provide sufficient cooling to limit an exposure fire's heat input to the vessels walls. Fire monitors with the characteristics to provide the requested cooling flow are mandatory.
- The crude oil tanks are not part of this study, but radiation effects on anyone of the side will affect the other. This makes a water curtain between the LNG Plant and the crude oil tanks farm being necessary.
- Water requirement as per NFPA 59A, Art. 12.5. Sometime the water requirement might be difficult to obtain, in that case, a compensation with dry chemicals may be required according to the LNG storage capacity.
- An Emergency Shut Down (ESD) system is mandatory

Two different measures of risk were calculated for BNOCL LNG Plant including Individual Risk and Societal Risk with below findings:

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Individual Risk

Firstly, Location Specific Individual Risk (LSIR) values were calculated for whole the LNG plant area to identify the LSIR profile within the plant. Then, the LSIR values of identified indoor populated areas (the areas with higher probability of personnel presence) were extracted. In conclusion, the highest LSIR values belong to near LNG ISO tanks (1.55E-06 1/yr) and the other area of the site are exposed to lower risk level which means that LNG ISO TANKS area has the highest individual risk potential.

This individual risk index (LSIR) only shows the potential magnitude of individual risk that cannot be compared with any criteria for the purpose of risk level identification. Therefore, another individual risk index called Individual Risk Per Annum (IRPA), which is the combination of LSIR value, and worker group population-time distribution was calculated for each worker group separately. In conclusion, worker groups who are being exposed to acceptable risk level from LNG plant and its equipment.

It should be noted that crude oil tanks, which could be a source of huge pool fires, are excluded from this report and therefore these risk levels could be higher if risk of crude oil tanks are considered as well.

Societal Risk

Once individual risk study was completed, the risk shall be also investigated for population groups rather than only individuals. Thus, a societal risk index called Potential for Loss of Life (PLL) was calculated for all personnel in each process area and also for whole BNOCL LNG plant personnel. In conclusion, below PLL values were estimated for personal working in each process unit:

- Operator of ISO TANKS: 1.42e-6
- Operator of crude TANKS: 8.34e-8
- TOTAL PLL: 1.51e-6

Main study conclusions are the following:

Based on the analysis performed, none cases of high probability of occurrence have been found. It may be concluded that BNOCL LNG Plant fulfill safety conditions appropriate to keep a risk low or tolerable. Nevertheless, it cannot be declared that the plant may be free from risks.

The mitigation measures that were considered by BNOCL and those recommend here that are not yet part of the plant integration (the plant was already partly in operation when risk analysis was conducted); may be sufficient to maintain a low or tolerable risk level.

BNOCL LNG Plant is supposed to be design according to NFPA 59A.

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The Level of Protection Analysis (LOPA) of the plant, existing and proposed by this study are the following:

- Control process variable and alarms system
- Maintain the level of fluid containment in vessels, equipment and piping via adequate corrosion allowance limits
- Control over pressure in the process system via adequate pressure safety valves
- A F&G system with the capability to detect, alarm and notify shall be in place
- Control all ignition source under control inside the plant. Naked light, open flame or other activities that may generate an ignition source have to be strictly prohibited. Facility entrance with portable cell phones, cameras and other non-approved electronics devices is not permitted. Any of the above mentioned equipment have to be listed (intrinsically safe or explosion proof).
- LNG spill to be collected in suited containment area with appropriate low temperature detection (part of the F&G System).
- Emergency Shut Down with different drive level is requested.
- Fire protection system with redundant fire pump and availability of water as stated by NFPA 59A is mandatory. In the case of the water based fire protection, a single listed UL/FM fire pump may be enough.
- Suited portable, stationary and wheeled type fire extinguishers are necessary around the transfer and process area. In the plant control room, the fire extinguisher must be clean agent.

The study recommendations are the following:

- Ensure the safety instrumented system including the ESD valves
- Stablish and maintain a preventive inspection maintenance on site, specially to the control and F&G system.
- Exercise periodic test as per manufacturer recommendation to all system in the plant. Special attention should be given to manual valves, F&G system and to the pressure safety and relief system.
- Implement an integrity program to all equipment in the facility

Based on the above mentioned and the recommended topics herein listed, and the low frequency of risk events; BNOCL LNG Plant is an industrial safety facility.

1. INTRODUCTION

The present study stablishes the Fire Risk Analysis (FRA) for the operational phase of the BNOCL LNG plant in Barbados. BNOCL project consists of an installation to produce NG from LNG using ISO containers and ambient vaporizers at nearly 8.27 BARG (120 PSIG) and 17°C. BNOCL foresees to bring the ISO containers overseas and transport them to site by mean of trailer.

The summary of NG production process is as follows:

- LNG is transported from the Dominican Republic or elsewhere using ISO tanks at pressure and temperature described.
- LNG is transferred from ISO tanks to the system via hoses by mean of a suit piping arrangement.
- Ambient vaporizer turns LNG to NG by mean of heat gain
- NG is measured
- NG enter the regulation station (single in line regulator)
- At the battery limit (Tie-in): NG is send at rated pressure and temperature to a pipeline that connect with utility grid.

Based on LNG plant dimension and information gathered, the FRA team made the entire process an Isolate Process Segment (IPS). Since some of the recommendation that are being arise have not yet being implement in the process; it means that any hazard source scenarios will feed the leak, independently from its location. BNOCL LNG plant is currently under operation test phase as a cargo has already being received. Primary hazards were identified and group as a single event.

Each scenario was analyzed by its frequency and possible consequence using Phast Risk, a powerful process hazards software tool. This tool aids in gathering identified hazard events by its probability of connecting any system failure, called hazard source scenarios with the Location of Specific Societal Risk (LISR) or the Individual Risk per Annum (IRPA). QRA determines a plant process safety based in any or combination of both of these two indexes.

Based on the software output, literature cited and process knowledge, the FRA team made some process and fire protection recommendations that are deemed necessary to better protect the facility and has the LNG plant meets NFPA 59A standard. In Appendix 4 a detailed HAZID is made for the corresponding facility. Some items listed are not yet in place, but were included for being necessary to carry daily operation with safety and reliability according to NFPA 59A.

The LNG plant operational safety is made via a combination preventive and corrective measures and systems that interact with different levels of layer of protection. It is the BNOCL management to carry an effective plan to achieve and maintain the facility in a good running state.

2. PROJECT DESCRIPTION

LNG Satellite plat is a Liquefied Natural Gas storage and gasification facility located in Spring Garden, Barbados. The overview of this plant is shown in Figure 2. As shown in this figure, a crude oil storage plant is located north west of this plant, which is excluded from the scope of this study.

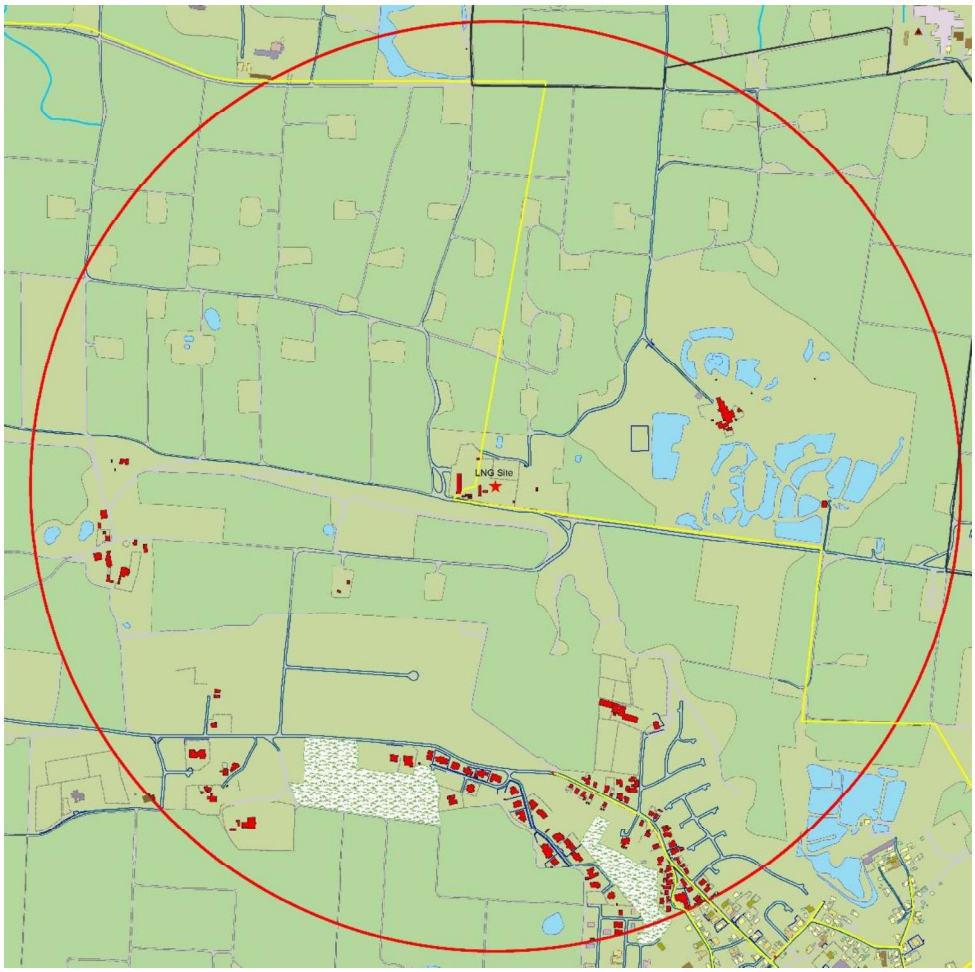

Figure 1. Woodbourne, St. Philip, Barbados 1KM radius LNG Plant Location

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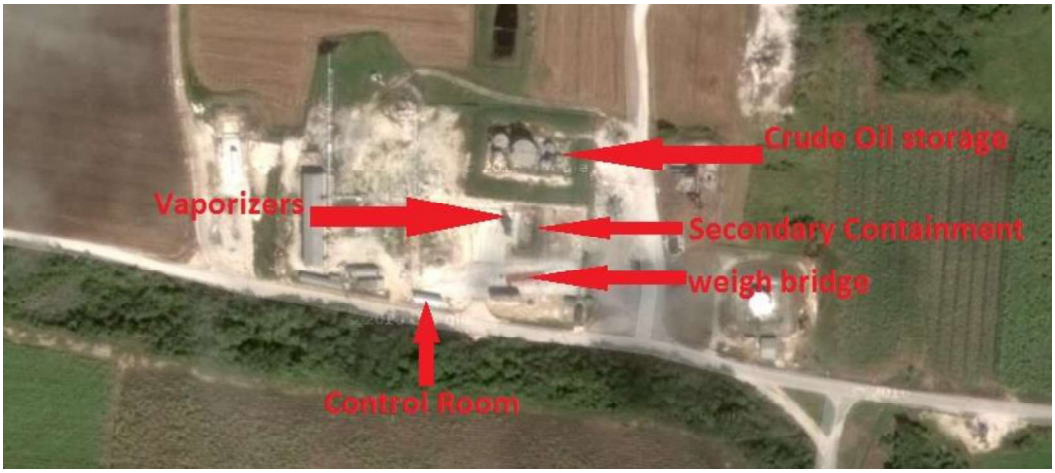

Figure 2. LNG plant Location

This plant consists of two storage ISO tanks available space operating at approximately 10 bar. The LNG in these tanks flows via transfer hoses through a 2 inches' line to the ambient vaporizer. LNG turn into NG by mean of heat gain at these exchangers. NG flow to a metering station that further travel to the in line regulation station that finally connect with the main grid at the tie-in point. A schematic PFD of this plant is shown in Figure 3.

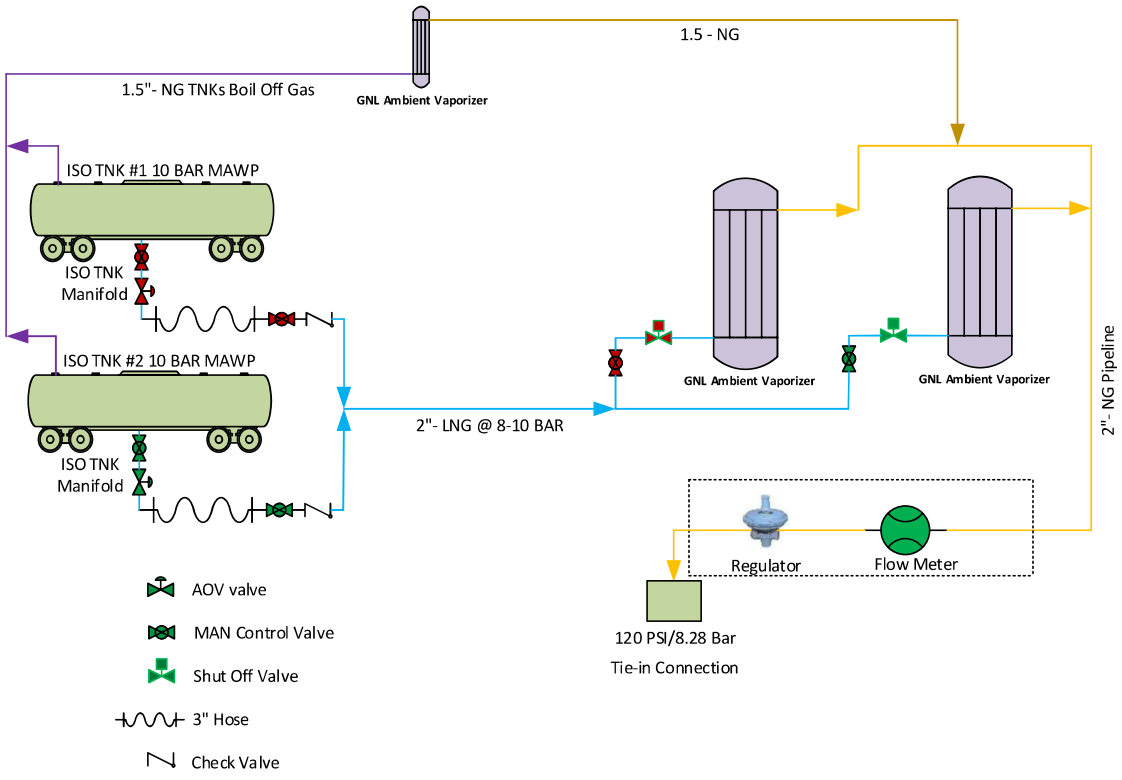

Figure 3. LNG plant schematic Process Flow Diagram (PFD)

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Some of the main equipment of this plant (no ISO tank is present) and the layout of them are shown in Figure 4 and Figure 5.

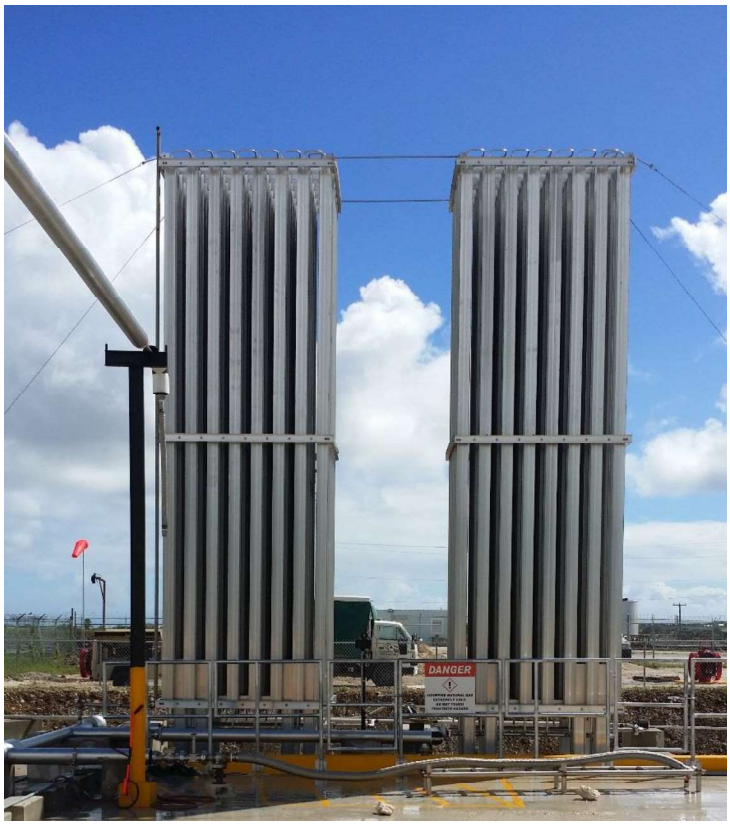

Figure 4. Ambient air vaporizers

Figure 5. ISO tanks parking area and adjacent crude oil storages view

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3. SCOPE

The scope of this work is limited to the LNG plant only and its equipment to estimate the risk of the plant imposed to individuals and possibly to public.

4. PURPOSE

The purpose of this document is to perform a QRA study for BNOCL LNG plant. The structure of this document has been designed to:

- Clear the assumptions and methodologies which are going to be used in this study;
- Distinguish a comprehensive list of hazard sources;
- Estimate the release frequency of all identified hazard sources;
- Calculate the LSIR values for identified risk monitor points;
- Calculate the IRPA value for all available worker groups within the LNG plant to find out if they are within the safe level or not.

5. REFERENCES

Following Codes, Standards, Text Books and Practices are referred in this document.

[1]. AIChE/CCPS, Guidelines for Chemical Process Quantitative Risk Analysis, 2004.
[2]. API RP 752, Management of Hazards Associated with Location of Process Plant Buildings, 1995
[3]. DNV, PHAST Risk Version 6.7.
[4]. F. P. Lees, Loss Prevention in the Process Industries, Butterworth-Heinemann, 3rd ed., 2004.
[5]. Health and Safety Executive (HSE), Hydrocarbon release reporting and statistics (www.hse.gov.uk/offshore/hydrocarbon.htm) accessed 2012.
[6]. IP Research Report, Ignition Probability Review, Model Development and Look-up Correlations, January 2006.
[7]. TNO, CPR 14E, Yellow Book: Methods for the Calculation of Physical Effects due to Releases of Hazardous Materials (Liquids and Gases), 2005.
[8]. TNO, CPR 18E, Purple Book: Guidelines for Quantitative Risk Assessment, 2005.
[9]. TOTAL, SAF General Specification 041, Technological Risk Assessment, 2012.
[10]. TOTAL, SAF General Specification 253: Impacted Area, Restricted Area and Fire Zones, 2012.
[11]. UK Health and Safety Executive (HSE), 2010.

6. QRA METHODOLOGIES AND ASSUMPTIONS

QRA refers to the calculation or estimation of numerical values (or graphical representations) that presents the effects of incidents involving flammable, explosive and toxic materials with respect to their potential risk. In order to evaluate the

potential risk of such incidents, several activities should be performed. Figure 6 presents a brief overview of a general QRA steps.

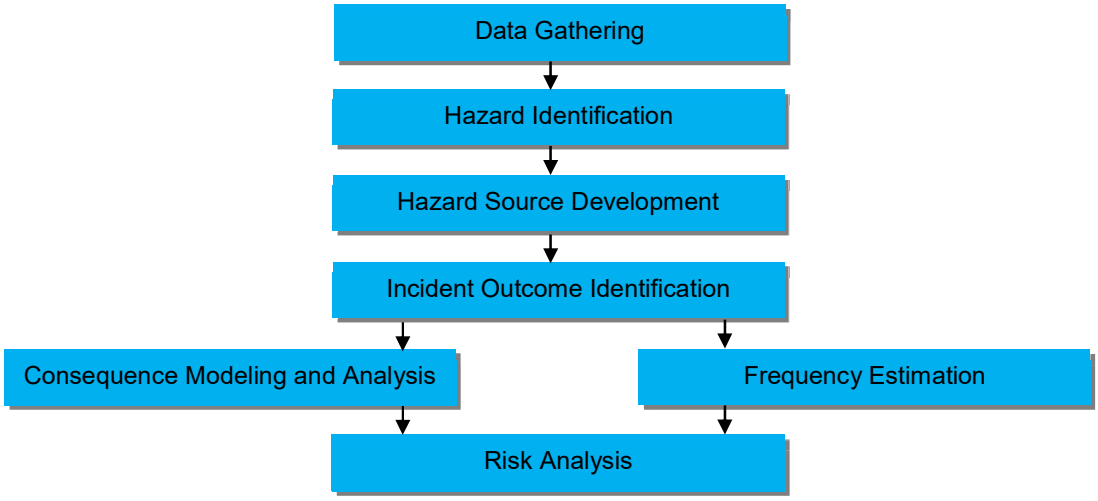

Figure 6. QRA study flow-chart, Ref [1]

Only flammable effects of released material are investigated in the current document because there is no source of toxic materials in BNOCL LNG PLANT capable of generating serious effects, Ref [8]

6.1 Data Gathering

The required data for the current study is described in below sections:

6.1.1 Process Data

This information includes numerous technical data that were collected by the experienced Operators/Experts who best knew the situations and operations at the site:

- Equipment arrangement and overall siting (Plant Layout and Overall Plot Plan)
- Process conditions including: phase, composition, pressure and temperature for main streams (PFD, P&ID)
- Dimensions, elevation and geometry of the equipment (Equipment List and Equipment Data Sheet)
- Dimensions of the pipes, valves and fittings (P&ID)
- Worker group and manning distribution

6.1.2 Meteorological and Site Data

Typically, different weather conditions representing all Pasquill atmospheric stability classes were used to predict different possible consequences and risks. Pasquill stability classes describe the amount of turbulence in the atmosphere.

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Table 1. Pasquill stability parameters definition

Class	Stability Status	Class Description
A	Very Unstable	Sunny, light winds
B	Unstable	As with A, only less sunny or windier
C	Moderately Unstable	Very windy/sunny or overcast/light wind
D	Neutral	Little sun and high wind or over cast/windy night
E	Moderately Stable	Less overcast and less windy than D
F	Stable	Night with moderate clouds and light/moderate wind

Each weather category should be characterized by a wind rose and averaged values of wind speed, air temperature, solar radiation and humidity and some other parameters. For this purpose, firstly, extensive daily records of air temperature, humidity and wind speed and direction should be gathered for the site, at least for a single year. Then, these data should be classified to weather categories characterized by A, B, C, D, E and F atmospheric stabilities. Wind-rose data is required in order to estimate the probability of each selected weather category in a year.

Appendix 1 summarizes provided wind rose data (16 wind directions) for BARBADOS region for each stability class. Besides, each stability class is characterized based on average wind speed, air temperature, humidity and solar radiation. In accordance to each weather category fraction of year, two representative weather categories of F and D with updated average values of wind speed, air temperature, humidity and solar radiation were used in subsequent QRA studies. These weather category classifications are normally recommended by majority of references.

Beside meteorological data, some information is required to introduce the type of ground in nearby areas or surface roughness. This parameter describes the type of surface over which the cloud is dispersing and can be identified using information shown in Table 2. For general onshore process plants, this parameter is considered in the range of 0.5 - 1.0 m.

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Table 2. Typical values for the surface roughness length

Surface Classification	Type of Surface	Roughness Length (m)
Highly urban	Centers of cities with tall buildings, very hilly or mountainous area	3-10
Urban area	Centers of towns, villages, fairly wooded country	1-3
Residential area	Industrial site without large obstacles	1
Large refineries	Distillation columns and other tall equipment pieces	1
Small refineries	Smaller equipment, over a smaller area	0.5
Cultivated land	Open area with great overgrowth, scattered houses	0.3
Flat land	Few trees, long grass, fairly level grass plains	0.1
Open water	Large expanses of water, desert flats	0.001
Sea	Calm open sea, snow covered flat, rolling land	0.0001

6.2 Hazard Identification

For the purpose of hazard identification studies, firstly hazard sources were identified and then HAZID studies were performed to characterize each hazard source. These data were further used for having more accurate consequence and risk analysis. The entire HAZID for the BNOCL may be found in Appendix 4.

6.2.1 Hazard Sources

Hazard sources originate from the presence of dangerous substances and from the hazardous activities that take place at the establishment. A safety report must thus provide the types and quantities of dangerous substances at the site, their physical and chemical properties, as well as flammability and explosive characteristics. The main purpose of this section is tabulating independent process parts of the plant which are expected to generate different consequences.

It is obvious that process conditions such as composition, phase, pressure, and temperature change through the process. In order to consider this change in consequence modeling and analysis, the process facilities should be divided to different Isolated Process Segments (IPS) separated by Emergency Shut Down Valves (ESDVs). Thus, each IPS has its own gas and liquid inventory during a release. After this classification, any part of these IPSs that may cause different

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outcomes because of different process conditions (Phase, Composition, Pressure and Temperature) and locations will be considered as an independent hazard source location [9].

Borders of IPSs in accordance with ESDVs configuration and the approximate location of hazard sources were determined graphically on the process map. Such illustration is typically illustrated in Figure 7 and prepared for whole BNOCL LNG PLANT that may be found in Table 3.

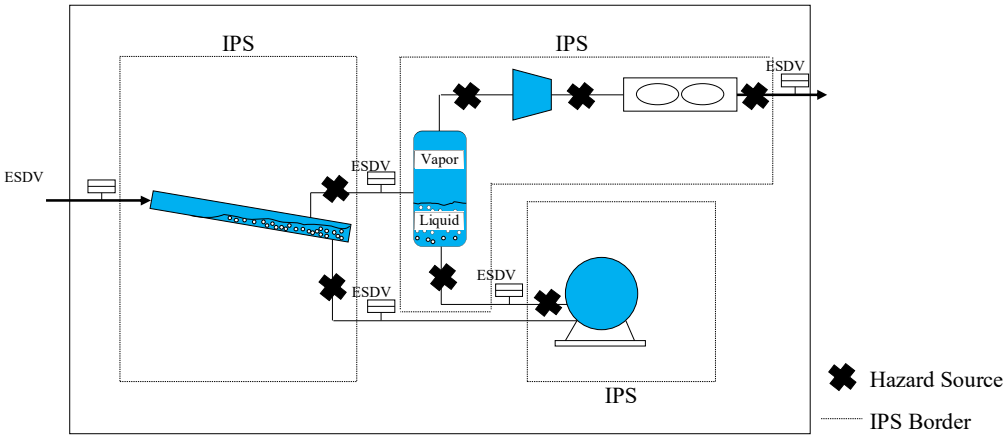

Figure 7. IPS borders and hazard source location

Regarding the identified IPS border and hazard source locations shown in Appendix 4, a list of all credible Hazard Sources in BNOCL LNG plant identifying included equipment, are shown in Table 3. It is important to remark that according to the provided data by the client all the plant considered as one IPS with different scenarios.

Table 3. Identified Hazard Sources

IPS No.	Hazard Source No.	Equipment Tag	Process Condition	
			Pressure (bar)	Temp (^{0}C)
IPS_01	STRG-01	LNG ISO TANK	10	-160
	STRG-02	LNG ISO TANK	10	-160
	AirHX-01	Ambient Air Vaporizer	10	25
	AirHX-02	Ambient Air Vaporizer	10	25
	MTRNG	Metering	8	25

6.3 Hazard Source Development

Each hazard source was characterized by following specifications.

- **Leak Location** (single equipment or a group of equipment which feed the leak)
- **Source Process Condition** (normal process condition just behind the leak including: material composition, phase, pressure and temperature) mentioned in Table 3.
- **Isolated Inventory** (the amount of potential material which is discharged through leak after successful isolation)
- **Leak Elevation** (the elevation of leak from ground level) the elevation of all leaks considered to be occurred at 1-meter height.

6.3.1 Leak Size

Based on Ref [1], for having reliable results in purpose of risk analysis, sufficient number of leak size ranges should be assigned for each hazard source in order to represent a meaningful risk of accidental releases which are called “Hazard Source Cases” from now on. Although all possible leak sizes ranging from pin hole to maximum connection diameter are likely to happen in each hazard source, generally, some discrete hole size ranges are used for risk based studies. In accordance to Ref [5], following ranges of leak size (Table 4 and Table 5) were used in this QRA (Ref [1]).

Table 4. Leak size categories and failure rate for QRA, Ref [5]

Equipment Failure Rate (1/yr)					
Leak size (mm)	**Representative**	**flange**	**manual valve**	**Control Valve**	**HX (Air Cooled)**
1 to 3	2mm	4.40E-05	4.40E-05	2.40E-04	1.00E-03
3 to 10	5mm	1.80E-05	2.30E-05	7.30E-05	4.90E-04
10 to 50	30mm	1.50E-05	2.10E-05	3.00E-05	2.40E-04

Table 5. Leak size for LNG vessel

Vessel failure rate (1/yr)	
Catastrophic	5.00E-08
Major (500 mm)	1.00E-06
Minor (150 mm)	3.00E-06

Considering these leak size and the scenario shown in Table 3, combination of these two tables are modeled to ensure that all possible conditions are considered.

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Table 6. Scenarios to be calculated

IPS No.	Hazard Source No.	Equipment Tag	Scenario	Process Condition	
				Pressure (bar)	Temp (^{0}C)
IPS_01	STRG-01	LNG ISO TANK	STRG-01-2mm	10	-160
			STRG-01-5mm		
			STRG-01-30mm		
			STRG-01-150mm		
			STRG-01-500mm		
			STRG-01-Catastrophic		
	STRG-02	LNG ISO TANK	STRG-02-2mm	10	-160
			STRG-02-5mm		
			STRG-02-30mm		
			STRG-02-150mm		
			STRG-02-500mm		
			STRG-02-Catastrophic		
	AirHX-01	Ambient Air Vaporizer	AirHX-01-2mm	10	25
			AirHX-01-5mm		
			AirHX-01-30mm		
	AirHX-02	Ambient Air Vaporizer	AirHX-02-2mm	10	25
			AirHX-02-5mm		
			AirHX-02-30mm		
	MTRNG	Metering	MTRNG-2mm	8	25
			MTRNG-5mm		
			MTRNG-30mm		

6.3.2 Leak Direction

Leak directions were conservatively assumed horizontal impinged covering a whole plane.

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6.4 Incident Outcome Identification

Incident outcomes depend on the conditions of the release, like temperature, pressure and phase of the released material, release rate, site condition, meteorological conditions, and ignition time and so on. The typical outcomes relating with the releases of flammable, explosive and toxic substances (Figure 8) are defined as bellow:

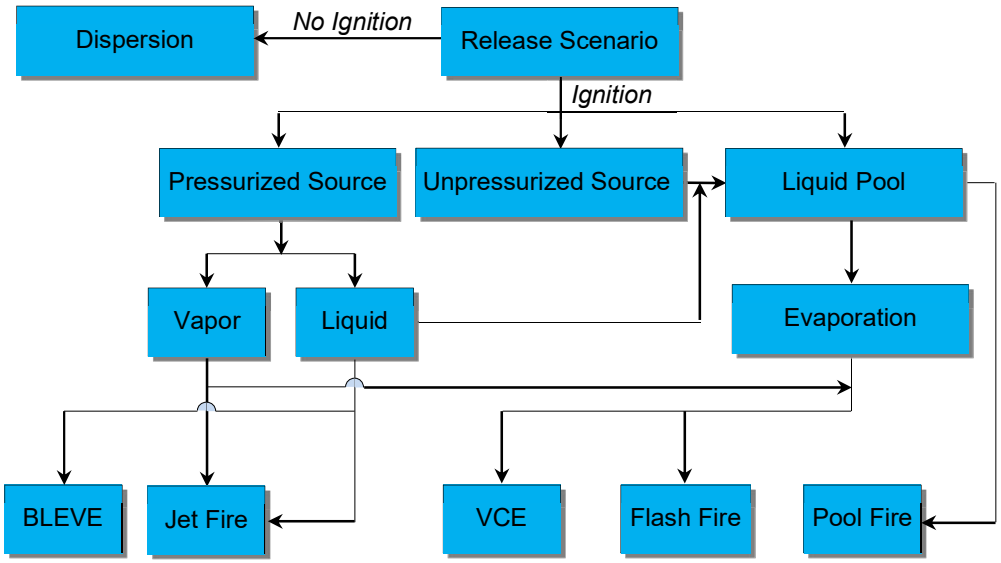

Figure 8. A logic diagram of all possible consequence outcomes

- **Flash Fire:** Occurs when a flammable material is released into the open air and forms a vapor cloud, which ignites without an explosion. Major effects from flash fires are due to thermal radiation.
- **Vapor Cloud Explosion (VCE):** Begins with a rapid release of a large amount of flammable vaporizing liquid or gas from storage or transport tanks, process equipment or pipelines. If the cloud ignites before dilution below its lower flammability limit, a VCE or flash fire will occur. Vapor cloud will explode if sufficient mass of flammable material is attained, which is possible if the ignition is delayed, and if intensely turbulent combustion is developed thus generating a blast. The main consequence of the VCE is an overpressure.
- **Jet Fire:** Occurs when a flammable liquid or gas is released from a leak hole, because of the released pressure a long flame is generated. The effects of jet fires are due to thermal radiation from the flame, which depends mostly on the release rate.
- **Pool Fire:** Begins with the release and ignition of a flammable liquid, which is accumulated in a pool whose geometry is given by the surroundings, e.g., diking. Thermal radiation from the flame depends mainly on the release rate and pool area.
- **Boiling Liquid Expanding Vapor Explosion (BLEVE):** Occurs due to a sudden rupture of a pressure vessel containing superheated liquid or liquefied gases. A large mass of boiling material is suddenly vaporized and

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released into the atmosphere, resulting in a fireball if the substance is flammable. The effects of BLEVE are usually evaluated as the thermal intensity of the fireball since the overpressure effects are usually small. Liquefied petroleum gas (LPG) is commonly associated with BLEVE, while substances below their normal boiling point cannot BLEVE. However, BLEVE outcome is possible when the containment is engulfed in an adjacent fire and an external flame impinges on the shell of the vessel.

6.5 Consequence Modeling and Analysis

Once incident outcomes are identified and corresponding data are available, consequence modeling can be carried out through three main steps as shown in Figure 9.

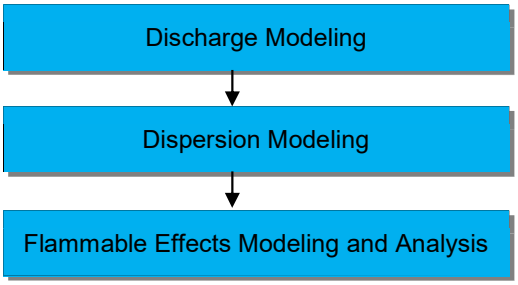

Figure 9. Consequence modelling steps, Ref [1]&[7]

6.5.1 Discharge Modeling

Discharge modeling is used in order to describe how material is discharged from the process. A discharge model estimates the state of the release, flow rate of the discharge, and the total mass discharged. The initial rate of release of hydrocarbon through a leak (Q_0) depends mainly on the pressure inside the equipment, the size of the hole and the phase of the release (liquid, gas or two-phase).

For gas phase (sonic, critical flow):

$$\dot{m}_0 = C_D P_0 A_L \left[\frac{\gamma M_W}{RT_0}\left(\frac{2}{\gamma+1}\right)^{\frac{\gamma+1}{\gamma-1}}\right]^{1/2}$$

For liquid phase:

$$\dot{m}_0 = C_D A_L [2\rho(P_0 - P_{atm})]^{1/2}$$

Where;

- $\dot{m}_0$ is initial discharge rate (kg/s);
- C_D is coefficient of discharge (it is assumed 0.8 for gas phase and 0.6 for liquid phase), A_L is leak area (m^2);

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- P_0 is the initial operating pressure;
- P_a is the atmospheric pressure;
- γ is the ratio of the specific heats for the gas;
- M_W is molecular weight (kg/kgmole);
- R is universal gas constant (8.314 kJ/mole.K);
- T_0 is gas temperature (K) and;
- ρ is the liquid density (kg/m3)

The release rate decreases with time as the equipment depressurizes. This reduction depends mainly on the hydrocarbon isolated inventory and the action taken to isolate the leak and blow down the equipment.

No credit will be given to Emergency Shut Down (ESD) and Blow Down Valve (BDV) actions (except for Fireproofing study) and it is assumed that release rate equals initial rate till the isolated inventory is depleted.

6.5.2 Dispersion Modeling

The results from the discharge models are transferred to the dispersion models either manually or automatically depending on options, which are used in the software package. The aim of this modeling is to find the concentration profile versus time for specified geographical points. Then a dispersion model is applied to evaluate how the material is dispersed downwind from the source to certain concentration levels (e.g., 100% LFL or other fraction of LFL). For this purpose, Unified Dispersion Model (UDM) is used by PHAST Risk software, Ref [3].

Once a material has been released into the atmosphere and has expanded so that its internal pressure has fallen to atmospheric pressure, it will travel away from the release point under the influence of its own initial velocity and the ambient wind velocity. Apart from discharge condition, the dispersion is dependent on the atmospheric conditions including: temperature, wind speed and atmospheric stability class.

The incident outcomes have influence on people, mainly due to thermal radiation and blast overpressure that are called causative variables. All of these variables were estimated via PHAST Risk software for all hazard sources, all leak sizes and all weather categories.

6.6 Frequency Estimation

Once the potential hazard sources were identified, frequency analysis estimated how likely it is for the leakage (F_L) and aftermath incident outcome (F_i) to occur.

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The frequency of leakage for different leak sizes and for different items conveying hydrocarbons (equipment, instruments, valves and fittings) was obtained from analysis of previous accident experiences represented by generic data. Then, the leak frequency of all identical items was integrated along the hazard source borders to have a meaningful estimation of each leakage frequency (F_L) for each independent hazard source. The results for Hazard Source release frequency estimation are shown in Table 5.

In order to estimate the frequency of final incident outcomes (F_i), the probabilities of sequential events to occur are also required. This sequence is in the form of internal Event Tree of DNV PHAST Risk software. Based on this approach, there are two types of ignitions including immediate and delayed ignitions. The probability of immediate ignition (P_{im}) is a function of released material reactivity and discharge flow rate. The delayed ignition probability (P_d) depends on the density of ignition sources and covered area by flammable gas. P_c is the probability of VCE rather than flash fire given delayed ignition that depends on the available degree of congestion and fraction of congested areas covered by flammable vapor.

By identifying leakage frequencies (F_L) and successive probabilities of immediate and delayed ignitions (P_{im}, P_d and P_c), the frequency of occurrence of each incident outcome (F_i) was estimated to be further combined by its respective consequence to calculate the amount of risk.

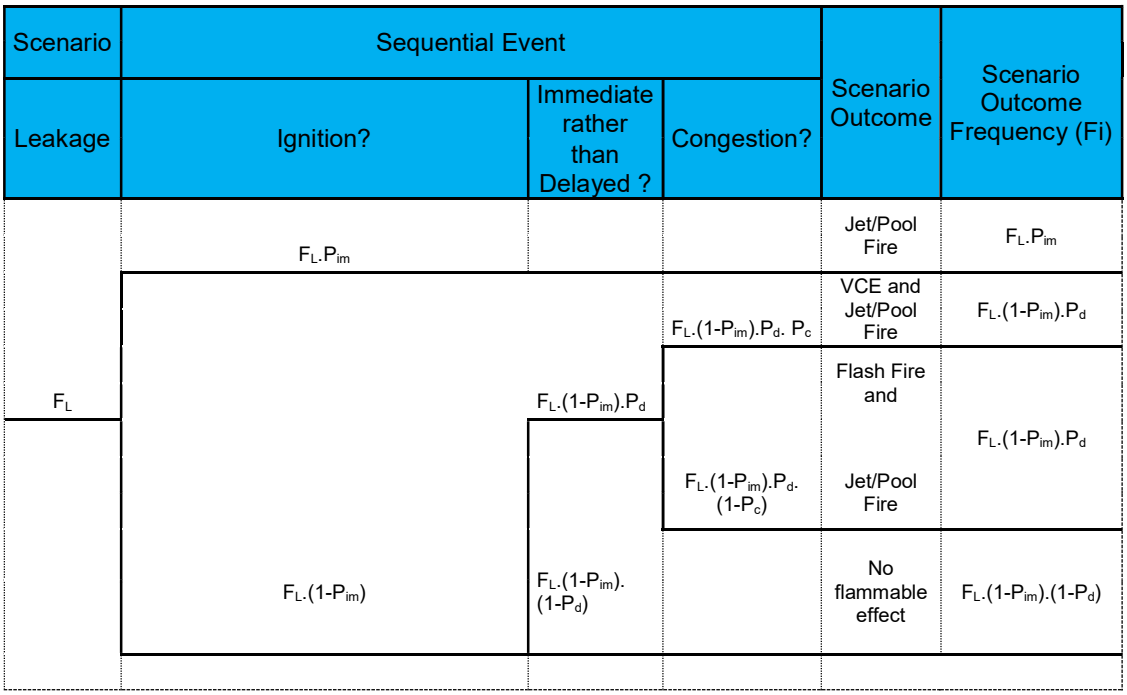

Figure 10. Event Tree Analysis (ETA)

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7. RISK ANALYSIS

Results from both stages above (Consequence Analysis and Frequency Estimation) should be integrated to derive the generated risk. The generated risk is normally expressed in two formats including Individual Risk and Societal Risk.

7.1 Individual Risk

The Location Specific Individual Risk (LSIR) represents the frequency of an individual dying due to loss of containment events for each geographical point within the intended area. The individual is assumed to be unprotected and to be present during the total exposure time and is presented as contour lines on a topographic map. PHAST Risk software calculates the amount of LSIR for each specified location as below:

$$LSIR\ (x, y) = \sum F_i\ Lethality_i\ (x, y)$$

Where,

- i index specifies all of the possible incident outcomes generated by all predetermined hazard sources.

Regarding the above calculations, Figure 11 illustrates outdoor LSIR contours in BNOCL LNG PLANT.

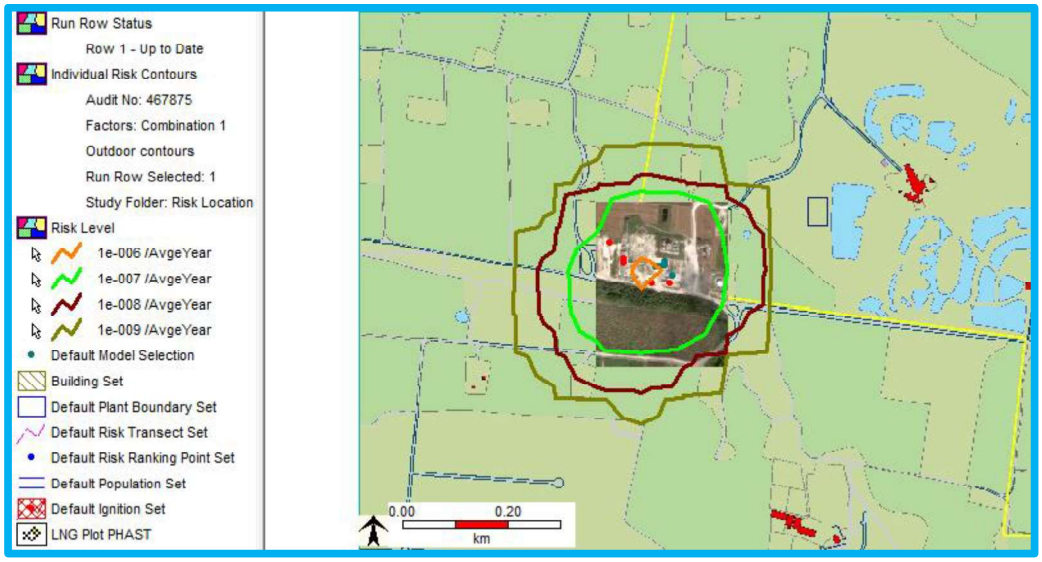

Figure 11. BNOCL LNG PLANT Outdoor LSIR Contours

There is no criterion for LSIR. Thus, a more useful and comprehensive presentation of individual risk is defined as Individual Risk Per Annum (IRPA) which takes into account the exposure time of each Worker Group. Thus, IRPA can be calculated for each worker group to evaluate the exposed risk on each worker group independently as a function of Worker Group location and exposure time as below:

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$$IRPA("i") = \sum_j IRPA("i" \text{ and } "j")$$

Where:

$$IRPA("i" \; and \; "j") = LSIR("j") \times P("i","j")$$

Where,

- P ("i","j") is the fraction of time that worker group ("i") spends in populated area ("j") and;
- LSIR ("j") is the LSIR value estimated in populated area ("j") regarding outdoor LSIR contours illustrated in Figure 111 and indoor LSIR values.

A summary of IRPA criteria for on-site (personnel) used by UK Health and Safety Executive (HSE) is given in Figure 12, Ref [11]. They all refer to risk of death for a human. These criteria are the most comprehensive and widely-used for individual risks, and those were developed for application to existing activities.

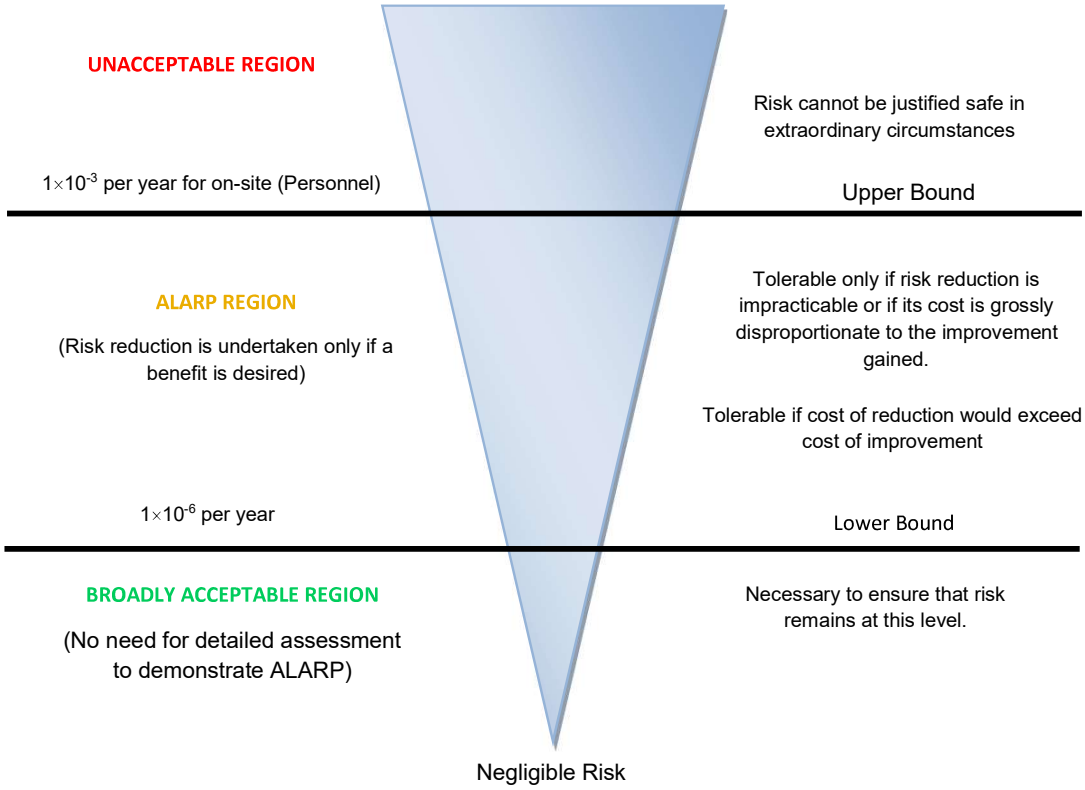

Figure 12. HSE IRPA Criteria, Ref [11]

In order to finalize IRPA calculation for each worker group ("i"), it is required to prepare a list of available worker groups ("i") in BNOCL LNG PLANT and

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estimate the population-time distribution, P("i","j"), within different populated areas ("j") in BNOCL LNG PLANT.

Table 7 shows a list of available worker groups ("i") in BNOCL LNG PLANT categorized by the unit they are working in.

Table 7. Available Worker Groups ("i") in BNOCL LNG PLANT

Worker Group Title ("i")		No. Personnel	Total Presence Time (hr.)	
Work Category	Task		Beside equipment	Safe Location
Operation	Operator of Oil Tanks	2	1 out of 8	7 out of 8
	Operator of LNG facility	2	1 out of 8	7 out of 8

Knowing populated areas and time workers might spend in different section of the sites, LSIR for each work group can be calculated. IRPA values for working group of BNOCL LNG plant are shown in Table 8.

Table 8. Populated Areas ("j") in BNOCL LNG PLANT and IRPA Values

Worker Group Title ("i")		**IRPA**
Work Category	**Task**	
Operation	Operator of LNG facility	7.08E-07
	Operator of Oil Tanks	4.17E-08

Considering HSE UK risk criteria, shown in Figure 12, green color in Table 8 indicates low risk exposed to workers. This table shows that workers are exposed to low risk level.

7.2 Societal Risk

One of the measures of Societal Risk is Potential of Loss of Life (PLL) which is defined for each worker group ("i") and all personnel as below:

$$PLL("i") = IRPA("i") \times N("i")$$

$$PLL_{TOTAL} = \sum_i PLL("i")$$

Where,

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- IRPA ("i") is the IRPA value for each worker group ("i") (Refer to Table 8);
- N ("i") is the number of personnel present in the plant for each worker group ("i") (Refer to Table 8);
- PLL ("i") is the PLL value for each worker group ("i") and;
- PLL_{TOTAL} is the PLL value for all personnel.

Table 9. Worker Groups ("i") IRPA Values in BNOCL LPG plant Categorized by Process Unit

Worker Group Title ("i")		PLL
Work Category	**Task**	
Operation	Operator of Oil Tanks	8.34E-08
	Operator of LNG facility	1.42E-06
TOTAL PLL		1.51E-6

8. CONCLUSION

Two different measures of risk were calculated for BNOCL LNG plant including Individual Risk and Societal Risk with below findings:

8.1 Individual Risk

Firstly, Location Specific Individual Risk (LSIR) values were calculated for whole LNG plant area to identify the LSIR profile within the plant. Then, the LSIR values of identified indoor populated areas (the areas with higher probability of personnel presence) were extracted. In conclusion, the highest LSIR values belong to near LNG ISO tanks (1.55E-06 1/yr) and the other area of the site are exposed to lower risk level which means that LNG ISO TANKS area has the highest individual risk potential.

This individual risk index (LSIR) only shows the potential magnitude of individual risk that cannot be compared with any criteria for the purpose of risk level identification. Therefore, another individual risk index called Individual Risk Per Annum (IRPA), which is the combination of LSIR value, and worker group population-time distribution was calculated for each worker group separately. In conclusion, worker groups who are being exposed to acceptable risk level from LNG plant and its equipment.

It should be noted that crude oil tanks, which could be a source of huge pool fires, are excluded from this report and therefore these risk levels could be higher if risk of crude oil tanks are considered as well.

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8.2 Societal Risk

Once individual risk study was completed, the risk shall be also investigated for population groups rather than only individuals. Thus, a societal risk index called Potential for Loss of Life (PLL) was calculated for all personnel in each process area and also for whole BNOCL LNG plant personnel. In conclusion, below PLL values were estimated for personal working in each process unit:

- Operator of ISO TANKS: 1.42e-6
- Operator of crude TANKS: 8.34e-8
- TOTAL PLL: 1.51e-6

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9. RECOMMENDATION

Considering the results of the study, following measures are recommended to improve safety level of this plant and also to clear the situation of plant for more mitigating and preventive measures:

1. This plant included two different section, LNG ISO TANKS and crude oil tanks. The possible effect of this section on each other is out of scope of this study but in case of an accident in one of this section, regarding the size of the accident, the other part may suffer and another accident could take place. Therefore, it's highly recommended to investigate the effect of these parts on each other. However, in order to reduce radiation effects of crude oil fire on LNG tanks it is highly recommended to protect ISO tanks with Fixed Water Spray system or a Water Curtain to avoid BLEVE (Boiling Liquid Expanding Vapor Explosion).
2. Although calculated risk levels in this study are broadly acceptable, it should be mentioned that the scope of this study is only LNG section and crude tanks are excluded. More detailed and better overview of site condition can be achieved via an all-inclusive risk assessment.

The BNOCL LNG plant handle gas and liquid. In case of a leakage from any part of the process like flanges, valves, hose connection, vessel body, vaporizers and so on; a massive cloud of flammable gas encompasses the whole plant including crude tanks, control sections and so on. Therefore, it's highly recommended to install preventive elements such as gas detection systems in combination with ESD valves to prevent cloud generation and to activate protection before worsening the condition.

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APPENDIX 1: METEOROLOGICAL DATA

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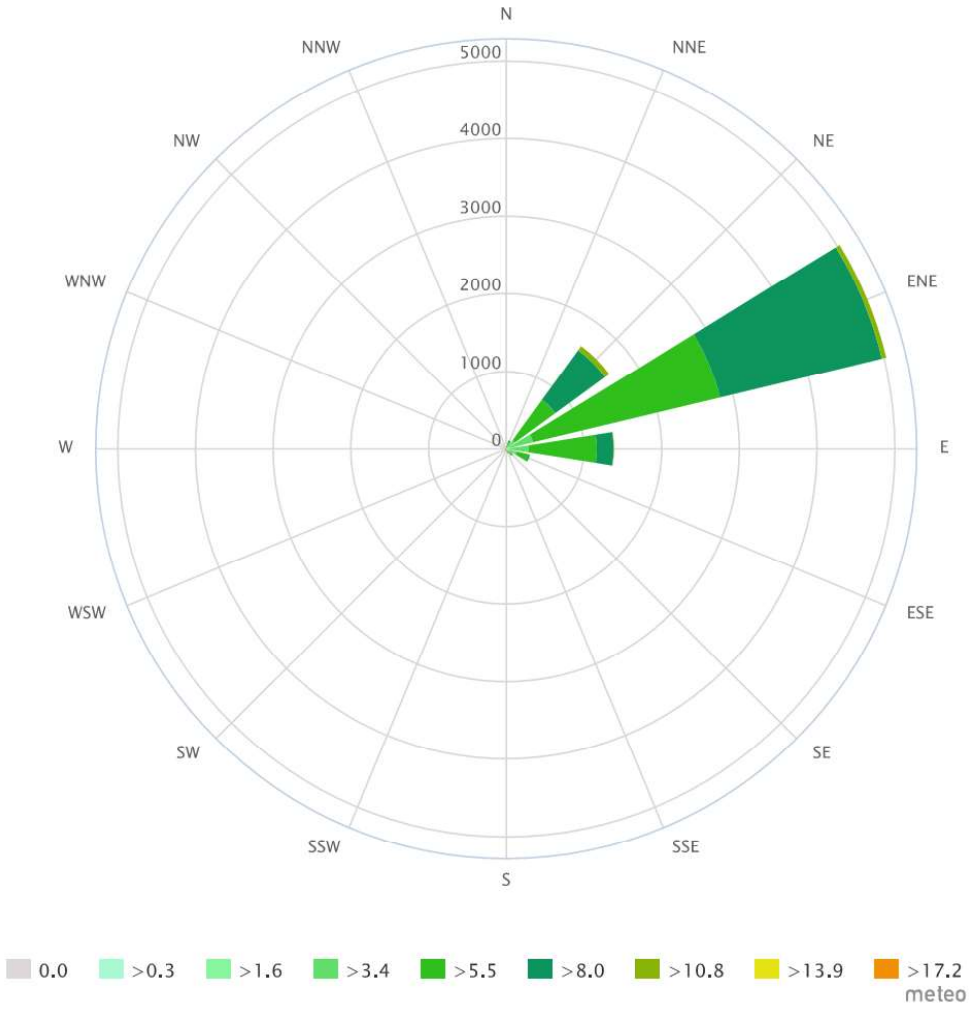

Figure A1- wind rose of BARBADOS

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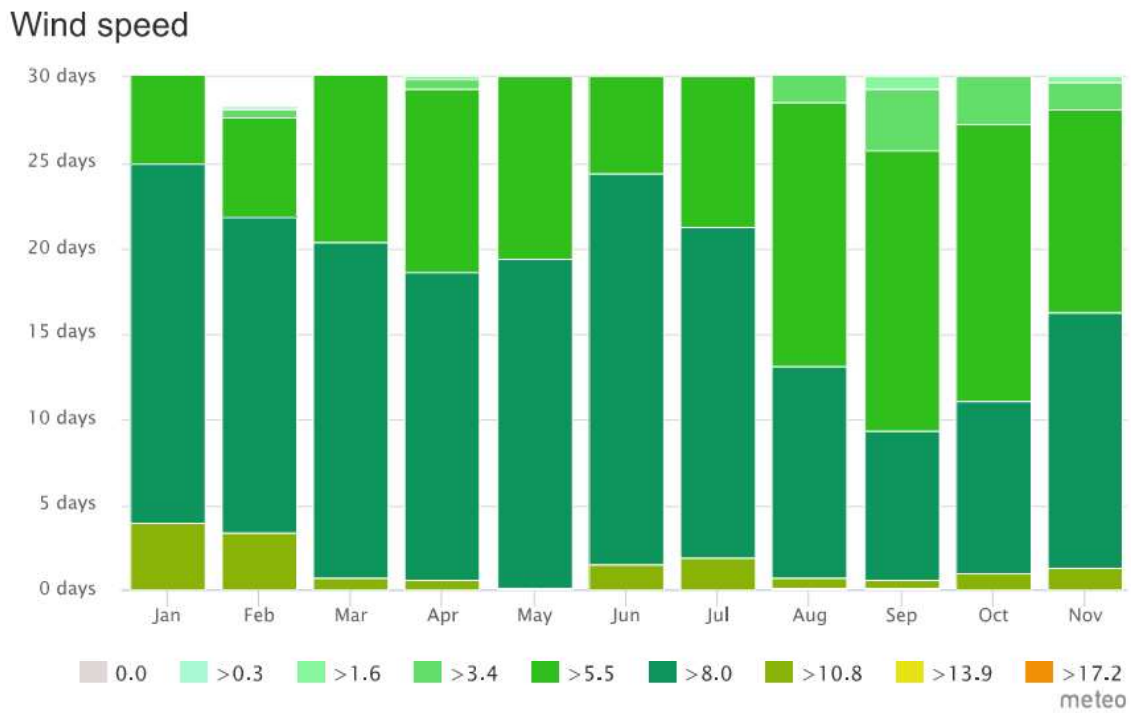

Figure A2- wind speed of BARBADOS

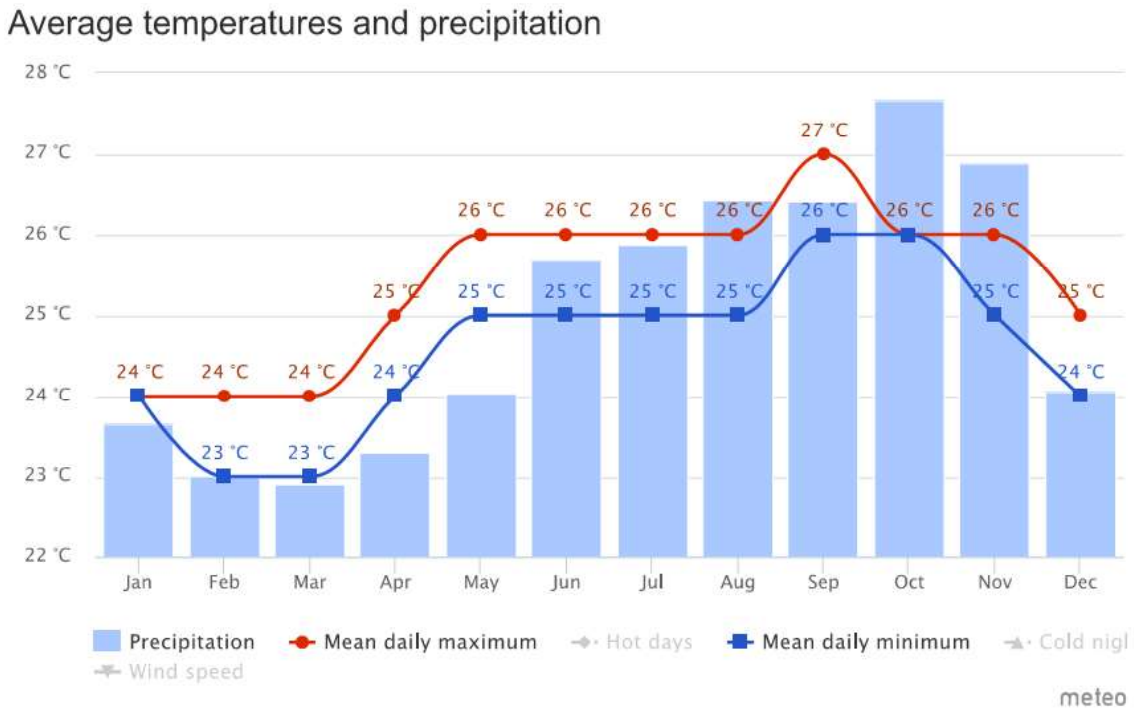

Figure A3- wind speed of BARBADOS

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Table A1- BARBADOS weather data

2015		Temp. (°C)			Dew Point (°C)			Humidity (%)			Sea Level Press. (hPa)			Visibility (km)			Wind (km/h)			Precip. (mm)	Events
		high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	high	sum	
Jan	1	30	27	24	24	23	22	83	74	57	1018	1016	1015	26	13	10	45	39.00	-	3.05	Rain
Jan	2	29	26	22	24	22	19	89	73	57	1019	1017	1015	26	14	10	48	39.00	55	0	Rain
Jan	3	29	27	23	24	22	20	89	74	59	1018	1016	1015	26	13	10	42	35.00	-	0.51	Rain
Jan	4	29	26	23	24	22	20	89	74	52	1019	1017	1016	27	13	10	45	35.00	63	0.76	
Jan	5	29	26	23	22	21	19	78	68	55	1019	1017	1016	27	13	2	47	39.00	-	0	Rain
Jan	6	29	26	23	22	21	20	83	71	55	1018	1016	1015	31	14	6	45	37.00	-	2.03	Rain
Jan	7	29	26	23	23	21	19	78	69	56	1017	1015	1013	31	14	10	37	32.00	-	0	
Jan	8	29	26	23	23	21	20	83	71	57	1017	1015	1013	26	13	10	39	29.00	-	0	Rain
Jan	9	29	26	23	24	23	21	94	78	61	1018	1016	1014	27	13	4	121	39.00	-	1.02	Rain
Jan	10	29	27	24	24	23	22	94	78	61	1018	1016	1015	26	13	10	45	35.00	-	2.03	Rain
Jan	11	29	26	23	25	23	22	94	85	77	1018	1016	1014	26	11	4	47	32.00	-	7.87	Rain
Jan	12	28	26	23	24	22	22	94	82	70	1017	1015	1014	26	11	1	50	37.00	71	7.87	Rain
Jan	13	29	26	23	24	23	22	94	80	63	1017	1015	1013	24	13	10	40	35.00	-	0	Rain
Jan	14	29	26	23	24	22	22	89	78	64	1016	1014	1013	27	13	10	37	31.00	-	0	
Jan	15	29	26	23	24	23	22	89	80	70	1017	1015	1014	27	12	10	34	29.00	55	2.03	Rain
Jan	16	29	27	24	23	22	21	83	75	62	1016	1015	1013	27	14	10	34	29.00	-	0	
Jan	17	29	27	24	23	22	22	83	76	59	1016	1015	1013	27	14	10	27	23.00	-	0	
Jan	18	29	26	23	25	22	21	89	78	64	1017	1015	1013	31	15	10	29	23.00	-	0.25	Rain
Jan	19	28	26	22	23	22	21	89	79	64	1016	1014	1013	31	14	10	27	19.00	-	0	Rain
Jan	20	29	26	22	23	22	21	88	76	60	1016	1014	1012	31	11	10	26	18.00	-	0	
Jan	21	29	26	23	23	22	21	83	74	60	1016	1014	1013	10	10	10	26	21.00	-	0	
Jan	22	29	27	24	23	22	21	83	75	59	1016	1014	1013	31	14	10	32	24.00	-	0	
Jan	23	29	26	23	22	22	20	89	75	59	1017	1015	1013	31	15	10	35	21.00	-	0	
Jan	24	29	26	22	22	21	21	94	74	57	1017	1015	1013	31	15	10	35	27.00	-	0	Rain
Jan	25	28	26	23	24	22	21	94	80	62	1016	1015	1013	31	12	8	37	26.00	-	0.76	Rain
Jan	26	29	26	22	23	22	21	94	75	52	1016	1015	1013	26	13	10	45	34.00	-	0.25	Rain
Jan	27	29	26	22	23	21	20	89	73	52	1017	1015	1014	27	12	10	151	35.00	-	0	
Jan	28	29	26	23	23	21	20	83	72	60	1016	1014	1013	31	14	10	40	32.00	-	0	Rain

2015		Temp. (°C)			Dew Point (°C)			Humidity (%)			Sea Level Press. (hPa)			Visibility (km)			Wind (km/h)			Precip. (mm)	Events
		high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	high	sum	
Jan	29	29	26	23	22	20	18	83	68	51	1016	1014	1013	31	12	10	34	27.00	-	0	
Jan	30	29	26	22	23	22	21	88	74	57	1015	1014	1013	10	10	10	29	19.00	-	0	
Jan	31	29	26	23	22	22	21	83	74	60	1016	1014	1013	10	10	10	27	19.00	-	0	
Feb	1	29	27	25	22	21	20	83	72	55	1018	1015	1014	24	11	10	95	24	-	0	
Feb	2	29	27	24	23	22	20	83	73	56	1017	1016	1014	31	14	10	40	29	-	0	Rain
Feb	3	29	27	24	23	22	21	83	75	60	1018	1016	1015	31	12	8	37	31	-	0	
Feb	4	29	27	24	23	22	21	83	74	57	1018	1016	1014	27	14	10	35	29	-	0	
Feb	5	29	27	24	22	21	20	83	72	61	1016	1014	1013	31	14	10	29	26	-	0	Rain
Feb	6	28	26	23	23	22	21	89	78	63	1015	1014	1012	31	14	10	39	27	-	0	Rain
Feb	7	28	24	21	23	22	21	95	85	66	1016	1013	1012	27	12	6	29	16	-	1.02	Rain
Feb	8	29	26	22	24	21	20	83	71	57	1017	1014	1013	27	11	10	32	24	-	0	
Feb	9	29	26	23	22	21	20	78	68	49	1016	1014	1012	10	10	10	32	26	-	0	
Feb	10	29	27	23	22	21	19	78	69	52	1014	1013	1011	10	10	10	27	23	-	0	
Feb	11	29	27	24	24	23	21	83	76	64	1015	1013	1012	10	10	10	27	23	-	0	
Feb	12	29	27	24	24	23	22	94	80	67	1017	1015	1012	31	12	10	27	23	-	0	
Feb	13	29	27	24	24	23	21	89	76	59	1018	1016	1014	31	12	10	29	24	-	0	
Feb	14	29	27	24	23	21	20	83	70	53	1018	1016	1014	10	10	10	37	29	-	0	Rain
Feb	15	29	26	23	22	21	20	83	73	51	1017	1015	1014	31	12	10	40	26	-	0.51	
Feb	16	29	26	22	24	22	20	100	77	53	1017	1015	1014	31	12	10	35	24	-	0.76	Rain
Feb	17	29	26	22	22	22	21	83	73	57	1017	1015	1014	27	11	10	37	34	-	2.03	
Feb	18	30	27	24	22	21	19	83	68	45	1017	1015	1013	31	12	10	42	34	-	0	Rain
Feb	19	29	26	22	22	21	19	94	73	46	1015	1014	1012	31	12	8	40	32	-	0	Rain
Feb	20	29	26	23	23	22	21	83	75	65	1016	1014	1012	31	12	10	37	29	-	2.03	Rain
Feb	21	29	26	22	22	21	20	90	74	53	1017	1015	1014	31	13	7	39	31	-	2.03	Rain
Feb	22	29	27	25	22	21	19	78	66	49	1017	1015	1013	31	14	10	47	39	-	1.02	
Feb	23	29	26	23	23	21	19	83	70	53	1016	1015	1013	31	14	10	39	31	-	2.03	Rain
Feb	24	29	26	22	22	21	18	83	71	57	1016	1015	1013	31	12	10	34	27	-	0	Rain
Feb	25	29	24	20	21	21	19	94	74	51	1017	1015	1014	31	12	10	40	31	-	0	Rain

2015		Temp. (°C)			Dew Point (°C)			Humidity (%)			Sea Level Press. (hPa)			Visibility (km)			Wind (km/h)			Precip. (mm)	Events
		high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	high	sum	
Feb	26	29	27	24	22	21	20	78	70	57	1017	1015	1014	31	14	10	40	32	-	0	
Feb	27	29	27	24	22	21	19	83	68	48	1017	1015	1014	27	14	10	45	37	-	0	
Feb	28	29	26	21	24	21	18	92	73	47	1018	1016	1014	31	13	5	48	35	77	4.06	Rain
Mar	1	29	26	22	23	21	19	89	70	50	1018	1015	1014	31	13	10	47	39	-	1.02	Rain
Mar	2	29	26	23	23	21	20	94	76	59	1016	1014	1012	27	13	10	42	34	-	0	Rain
Mar	3	28	24	22	23	22	21	100	84	66	1016	1014	1012	19	10	5	37	29	-	7.11	Rain
Mar	4	29	26	22	22	21	20	83	71	56	1016	1015	1013	26	12	10	40	35	-	0	Rain
Mar	5	29	26	23	21	19	18	83	65	46	1017	1015	1014	27	11	8	180	40	-	0	Rain
Mar	6	29	25	21	21	21	19	88	74	54	1017	1015	1014	26	12	10	47	39	-	0	Rain
Mar	7	29	26	22	21	19	16	78	63	35	1018	1015	1014	27	12	8	47	37	-	0	Rain
Mar	8	28	26	22	22	20	18	83	69	54	1017	1015	1013	31	12	10	37	29	-	0	Rain
Mar	9	29	24	21	22	22	20	94	75	58	1017	1015	1013	27	12	4	48	40	69	22.1	Rain
Mar	10	29	27	23	22	21	20	83	72	56	1018	1016	1014	26	13	10	47	42	-	0	Rain
Mar	11	28	26	22	22	21	19	83	73	57	1017	1015	1014	31	13	2	127	37	-	0	Rain
Mar	12	29	26	23	22	21	19	94	70	57	1016	1014	1013	27	10	6	39	32	-	0.25	Rain
Mar	13	28	24	21	22	21	20	94	73	55	1015	1014	1012	24	11	6	45	34	-	0	Rain
Mar	14	29	26	23	21	20	19	78	68	54	1015	1014	1012	24	13	10	40	31	-	0	
Mar	15	29	26	22	22	21	20	79	71	52	1016	1014	1013	23	13	10	42	32	-	0	Rain
Mar	16	29	26	23	22	20	19	78	68	48	1015	1014	1012	23	13	10	32	26	-	0	
Mar	17	28	24	20	22	21	19	89	75	56	1015	1014	1012	24	13	10	26	16	-	0	
Mar	18	29	26	23	23	22	21	89	77	58	1016	1014	1012	24	13	10	32	23	-	0	
Mar	19	29	26	23	23	23	22	94	77	61	1016	1014	1013	23	12	10	29	23	-	0.25	Rain
Mar	20	29	26	22	23	22	21	100	84	62	1016	1014	1013	27	10	0	32	21	-	16	Rain
Mar	21	28	24	21	23	22	21	100	80	57	1016	1014	1013	27	13	10	26	14	-	0	
Mar	22	28	26	23	21	21	19	83	70	57	1016	1015	1013	10	10	10	29	21	-	0	
Mar	23	29	26	23	23	21	20	94	74	57	1017	1016	1014	31	11	10	29	23	-	0	
Mar	24	28	26	22	24	23	22	100	84	67	1019	1016	1015	31	13	10	32	23	-	1.02	Rain
Mar	25	29	26	23	23	22	22	89	78	64	1017	1016	1014	31	12	10	32	23	-	0	

2015		Temp. (°C)			Dew Point (°C)			Humidity (%)			Sea Level Press. (hPa)			Visibility (km)			Wind (km/h)			Precip. (mm)	Events
		high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	high	sum	
Mar	26	30	26	22	23	22	20	95	78	59	1017	1015	1014	31	11	8	39	29	-	0	Rain
Mar	27	29	26	22	21	21	19	78	69	53	1018	1016	1015	27	11	10	42	31	-	0	
Mar	28	29	26	22	23	22	19	94	77	59	1020	1017	1016	31	14	10	48	34	-	2.03	Rain
Mar	29	28	26	23	22	21	20	94	74	62	1019	1017	1015	31	13	8	42	35	-	0.25	Rain
Mar	30	29	26	22	21	19	16	83	61	36	1017	1016	1014	19	11	10	39	31	42	0	
Mar	31	28	24	21	22	20	14	89	70	50	1017	1015	1014	26	12	4	27	21	-	4.06	Rain
Apr	1	29	27	24	23	21	20	83	72	60	1018	1016	1014	26	12	10	35	23	-	0	Rain
Apr	2	29	27	24	24	22	21	89	75	59	1018	1016	1014	31	12	10	32	26	-	0	Rain
Apr	3	29	26	22	23	21	20	94	74	56	1016	1014	1013	31	13	10	37	29	-	1.02	Rain
Apr	4	29	27	23	21	21	20	74	67	49	1014	1013	1011	27	11	10	34	26	-	0	
Apr	5	29	27	24	22	21	20	83	69	51	1014	1013	1011	18	10	8	29	24	-	0	
Apr	6	29	27	24	23	21	20	83	70	55	1016	1014	1012	27	12	8	37	27	-	0	Rain
Apr	7	30	27	24	23	22	20	89	72	54	1016	1014	1013	31	14	10	35	29	-	0	Rain
Apr	8	28	25	22	24	22	20	94	81	65	1016	1014	1013	26	12	5	37	26	-	5.08	Rain
Apr	9	29	26	23	23	22	21	83	73	59	1017	1015	1013	31	13	10	35	29	-	0	Rain
Apr	10	29	25	21	23	22	21	94	77	63	1017	1016	1014	26	11	2	42	34	-	0.51	Rain
Apr	11	28	26	23	24	23	21	100	84	70	1018	1016	1014	26	11	3	40	32	-	4.06	Rain
Apr	12	29	26	23	23	22	21	83	73	60	1018	1016	1015	31	15	10	35	31	-	0	Rain
Apr	13	30	27	24	23	22	21	83	73	59	1019	1017	1015	31	15	10	40	31	-	0	Rain
Apr	14	30	27	24	23	23	22	83	74	61	1018	1016	1015	31	13	10	37	31	-	0	
Apr	15	30	27	24	24	23	22	89	77	64	1017	1015	1014	19	11	10	37	29	-	0	Rain
Apr	16	29	26	23	24	23	22	89	76	62	1016	1015	1013	14	11	10	37	31	-	0	Rain
Apr	17	29	27	24	24	23	21	89	77	60	1042	1016	1013	14	11	10	40	35	-	0.51	Rain
Apr	18	30	27	24	24	22	22	83	73	64	1017	1016	1014	16	11	10	40	35	-	0	
Apr	19	29	27	24	23	22	22	83	74	55	1017	1015	1013	23	12	10	40	32	-	0	Rain
Apr	20	30	27	24	23	22	2	83	71	19	1016	1015	1013	27	13	10	37	29	-	0	Rain
Apr	21	30	27	23	23	22	21	89	76	55	1016	1014	1013	27	11	4	32	23	-	8.89	Rain
Apr	22	28	24	22	24	22	21	94	82	62	1016	1014	1013	27	13	10	37	26	-	6.1	Rain

2015		Temp. (°C)			Dew Point (°C)			Humidity (%)			Sea Level Press. (hPa)			Visibility (km)			Wind (km/h)			Precip. (mm)	Events
		high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	high	sum	
Apr	23	29	27	25	24	23	21	89	76	62	1016	1014	1013	27	13	10	34	27	-	0	
Apr	24	30	27	24	24	23	23	84	76	65	1016	1015	1013	27	13	10	34	27	-	0	Rain
Apr	25	30	28	26	24	23	23	89	78	65	1017	1015	1013	19	12	10	32	24	-	0	
Apr	26	30	28	26	25	24	23	89	78	67	1016	1014	1013	19	11	10	35	26	-	0	
Apr	27	30	28	25	24	23	23	83	74	59	1016	1014	1013	14	11	10	32	27	-	0	
Apr	28	30	27	24	24	22	22	84	71	59	1016	1014	1013	19	11	10	32	26	-	0	
Apr	29	31	28	24	23	22	21	78	69	55	1017	1015	1013	19	12	10	32	26	-	0	
Apr	30	31	28	24	23	22	21	78	70	55	1017	1015	1013	31	14	10	32	27	-	0	
May	1	30	27	24	23	22	21	78	70	52	1017	1015	1012	31	12	10	39	31	-	0	
May	2	30	27	24	23	22	21	79	69	52	1016	1014	1013	10	10	10	35	26	-	0	
May	3	30	27	24	23	22	22	79	71	54	1016	1015	1013	31	12	10	37	29	-	0	
May	4	31	28	26	22	22	21	78	68	49	1018	1016	1014	31	13	10	39	34	-	0	
May	5	31	28	24	23	22	21	78	68	51	1018	1016	1015	14	11	10	42	35	-	0	Rain
May	6	30	28	25	22	22	21	78	68	55	1017	1016	1015	11	10	9	42	35	-	0	
May	7	30	28	25	22	22	20	78	68	55	1018	1017	1015	11	10	9	39	34	-	0	
May	8	31	28	24	22	21	21	78	67	55	1018	1016	1015	14	11	10	39	32	-	0	
May	9	30	27	24	24	22	21	78	70	53	1018	1016	1015	27	13	10	39	29	-	1.02	
May	10	31	27	24	23	22	22	79	72	58	1017	1016	1015	27	12	10	52	37	-	0	Rain
May	11	31	27	24	23	22	21	83	72	53	1017	1016	1015	16	11	10	48	40	-	0	Rain
May	12	31	27	24	24	22	21	84	71	51	1017	1016	1014	18	11	9	52	40	74	0	Rain
May	13	31	27	23	23	22	21	89	71	51	1017	1015	1014	16	11	8	47	39	-	0	Rain
May	14	31	28	24	23	22	21	79	69	53	1017	1015	1014	18	11	10	42	37	-	0	
May	15	31	28	24	24	22	21	83	69	53	1016	1015	1014	18	11	5	45	35	-	0	
May	16	30	27	23	24	22	21	94	72	57	1017	1016	1014	18	12	10	35	29	-	0.51	Rain
May	17	31	27	22	25	23	22	89	77	62	1017	1016	1015	26	13	10	39	31	-	0	Rain
May	18	31	27	23	24	23	22	89	78	56	1017	1015	1014	26	13	10	35	27	-	0.25	Rain
May	19	31	28	24	24	23	23	84	77	63	1016	1015	1014	26	13	10	32	27	-	0	
May	20	30	27	24	24	23	22	89	74	56	1016	1015	1013	23	12	10	32	27	-	0	

2015		Temp. (°C)			Dew Point (°C)			Humidity (%)			Sea Level Press. (hPa)			Visibility (km)			Wind (km/h)			Precip. (mm)	Events
		high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	high	sum	
May	21	31	28	24	23	23	22	83	71	57	1017	1015	1014	11	9	6	39	31	-	0	
May	22	31	28	25	23	22	21	83	71	55	1019	1017	1016	10	9	6	42	34	-	0	
May	23	31	28	24	25	23	22	94	75	57	1018	1017	1015	10	9	9	40	34	-	1.02	
May	24	31	28	24	23	22	21	83	70	48	1017	1016	1015	16	10	2	39	34	-	0	Rain
May	25	29	27	23	23	22	21	89	75	58	1017	1015	1014	23	12	8	39	31	-	1.02	Rain
May	26	30	27	24	22	21	20	74	67	52	1016	1015	1013	31	14	10	32	26	-	0	Rain
May	27	30	27	23	24	22	19	91	73	53	1015	1014	1013	31	15	10	37	19	-	0	
May	28	29	27	24	25	24	23	94	82	70	1015	1014	1012	31	14	9	35	29	-	0.51	Rain
May	29	29	27	23	25	24	23	89	78	63	1015	1014	1013	23	12	10	50	35	-	0	Rain
May	30	31	28	25	24	23	22	84	75	57	1016	1014	1012	23	12	10	39	32	-	0	
May	31	31	28	25	24	23	22	94	75	58	1017	1015	1013	27	12	10	45	35	66	0	Rain
Jun	1	30	27	24	24	23	22	89	76	64	1017	1016	1014	31	13	10	40	32	-	0	Rain
Jun	2	31	28	25	23	22	22	83	71	55	1016	1014	1013	31	14	10	32	27	-	0	Rain
Jun	3	31	28	24	24	23	21	84	73	61	1016	1014	1013	31	14	10	35	29	-	0	
Jun	4	31	28	25	25	23	23	89	77	65	1017	1015	1013	31	14	10	40	29	-	0	Rain
Jun	5	30	28	25	24	23	22	84	72	53	1016	1015	1014	31	13	10	37	32	-	0	Rain
Jun	6	31	27	23	25	24	23	89	79	66	1016	1015	1013	23	11	5	42	35	-	0	Rain
Jun	7	31	28	25	24	23	22	79	71	55	1016	1015	1014	27	12	10	42	35	-	0	
Jun	8	30	27	24	24	22	21	94	73	59	1017	1015	1013	27	12	6	42	31	-	0.51	Rain
Jun	9	29	27	24	23	22	21	94	75	65	1015	1014	1013	26	11	5	37	29	-	1.02	Rain
Jun	10	31	27	23	24	22	21	89	72	55	1016	1014	1013	31	13	10	39	34	-	0	Rain
Jun	11	31	28	24	25	24	22	94	78	52	1017	1016	1014	27	13	10	42	35	-	1.02	Rain
Jun	12	31	28	24	25	23	22	84	74	59	1018	1016	1014	27	11	10	48	39	-	0	
Jun	13	31	28	24	25	23	22	89	75	54	1017	1015	1014	16	10	6	48	42	-	0.25	Rain
Jun	14	31	28	24	24	23	22	84	72	54	1016	1015	1014	11	10	10	47	40	-	0.25	
Jun	15	31	28	25	25	24	22	94	81	67	1017	1015	1014	11	9	6	45	35	-	3.05	Rain
Jun	16	31	28	24	25	23	2	94	78	18	1017	1016	1015	19	11	8	40	32	-	0	Rain
Jun	17	30	28	25	24	23	22	84	76	62	1018	1016	1014	10	8	6	42	37	-	0	Rain

2015		Temp. (°C)			Dew Point (°C)			Humidity (%)			Sea Level Press. (hPa)			Visibility (km)			Wind (km/h)			Precip. (mm)	Events
		high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	high	sum	
Jun	18	31	28	24	24	23	22	89	75	57	1017	1016	1014	7	6	6	40	37	-	0	
Jun	19	31	28	26	23	23	22	83	72	58	1018	1016	1014	18	10	6	42	35	-	0	Rain
Jun	20	31	28	26	23	22	21	83	71	54	1017	1016	1015	31	12	10	40	32	-	0	
Jun	21	31	27	24	25	24	21	94	85	63	1018	1016	1015	26	10	1	47	34	63	0.76	Rain
Jun	22	30	28	26	26	24	23	94	84	74	1019	1017	1016	10	10	9	40	29	-	0	Rain
Jun	23	30	28	26	24	23	23	89	76	66	1019	1017	1016	10	10	10	55	39	-	0	
Jun	24	31	29	27	23	23	22	79	72	62	1019	1018	1017	10	10	10	45	37	-	0	Rain
Jun	25	30	28	26	24	23	22	89	75	62	1019	1018	1016	10	10	10	39	32	-	0	Rain
Jun	26	30	28	25	25	24	21	94	83	70	1019	1017	1016	10	10	3	42	35	63	0	Rain
Jun	27	30	28	25	25	24	23	94	81	66	1019	1018	1016	10	10	10	40	35	-	0	Rain
Jun	28	31	29	27	25	23	22	89	75	62	1019	1017	1016	10	10	10	45	37	-	0	
Jun	29	30	28	26	23	22	22	79	72	62	1018	1016	1015	10	10	10	48	40	-	0	
Jun	30	30	28	26	24	23	23	89	77	66	1018	1016	1015	10	10	10	47	39	-	0	
Jul	1	31	28	26	24	23	22	89	74	62	1018	1016	1015	10	10	9	47	37	-	0	Rain
Jul	2	30	28	25	25	24	22	94	83	70	1017	1015	1014	16	10	10	42	34	-	0	Rain
Jul	3	29	27	25	25	24	23	94	81	65	1016	1015	1014	11	10	7	47	37	63	0.25	Rain
Jul	4	31	28	26	24	23	22	84	74	66	1016	1015	1014	10	9	8	50	40	-	0	Rain
Jul	5	30	28	27	23	23	22	79	73	66	1017	1015	1014	10	10	9	47	42	-	0	
Jul	6	29	27	26	24	23	22	89	78	66	1016	1015	1014	10	10	10	45	35	-	0	
Jul	7	30	28	27	24	23	22	84	76	66	1016	1015	1014	10	10	10	40	34	-	0	
Jul	8	30	28	26	23	23	22	79	73	62	1016	1015	1014	10	10	10	39	32	-	0	
Jul	9	30	28	26	24	23	22	89	77	66	1016	1014	1013	10	10	10	34	29	-	0	Rain
Jul	10	30	28	25	25	23	22	94	81	66	1017	1016	1014	10	10	4	35	29	-	0	Rain
Jul	11	29	27	25	25	24	22	100	84	74	1017	1016	1015	10	9	7	42	32	-	0	Rain , Thunderstorm
Jul	12	30	28	26	24	23	22	84	77	66	1017	1016	1014	10	10	10	40	35	-	0	
Jul	13	30	28	26	25	24	23	89	80	70	1016	1015	1013	10	10	10	39	31	-	0	
Jul	14	30	28	25	25	24	22	100	79	66	1016	1015	1013	10	10	10	47	34	-	0	Rain

2015		Temp. (°C)			Dew Point (°C)			Humidity (%)			Sea Level Press. (hPa)			Visibility (km)			Wind (km/h)			Precip. (mm)	Events
		high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	high	sum	
Jul	15	30	28	26	25	23	22	94	79	62	1016	1014	1013	10	10	10	39	32	-	0	Rain , Thunderstorm
Jul	16	30	28	25	25	24	23	94	82	70	1016	1015	1014	10	10	10	39	34	-	0	Rain , Thunderstorm
Jul	17	30	28	26	23	22	22	79	72	62	1017	1016	1014	10	10	10	39	31	-	0	
Jul	18	30	28	26	22	22	21	78	69	58	1016	1015	1014	10	10	10	35	29	-	0	
Jul	19	30	28	26	24	23	21	84	75	62	1016	1015	1014	10	10	10	35	29	-	0	
Jul	20	30	28	25	26	24	23	94	82	70	1016	1014	1013	10	9	5	39	27	-	0	
Jul	21	30	28	27	26	24	23	89	81	70	1016	1015	1014	10	10	9	35	29	-	0	
Jul	22	31	28	26	26	25	23	94	83	66	1017	1016	1015	10	10	10	37	26	-	0	Rain
Jul	23	31	29	27	25	24	23	89	77	66	1018	1017	1016	10	10	10	39	31	-	0	
Jul	24	31	28	26	25	23	23	94	76	66	1018	1017	1015	10	10	10	37	27	-	0	Rain
Jul	25	31	29	27	26	24	23	89	81	70	1017	1016	1014	10	9	1	47	34	-	0	Rain
Jul	26	30	28	26	24	23	22	89	74	66	1017	1016	1014	10	10	10	39	32	-	0	Rain
Jul	27	30	28	25	25	24	23	94	79	70	1016	1015	1013	10	10	8	42	32	-	0	Rain
Jul	28	31	29	27	24	23	22	84	72	62	1016	1014	1013	10	10	10	40	34	-	0	
Jul	29	30	28	27	25	24	22	89	79	70	1015	1014	1013	10	10	6	39	29	-	0	Rain
Jul	30	31	28	25	25	24	24	100	83	70	1016	1015	1014	10	9	5	39	32	-	0	Rain , Thunderstorm
Jul	31	31	28	26	26	24	23	94	81	66	1016	1015	1014	10	9	6	40	31	-	0	Rain
Aug	1	30	28	27	23	22	22	79	70	62	1015	1014	1012	10	10	10	37	29	-	0	
Aug	2	31	28	25	25	24	23	94	85	70	1015	1013	1012	10	10	10	34	23	-	0	Rain
Aug	3	29	27	26	26	25	24	94	87	79	1016	1014	1013	10	9	1	42	32	-	0	Rain
Aug	4	31	28	26	25	23	23	89	76	66	1016	1015	1014	10	10	6	40	32	-	0	Rain
Aug	5	31	29	27	24	23	22	84	76	62	1016	1015	1013	27	11	10	34	27	-	0	Rain
Aug	6	30	28	26	24	23	22	84	75	66	1015	1014	1012	10	10	10	29	23	-	0	
Aug	7	31	28	26	26	24	24	89	80	66	1014	1013	1012	10	10	10	34	19	-	0	Rain
Aug	8	31	29	27	25	24	23	84	77	66	1015	1014	1012	10	10	10	37	29	-	0	Rain
Aug	9	31	28	26	25	24	22	94	77	62	1015	1014	1012	10	10	9	39	29	-	0	Rain

2015		Temp. (°C)			Dew Point (°C)			Humidity (%)			Sea Level Press. (hPa)			Visibility (km)			Wind (km/h)			Precip. (mm)	Events
		high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	high	sum	
Aug	10	31	28	26	24	23	21	84	73	53	1015	1014	1012	10	10	8	34	24	-	0	
Aug	11	31	28	26	26	25	24	94	85	70	1016	1014	1013	10	10	8	37	31	-	0	Rain
Aug	12	31	28	26	26	24	24	94	81	66	1015	1014	1012	10	10	9	37	31	-	0	Rain
Aug	13	31	28	25	24	23	22	94	74	62	1015	1014	1013	10	10	10	34	27	-	0	
Aug	14	30	28	26	26	25	23	94	85	79	1016	1014	1013	10	10	8	34	21	-	0	Rain
Aug	15	31	29	27	25	24	23	89	75	62	1016	1015	1014	10	10	10	39	34	-	0	Rain
Aug	16	31	28	25	24	23	21	89	71	58	1016	1015	1013	10	10	10	29	26	-	0	
Aug	17	31	29	27	24	23	22	79	73	66	1016	1015	1014	10	10	10	45	27	-	0	
Aug	18	31	29	27	25	23	22	89	74	62	1016	1014	1013	10	10	10	40	29	-	0	Rain
Aug	19	31	29	27	26	24	23	89	78	70	1015	1013	1012	31	11	10	39	31	-	0	
Aug	20	32	30	28	25	25	24	84	77	66	1014	1013	1012	10	9	9	40	31	-	0	
Aug	21	31	29	27	25	24	23	89	77	70	1015	1013	1012	10	10	9	35	27	-	0	
Aug	22	31	28	26	24	23	23	83	73	62	1014	1012	1011	10	10	10	29	23	-	0	
Aug	23	31	28	26	25	24	23	84	77	66	1013	1011	1010	10	10	10	24	18	-	0	
Aug	24	31	27	24	25	24	23	94	79	66	1014	1012	1011	10	10	10	24	11	-	0	Rain
Aug	25	32	28	25	25	25	24	94	82	66	1013	1011	1010	10	10	6	29	18	-	0	Rain
Aug	26	31	28	25	26	25	24	100	84	70	1012	1011	1010	10	10	7	32	14	-	0	Rain
Aug	27	31	29	28	26	25	24	84	77	70	1015	1013	1010	10	10	10	39	31	-	0	
Aug	28	32	29	27	25	24	23	89	76	59	1015	1014	1013	10	10	10	39	26	-	0	Rain
Aug	29	31	29	27	26	26	24	94	83	74	1015	1014	1012	10	10	10	35	26	-	0	Rain
Aug	30	31	28	26	27	25	23	94	83	66	1016	1014	1013	10	10	10	34	24	-	0	
Aug	31	31	29	27	26	25	23	89	82	70	1016	1015	1013	10	10	10	26	16	-	0	Rain
Sep	1	32	30	28	26	25	24	89	78	66	1016	1015	1013	10	10	10	32	21	-	0	
Sep	2	32	30	28	25	24	23	84	75	66	1016	1015	1013	10	10	10	29	26	-	0	
Sep	3	32	29	27	25	24	23	84	75	62	1015	1014	1012	10	10	10	26	16	-	0	
Sep	4	32	30	28	25	24	23	84	72	62	1015	1014	1013	10	10	10	26	19	-	0	
Sep	5	31	28	26	26	24	22	89	79	66	1016	1014	1013	10	10	8	39	23	-	0	
Sep	6	32	30	28	25	24	24	84	75	66	1015	1014	1013	10	10	10	34	26	-	0	

2015		Temp. (°C)			Dew Point (°C)			Humidity (%)			Sea Level Press. (hPa)			Visibility (km)			Wind (km/h)			Precip. (mm)	Events
		high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	high	sum	
Sep	7	30	28	26	26	24	24	94	83	70	1014	1013	1012	10	9	0	48	27	74	0	Rain
Sep	8	31	28	26	25	24	23	89	76	62	1014	1013	1011	10	10	10	39	29	-	0	Rain
Sep	9	31	28	26	27	25	24	94	80	70	1012	1011	1010	10	10	1	39	31	-	0	Rain , Thunderstorm
Sep	10	30	28	26	26	26	24	94	89	74	1014	1012	1010	10	9	3	27	19	-	0	Rain , Thunderstorm
Sep	11	31	28	25	26	24	22	94	83	66	1015	1013	1012	10	9	5	24	13	-	0	Rain
Sep	12	31	28	26	26	24	24	94	80	70	1016	1014	1012	10	10	10	42	23	-	0	Rain
Sep	13	30	28	26	26	25	24	94	85	74	1016	1014	1013	10	10	8	40	29	-	0	Rain
Sep	14	31	28	26	27	25	24	94	84	75	1015	1014	1012	10	10	10	35	26	-	0	Rain
Sep	15	31	29	28	27	26	25	89	81	70	1016	1014	1013	10	10	10	35	29	-	0	
Sep	16	31	29	27	26	25	23	84	78	70	1015	1013	1011	10	10	10	35	29	-	0	
Sep	17	31	29	27	25	24	22	84	75	70	1013	1011	1010	10	10	10	26	21	-	0	
Sep	18	31	29	27	25	24	24	84	77	70	1013	1011	1010	10	10	7	21	18	-	0	Rain
Sep	19	31	29	27	25	24	23	84	76	66	1014	1012	1011	10	10	10	23	18	-	0	
Sep	20	31	29	26	25	24	23	84	77	66	1013	1012	1011	10	10	10	24	16	-	0	
Sep	21	32	28	25	26	24	23	94	80	66	1014	1012	1011	10	10	10	24	13	-	0	
Sep	22	32	30	28	25	24	23	84	76	66	1014	1012	1011	10	10	10	23	18	-	0	
Sep	23	31	29	28	25	25	24	84	78	70	1013	1011	1010	10	10	10	23	16	-	0	Rain
Sep	24	31	28	25	25	24	24	94	79	66	1014	1012	1010	10	10	10	23	14	-	0	
Sep	25	31	29	27	25	24	23	89	75	62	1015	1013	1012	10	10	10	19	14	-	0	
Sep	26	31	28	26	25	24	23	89	76	62	1015	1013	1011	10	10	10	19	14	-	0	
Sep	27	31	28	25	25	24	23	94	78	66	1015	1013	1012	10	10	10	16	8	-	0	
Sep	28	31	28	25	25	24	23	94	82	66	1014	1012	1011	10	10	10	24	11	-	0	Rain
Sep	29	32	29	27	26	25	24	89	77	66	1012	1010	1009	10	10	10	23	18	-	0	Rain
Sep	30	33	30	28	26	25	24	84	76	66	1011	1009	1009	10	10	10	26	18	-	0	
Oct	1	32	30	28	26	25	24	84	76	66	1011	1009	1008	10	10	10	26	21	-	0	
Oct	2	32	30	29	26	25	24	84	75	66	1012	1010	1009	10	10	10	24	19	-	0	
Oct	3	32	30	28	25	24	24	79	72	62	1014	1012	1010	10	10	10	24	21	-	0	

2015		Temp. (°C)			Dew Point (°C)			Humidity (%)			Sea Level Press. (hPa)			Visibility (km)			Wind (km/h)			Precip. (mm)	Events
		high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	high	sum	
Oct	4	33	30	28	25	25	23	84	74	62	1014	1013	1011	10	10	10	34	23	-	0	Rain
Oct	5	33	29	26	26	25	24	100	77	59	1016	1014	1012	10	10	10	35	26	-	0	Rain , Thunderstorm
Oct	6	32	30	28	27	26	24	89	81	70	1016	1014	1013	10	10	6	39	29	-	0	Rain , Thunderstorm
Oct	7	29	27	25	26	25	24	100	88	79	1015	1013	1011	10	9	3	27	18	-	0	Rain , Thunderstorm
Oct	8	30	28	25	26	25	22	100	86	79	1015	1013	1011	10	8	2	42	23	-	0	Rain , Thunderstorm
Oct	9	32	30	28	26	25	23	84	76	70	1015	1013	1011	8	8	8	39	34	-	0	
Oct	10	32	29	26	26	25	23	94	80	70	1014	1013	1011	10	8	4	40	35	-	0	Rain , Thunderstorm
Oct	11	31	29	27	26	24	23	89	77	66	1014	1012	1011	9	9	9	39	29	-	0	
Oct	12	31	29	28	25	24	23	79	75	66	1015	1013	1011	10	10	9	42	31	-	0	
Oct	13	31	29	27	26	25	24	89	79	70	1015	1013	1011	10	10	10	42	35	-	0	Rain
Oct	14	31	28	26	26	24	23	94	81	70	1016	1014	1012	10	10	8	29	26	-	0	Rain
Oct	15	31	29	27	25	24	23	84	76	66	1014	1012	1011	10	10	10	27	23	-	0	
Oct	16	30	28	27	26	25	24	89	81	74	1014	1012	1011	10	10	10	26	23	-	0	Rain
Oct	17	31	28	26	26	25	24	94	81	74	1016	1014	1012	10	10	10	24	19	-	0	
Oct	18	31	28	26	25	24	23	89	78	66	1016	1014	1012	10	10	10	29	18	-	0	
Oct	19	31	27	24	26	24	23	94	79	66	1016	1014	1012	10	10	10	19	11	-	0	
Oct	20	32	29	26	26	25	24	94	81	70	1015	1013	1012	10	10	10	34	19	-	0	Rain
Oct	21	32	30	28	26	25	24	84	80	70	1014	1012	1011	23	10	10	34	26	-	0	
Oct	22	31	29	28	26	25	24	89	77	66	1013	1011	1009	24	11	10	32	27	-	0	
Oct	23	31	29	27	25	24	24	84	76	66	1013	1011	1009	10	10	10	24	19	-	0	Rain
Oct	24	32	29	26	26	25	24	84	77	65	1013	1011	1010	10	10	10	29	19	-	0	
Oct	25	31	28	26	25	24	24	89	79	70	1015	1013	1011	10	10	10	26	14	-	0	
Oct	26	32	30	28	26	25	24	84	78	66	1015	1013	1012	10	10	7	34	24	-	0	Rain
Oct	27	32	30	28	28	24	23	84	72	59	1015	1013	1012	10	10	10	37	31	-	0	
Oct	28	32	29	27	26	24	23	89	76	62	1015	1013	1012	10	10	10	27	19	-	0	

2015		Temp. (°C)			Dew Point (°C)			Humidity (%)			Sea Level Press. (hPa)			Visibility (km)			Wind (km/h)			Precip. (mm)	Events
		high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	high	sum	
Oct	29	31	28	26	28	25	24	94	82	70	1014	1012	1010	10	10	10	29	16	-	0	Rain
Oct	30	32	28	25	25	24	24	94	78	66	1014	1012	1011	10	10	10	29	23	-	0	
Oct	31	32	29	27	25	24	23	89	79	62	1014	1012	1010	10	10	10	37	21	-	0	Rain , Thunderstorm
Nov	1	32	30	28	26	24	24	84	77	66	1013	1011	1010	10	10	10	32	27	-	0	Rain
Nov	2	32	29	26	25	25	24	94	81	62	1013	1011	1009	10	10	10	34	21	-	0	Rain
Nov	3	31	29	27	25	24	23	89	75	62	1013	1012	1010	10	10	10	39	31	-	0	
Nov	4	32	29	26	25	24	23	94	76	59	1014	1012	1011	10	10	9	40	27	-	0	Rain , Thunderstorm
Nov	5	28	24	22	25	24	22	100	87	74	1014	1012	1010	10	8	0	48	32	72	0	Rain
Nov	6	30	27	24	25	24	23	94	82	74	1014	1013	1010	10	9	6	35	21	-	0	Rain
Nov	7	30	28	27	25	25	24	89	81	74	1015	1013	1012	10	10	10	37	24	-	0	
Nov	8	31	28	25	26	25	23	94	84	74	1015	1013	1012	10	9	2	53	37	-	0	Rain
Nov	9	28	26	24	25	24	23	100	89	79	1017	1015	1013	10	8	2	45	32	72	0	Rain
Nov	10	31	29	27	26	24	23	89	80	70	1016	1014	1013	10	10	9	39	34	-	0	Rain
Nov	11	30	28	27	24	23	23	84	78	70	1015	1013	1012	10	10	10	27	26	-	0	
Nov	12	31	28	25	25	23	22	89	76	66	1014	1012	1011	10	10	9	29	23	-	0	
Nov	13	30	28	27	24	23	23	84	76	66	1014	1012	1011	10	10	10	29	26	-	0	
Nov	14	30	28	27	24	23	22	84	74	62	1016	1014	1012	10	10	10	37	31	-	0	
Nov	15	31	29	27	25	22	2	84	72	20	1016	1014	1013	10	10	10	32	29	-	0	Tornado
Nov	16	31	29	27	24	23	23	84	76	66	1015	1013	1011	10	10	10	39	32	-	0	
Nov	17	30	28	27	24	23	22	84	76	66	1013	1011	1010	10	10	10	37	29	-	0	
Nov	18	31	29	26	24	23	21	83	72	62	1013	1011	1009	10	10	10	37	29	-	0	
Nov	19	30	28	25	24	23	21	89	77	66	1012	1011	1009	10	10	10	26	16	-	0	
Nov	20	30	28	25	24	22	22	89	76	66	1015	1010	1008	10	10	10	26	14	-	0	
Nov	21	30	27	24	24	23	22	94	75	63	1013	1011	1009	10	10	10	32	18	-	0	
Nov	22	31	29	27	25	24	23	84	78	70	1015	1013	1011	10	10	10	34	31	-	0	Rain
Nov	23	30	28	27	25	24	23	84	78	70	1013	1012	1010	10	10	10	35	27	-	0	
Nov	24	30	28	26	25	24	23	89	80	70	1013	1011	1009	10	10	10	27	23	-	0	

2015		Temp. (°C)			Dew Point (°C)			Humidity (%)			Sea Level Press. (hPa)			Visibility (km)			Wind (km/h)			Precip. (mm)	Events
		high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	high	sum	
Nov	25	30	28	27	25	24	23	84	78	66	1014	1012	1011	10	10	10	37	27	-	0	
Nov	26	30	28	27	25	24	23	84	78	70	1015	1013	1012	10	10	10	32	26	-	0	
Nov	27	31	29	27	25	24	23	84	79	66	1014	1012	1011	10	10	10	35	26	-	0	
Nov	28	30	28	26	24	24	23	84	78	70	1013	1012	1010	10	10	10	37	32	-	0	Rain
Nov	29	30	28	26	25	24	23	94	83	70	1014	1012	1010	10	9	6	40	32	-	0	Rain
Nov	30	30	28	25	26	25	24	100	86	74	1014	1012	1010	10	10	10	34	27	-	0	Rain
Dec	1	30	28	27	25	24	23	89	81	74	1016	1014	1011	10	10	10	29	24	-	0	Rain
Dec	2	30	28	26	25	24	23	94	82	70	1016	1015	1013	10	10	10	35	31	-	0	
Dec	3	29	27	24	25	24	23	100	86	79	1017	1015	1014	10	9	4	35	27	-	0	Rain
Dec	4	30	28	27	25	24	23	89	78	70	1018	1016	1015	10	10	10	42	35	-	0	
Dec	5	30	28	27	24	23	22	79	73	62	1018	1016	1015	10	10	10	39	32	-	0	Rain
Dec	6	29	27	25	23	22	20	89	73	65	1016	1015	1014	10	10	10	37	34	-	0	Rain
Dec	7	28	27	26	24	22	22	84	76	74	1015	1014	1012	10	10	10	34	31	-	0	
Dec	8	29	27	25	24	23	22	94	80	70	1017	1014	1013	10	10	10	35	27	-	0	Rain
Dec	9	30	28	26	24	23	22	89	74	62	1017	1015	1013	10	10	10	35	31	-	0	
Dec	10	28	26	24	24	23	21	94	83	70	1017	1015	1013	10	10	6	42	32	-	0	Rain
Dec	11	30	28	26	23	23	22	83	73	62	1017	1015	1014	10	10	10	37	31	-	0	Rain
Dec	12	30	28	26	23	22	22	83	73	62	1016	1015	1014	10	10	10	35	29	-	0	Rain
Dec	13	31	28	26	24	23	22	84	76	62	1015	1014	1012	10	10	10	37	27	-	0	
Dec	14	30	28	26	25	23	22	89	79	70	1015	1013	1012	10	10	10	29	26	-	0	
Dec	15	30	28	25	23	22	22	89	74	62	1014	1013	1011	10	10	10	29	24	-	0	
Dec	16	30	28	26	23	22	21	83	73	58	1015	1013	1012	10	10	10	27	23	-	0	
Dec	17	30	28	26	24	23	22	84	77	66	1016	1014	1013	10	10	10	37	27	-	0	Rain
Dec	18	30	28	26	24	23	22	89	77	66	1017	1015	1013	10	10	10	39	34	-	0	Rain
Dec	19	30	28	25	24	23	21	83	75	66	1018	1016	1014	10	10	10	42	35	-	0	Rain
Dec	20	30	28	26	23	23	22	83	74	66	1018	1016	1015	10	10	10	42	39	-	0	
Dec	21	30	28	25	24	23	21	94	75	66	1018	1016	1014	10	10	9	47	37	-	0	Rain
Dec	22	30	28	26	23	22	22	79	73	62	1017	1015	1013	10	10	10	48	42	-	0	

2015		Temp. (°C)			Dew Point (°C)			Humidity (%)			Sea Level Press. (hPa)			Visibility (km)			Wind (km/h)			Precip. (mm)	Events
		high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	low	high	avg	high	sum	
Dec	23	29	27	24	24	23	22	94	81	70	1017	1015	1013	10	10	9	50	35	71	0	Rain
Dec	24	29	27	24	24	23	22	94	84	66	1018	1016	1014	10	9	3	40	35	-	0	Rain
Dec	25	29	27	24	23	22	21	94	76	66	1018	1016	1014	10	10	10	42	35	-	0	Rain
Dec	26	28	26	24	23	22	21	83	76	66	1016	1015	1013	10	10	10	48	39	-	0	Rain
Dec	27	29	27	26	23	22	21	83	75	66	1015	1013	1012	10	10	6	40	35	-	0	Rain
Dec	28	30	28	25	23	22	21	89	75	66	1017	1015	1013	10	10	10	35	32	-	0	Rain
Dec	29	30	28	26	23	23	22	83	77	66	1019	1017	1016	10	10	10	37	32	-	0	Rain
Dec	30	30	28	25	25	23	22	89	77	66	1020	1018	1017	10	10	9	40	32	-	0	
Dec	31	29	27	25	23	22	21	89	76	66	1018	1016	1015	10	10	10	45	32	-	0	Rain

APPENDIX 2: SCENARIOS AND IGNITION SOURCE LOCATION

One of the most important steps in QRA is to find the location of scenarios, ignition source and any other feature on the map of the plant. The more accurate locating these elements, the more accurate results of the QRA. The location of scenarios and ignition sources are shown in Figure B3.

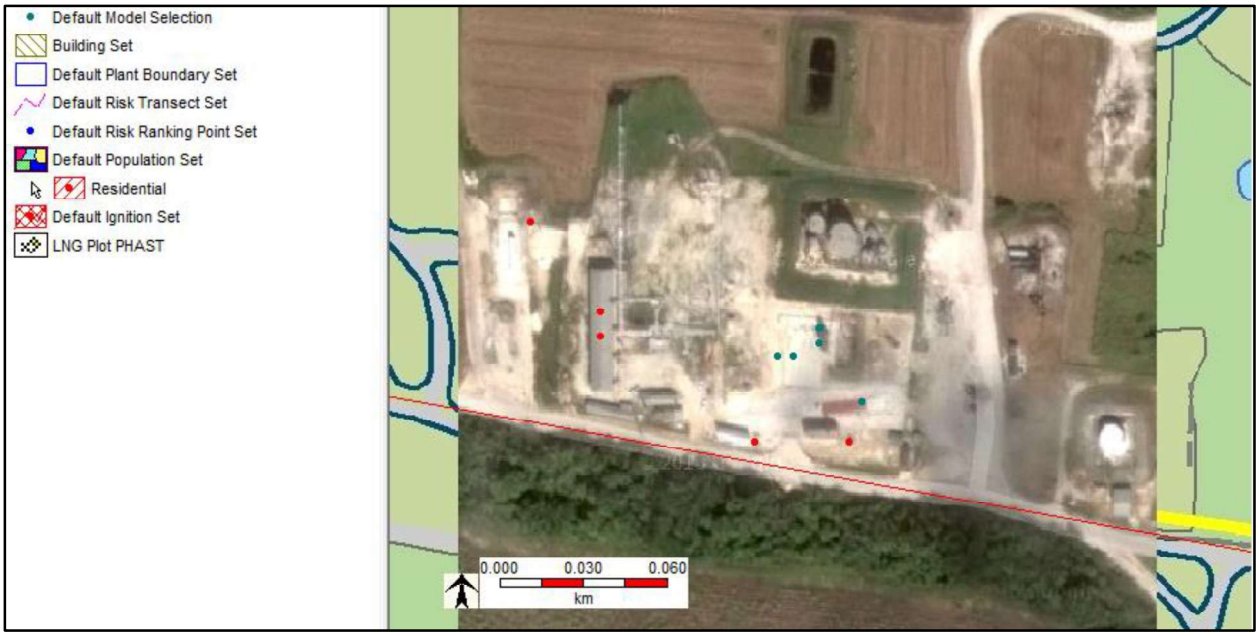

Figure B3- Location of scenarios and ignition sources

In this figure, red dots stand for ignition sources and blue dots for scenarios.

Ignition source in this plant are considered equipment like compressors and pumps. The value of the probability according to references are shown in table B1.

TableB1- Ignition probability

Ignition source	Pump	Compressor
Ignition Probability per second	2.1e-7	5.1e-6

APPENDIX 3: CONSEQUENCE (FLASH FIRE AND JET FIRE) OF SELECTED SCENARIOS

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Risk of a process area is a cumulative view of all possible consequences together with their relevant frequencies. Some of the scenarios might have insignificant outcomes, but high frequency (For example scenarios with pin hole size leakage). On the other hand, to have a better risk estimation the largest possible scenarios (Like catastrophic failures) with lower frequency have to be considered as well (Experience and calculations show that the most major consequences are because of the catastrophic failures with lower frequency). For example, for a LNG vessel a 150 mm leak (which is far larger than a pin hole and its outcome is serious) is two order of magnitude more frequent than a catastrophic release. To show the size of the effect of the scenarios, some scenarios are selected, and the flash fire and jet fire radius of these scenarios are shown in below figures.

Selected Scenarios		
LNG Storage 30 mm Leak	LNG Air Vaporizer 30 mm Leak	LNG Metering 30 mm Leak

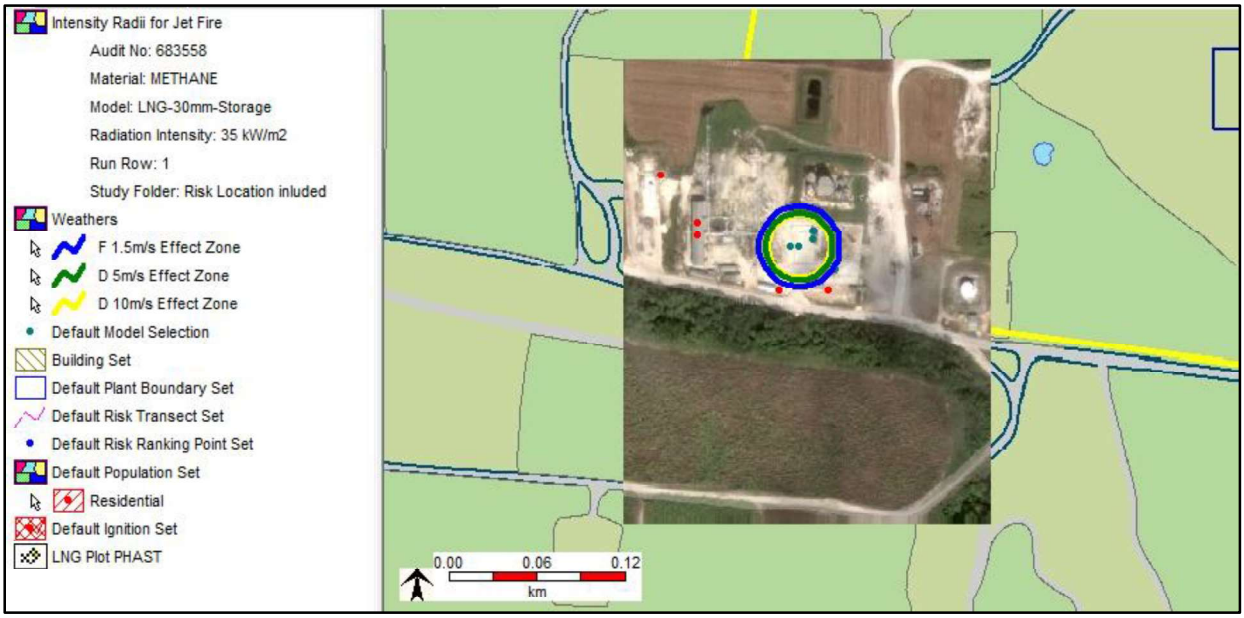

Figure C1- Flash fire of LNG Storage 30 mm hole size

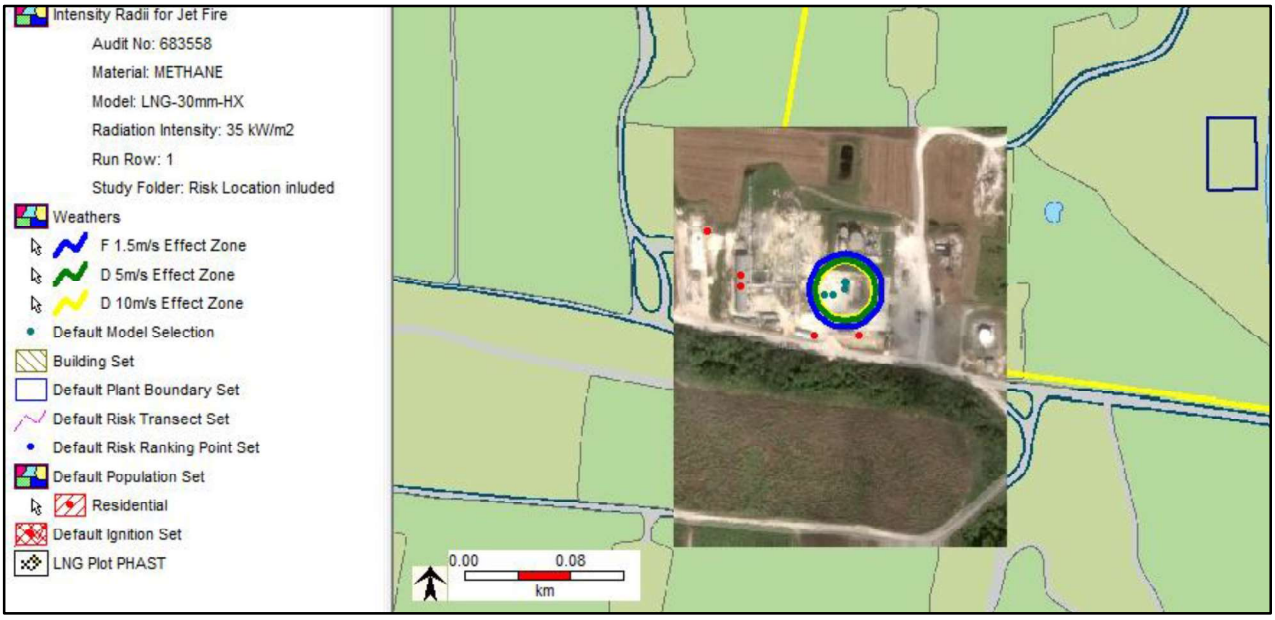

Figure C2- Flash fire of LNG Vaporizer 30 mm hole size

Figure C3- Flash fire of LNG metering 30 mm hole size

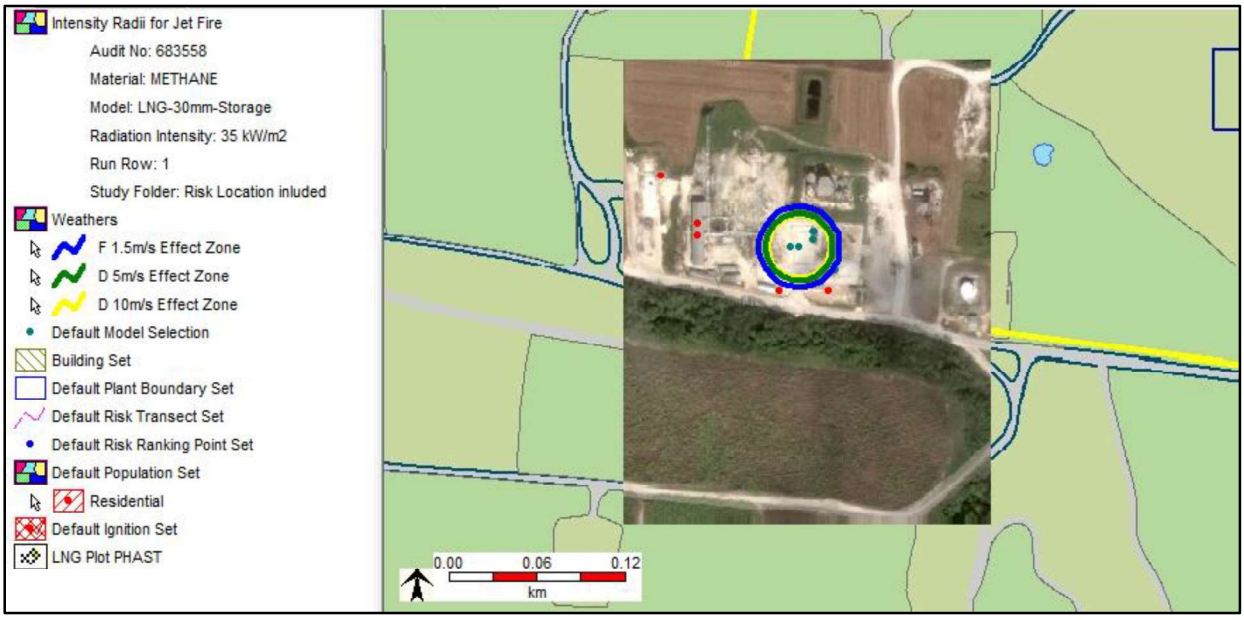

Figure C4- Jet fire radiation of LNG storage 30 mm hole size

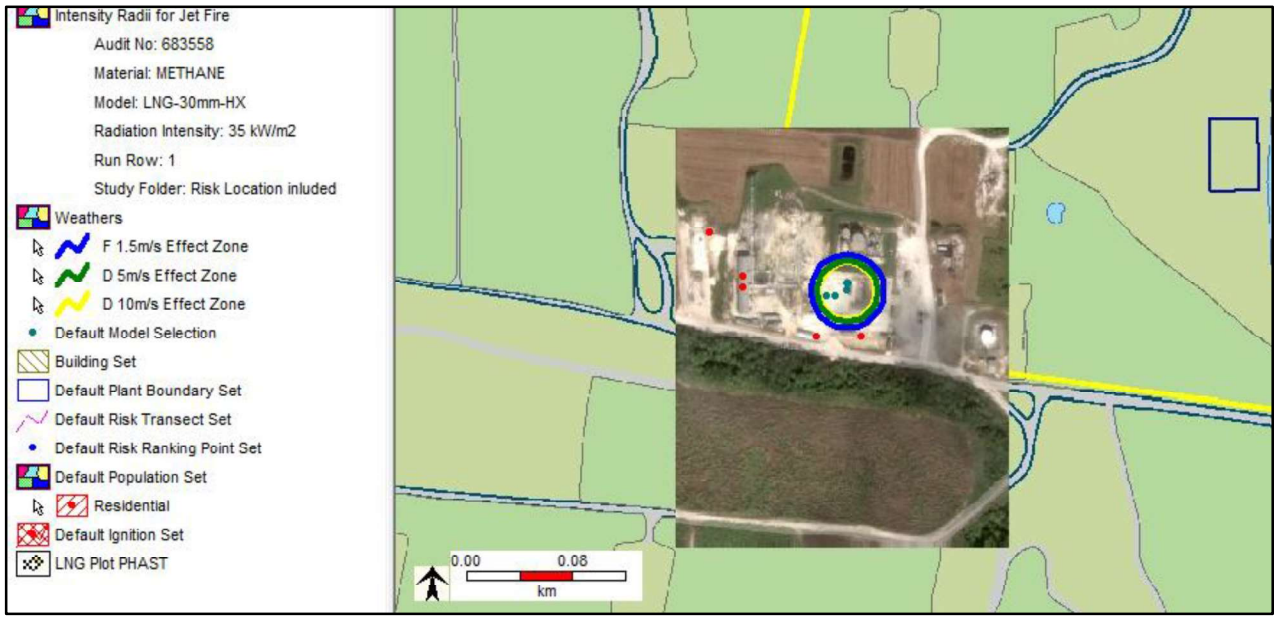

Figure C5- Jet fire radiation of LNG Vaporizer 30 mm hole size

APPENDIX 4: HAZARD IDENTIFICATION (HAZID) FOR BNOCL LNG PLANT

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Hazards Identification (HAZID) for Barbados National Oil Company Limited (BNOCL) LNG Satellite Plant

Tittle:	Hazard Identification (HAZID)
Emission for:	Review and Approval
Doc. No:	BNOCL-PRO-HZID-201603-1001
Revision:	2
Date:	March 03, 2016

Made	Review	Approved
JRA	FM	FM

TRACKS CHANGES

Rev.	Date	Author	Affected Section	Change Reason
0	10.February.2016	JRA	All	Initial Document
1	20.February.2016	JRA	All	Wide Review
2	25.February.2016	JRA	All	Final Review

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Contents

1. INTRODUCTION

The purpose of this document is to identify hazards using the Hazards Identifications technique (HAZID) related with the operation of the LNG Satellite Plant (LNG-SP) of the BNOCL Project in Barbados. At the same time, to assess the level of risk associated with the storage, handling, process and delivery of natural gas (NG) to serve the company utility grid using the following equipment:

- 2 storage tanks (ISO containers) with a rated capacity of 43 M^3 of LNG, provided by the client (combination of 1 or 2 ISO TNK)
- Regas system with a net gasification capacity of 40K standard cubic feet per hour [(SCFH), approximately 40 million of British Thermal Units (40 MBTU)]
- Natural gas at nearly 8.27 BARG (120 psig) at grid Tie-in
- Natural gas at nearly 17°C of ambient temperature

A methodology that identifies hazards and assesses the risks associated with them is applied. Existing safeguards and barriers as well as measures that are deemed necessary to reduce the level of risk to a level As Low As Reasonably Practicable (ALARP) is likewise identified.

The potential hazards in such activities are:

- Reception of LNG via ISO container coming from the AES Import Terminal in the Dominican Republic or from elsewhere (entire container operation, no transfer process), with a nominal capacity of 45 M^3 and a working pressure estimated between 8-10 BARG and temperature ranging between -150°C and -160°C.
- Flammability ranges in proportion 5-15% by volume in air, qualities that approximate these operational parameters to cause susceptibility with three undesirable phenomena:
    - Fire if an ignition source is present during a leak
    - Deflagration (subsonic explosion, less than the speed of sound)
    - Explosion or Detonation (Sonic explosion, greater than the speed of sound)
- LNG storage in ISO container at nearly 7 BARG (no transfer operation from trailer to ISO Tank will take place)
- LNG transfer process via hoses
- Regas process using ambient vaporizer
- NG metering
- NG pressure regulation

LNG and NG require the adoption of special measures to protect:

- *The facility*: Associated with Asset protection as an integral part of the Loss Control Program (LCP) in the Integrated Management System (SIG).
- *The employees*: Associated with Human Loss Control as an integral part of the LCP (zero Loss Time Accidents "LTAs" or fatality) in the SIG.
- *The populations and facilities around*: Associated with Asset and Environment protection as an integral part of the LCP in the SIG.

Integrated Management System or SIG comprises of the main three topics in today modern organization:

- Health
- Safety and
- Environment

Risks must be keep under control within the perimeter of the LNG-SP.

Risk scenarios and possibilities of response, always trying to control, contain, confine and limit the event, and mitigating its effects to the highest possible extent.

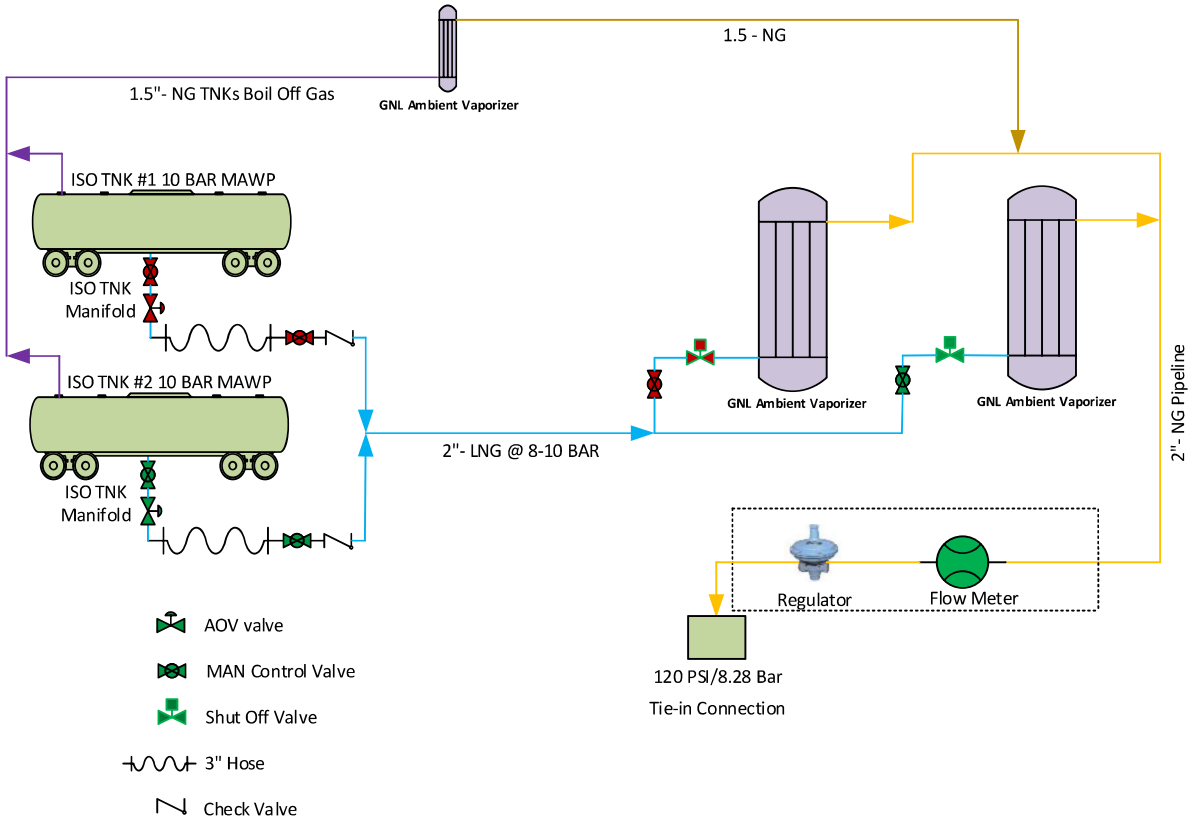
2. DESCRIPTION

The project consists of an installation to produce NG from LNG using ISO containers and ambient vaporizers at nearly 120 psig and 17°C.

The summary of NG production process is as follows:

- LNG is transported from the Dominican Republic using ISO tanks at pressure and temperature described.
- LNG is transferred from ISO tanks to the system via hoses by mean of a suit piping arrangement.
- Ambient vaporizer turns LNG to NG by mean of heat gain
- NG is measured
- NG enter the regulation station (single in line regulator)
- At the battery limit (Tie-in): NG is send at rated pressure and temperature to a pipeline that connect with utility grid.

2.1 LNG plant schematic Process Flow Diagram (PFD)



3. OBJETIVES

Identify and assess potential hazards in the following areas, referred to as operational nodes of the process:

- Storage in ISO container at nearly 7 BARG
- LNG transfer via hoses
- Regas process using ambient vaporizer
- NG metering
- NG pressure regulation

Identify for each potential hazard based on its criticality and the likelihood, mitigation measures necessary to achieve an acceptable level of risk (ALARP). The designation of mitigation associated with the identification of hazards is defined as Hazard Operability technique (HAZOP), not covered in this part of the HAZID. The HAZID technique approaches the risks associated with a process from a prescriptive perspective.

4. METHODOLOGY

First it is to identify and assess the potential risks associated with the different areas of the LNG SP and in particular those which may affect the surrounding population:

- Storage in ISO container
- LNG transfer via hoses
- Regas process using ambient vaporizer
- NG metering
- NG pressure regulation

4.1 Activities during the risk identification process:

- Hazards are identified
- Causes that may lead to them are identified
- Implications or impact are identified
- Existing protection measures are identified
- Risk mitigation measures are identified
- Identified risks are mitigated (proposal to mitigate)

5. SUMMARY OF RISKS

Depending on its phase, liquid or gas; natural gas by its intrinsic characteristics is a dangerous substance that may lead to one or several of the following scenarios:

- As LNG may cause cold burn and asphyxiation in the present of a leak or vapor cloud.
- As NG in proportion to 5-15% by volume in air may be ignited if an ignition source is present.
- Depending on the level of pressure, may cause deflagration, explosion or detonation.

5.1 Scenarios

5.1.1 LNG leak

Failure or breakage hoses, valves, flanges, pipelines and/or fittings in the reception area, transfer line and process area, including the ISO tanks. The following should be identified and quantified:

- Vapor cloud dispersion (Covered in QRA)
- Ignition source in the surrounding must be eliminated "*area classification*" (examine the site by Class and Division so that the electrical appliance being used are classified according to it (intrinsically safe, flame or explosion proof)
- Special procedures must be established to handle any LNG

leak. Depending on the case, an Emergency Shutdown or ESD might be necessary.
- Inspection and maintenance plan must be stablished
- Emergency response procedures must be established
- Area must be labeled with warning sign

5.1.2 NG leakage

Failure or breakage valves, flanges, pipes and/or fittings in the process area (vaporizer, regulation, metering).

Accidental NG leak can cause damage to person and become a fire hazard. The following should be identified and quantified:

- All necessary measures during detailed design must be taken in order to reduce the level of risk associated with this event.
- Training in LNG and NG handling. This cover spill, leakages, fire scenarios and emergency response. A clear understanding of the products safety information is very important; it means that a Material Safety Data Sheet (MSDS) must be in place for all the products being handled in the facility.
- On site and local fire brigades must keep a two-way communication path in the case of a major event.

5.1.3 LNG and NG fire

LNG and GN fires pose high risk. Therefore, it is necessary that protection systems be designed considering that level involved. In case of fire, special precautions need to be taken to avoid hazard to personnel and property due to radiation exposure. The following should identified and quantified:

- In place Prepared Mitigation Procedures
- Suitable training to personnel to reduce and mitigate any type of event by using right tools and Personal Protective Equipment (PPEs).
- Involve local emergency services, which should be contained in the Emergency Response Plan (Pre-Planning for Emergency Incidents Response).

5.1.4 Force majeure event

In case of a force majeure event; GasEner highly recommend to follow the property owner emergency plan and procedures. Among those phenomena might be found:

- Hurricanes
- Earthquakes
- Tsunami

- Floods
- forest fire
- Terrorism actions

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TABLE # 1[1]: RISK IDENTIFICATION ANALYSIS AND MITIGATION MEASURES (PRESCRIPTIVE)

ID	HAZARD OR RISK	CAUSE	POSSIBLE CONSEQUENCE	MITIGATION MEASURE
1.0	**LNG Transfer**			
1.1	Breakdown/failure in LNG transfer hoses, connecting flanges, valves and fittings	Wear out component, flanges failure, grounding system, corrosion effect, vandalism impact action	LNG leaks, fire risk, personnel and property damage	Condition review: ○ Ultrasonic analysis ○ Routine checks ○ Appropriate Operational and Maintenance procedures ○ Grounding system Fire and Gas (F&G) system requirement. Pressure test as per ASME B31.3. Industry best operation practice.
1.2	Process piping (vaporizers inlet line), valves, fittings and accessories leak	Leakage in ISO container access elements (main valves, instrumentation and control and relief valves)	LNG leaks, fire risk, personnel and property damage	Risk Based Inspection Model. As a minimum requirement it may apply: ○ Asset identification. Supplier, test, commissioning and operation details, maintenance records ○ Condition review: Valves maintenance program ○ F&G system requirement
1.3	Access valve accidental opening or closing (ISO or vaporizer inlet valves)	Main valve element failure or gas, nitrogen or instrument air pressure drop,	LNG leaks, fire risk, personnel and property damage	Valves maintenance program, operating pressure source routine checks, establish a "Lock Out-Tag Out, LOTO" program during maintenance. Human Machine Interface (HMI) or Panel View monitoring.
2.0	**Storage in ISO container**			
2.1	Breakdown/failure in transfer hoses and transfer manifold connecting flanges, valves and fittings	Equipment and/or accessory failure	LNG leaks, cold vapor venting, fire risk, personnel and property damage	Follow manufacture Operation and Maintenance program best practice. Fire and Gas (F&G) system requirement. Human Machine Interface (HMI) or Panel View monitoring. Close Circuit Television (CCTV) system.
3.0	**Transportation equipment and maneuvering**			

[1] Some of the items listed here, by the moment do not apply to BNOCL LNG Plant, even though, GasEner considered the inclusion of them as a general reference. With some of the process enhancements being proposed, those few items will be covered.

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ID	HAZARD OR RISK	CAUSE	POSSIBLE CONSEQUENCE	MITIGATION MEASURE
3.1	Trailer accident maneuver or misoperation (drive scale and ISO TNK)	insufficient lighting	Human induced errors	Provision of adequate maneuvering space and lighting in circulating areas.
3.2	Excessive hours of work	Fatigue/Tiredness	Human induced errors	Carrying detailed working time of each driver /operator record. No more than 12 hours in a day, with no more than seven hours without a break of 1½ hours. Allow at least 8 hours of rest between workdays. No more than three day straight runs (36 hours without rest). According to the Occupational Safety and Health Administration (OSHA), if it is necessary to extend a worker for some circumstances a day up to 16 hours, it requires a day of rest automatic (next to the day).
3.3	Fire in ISO/Trailer	Breakdown/failure in transfer hoses and transfer manifold connecting flanges, valves and fittings	LNG leaks, cold vapor venting, fire risk, personnel and property damage	Notify immediately the local Emergency Response Authority. If necessary, evacuate the area. Passive fire protection system (fire Wall or barrier rated at no less than 2 hours fire resistance rating or as quantified in a Quantitative Risk Assessment (QRA).
3.4	Transfer hose failure	Deterioration and breakage in hose	Ignition follow by fire	Follow manufacturer Operational and Maintenance program. Periodic inspections. Replacement program: ○ Based on manufacturing time ○ Operational equivalents hours (Net Operating Hours-NOH). ○ Accidental impact or visible structural damage
4.0	**LNG Regas Process**			

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ID	HAZARD OR RISK	CAUSE	POSSIBLE CONSEQUENCE	MITIGATION MEASURE
4.1	Breakdown/failure in main process sendout lines (ISO TNK #1 and ISO TNK # 2) LNG common header, Switch Stand Manifold, connecting flanges, valves and fittings	Wear out component, flanges and valves failure, grounding system, corrosion effect, relief valves, vandalism impact action	LNG leaks, cold vapor venting, fire risk, personnel and property damage	Condition review: ○ Ultrasonic analysis ○ Routine checks ○ Operational and Maintenance procedures ○ Grounding system Fire and Gas (F&G) system requirement. Pressure test as per ASME B31.3. Industry best operation practice.
4.2	LNG Vaporizers failure	Wear out component, corrosion effect, relief valves), vandalism impact action	LNG leaks, cold vapor venting, fire risk, personnel and property damage	Follow manufacturer Operational and Maintenance program. Periodic inspections. Operational redundancy Replacement program: ○ Based on manufacturing time ○ Operational equivalents hours (Net Operating Hours-NOH).
5.0	**NG pressure regulation station (single in line regulator)**			
5.1	Breakdown/failure in main regulators, valves, connecting flanges and fittings	Elements failure in regulator, valves, instrumentation and control and relief valves	NG leakage, fire risk, personnel and property damage	Follow manufacturer Operational and Maintenance program. Periodic inspections. Replacement program: ○ Based on manufacturing time ○ Operational equivalents hours (Net Operating Hours-NOH).
6.0	**NG Metering station**			
6.1	Breakdown/failure in main meter, valves, connecting flanges and fittings	Elements failure in meter, valves, instrumentation and control and relief valves	NG leakage, fire risk, personnel and property damage	Follow manufacturer Operational and Maintenance program. Periodic inspections. Replacement program: ○ Based on manufacturing time ○ Operational equivalents hours (Net Operating Hours-NOH).
7.0	**Instrument air Compressors**			

ID	HAZARD OR RISK	CAUSE	POSSIBLE CONSEQUENCE	MITIGATION MEASURE
7.1	Electrical motor failure	Insulation problem, control and protection devices damage, poor maintenance	Process shutdown	Follow manufacturer Operational and Maintenance program. Operational redundancy (two equipment) Periodic inspections. Replacement program: ○ Based on manufacturing time ○ Operational equivalents hours (Net Operating Hours-NOH).
7.2	Compressor failure	Mechanical problem, poor maintenance	Process shutdown	Follow manufacturer Operational and Maintenance program. Periodic inspections. Operational redundancy (two equipment) Replacement program: ○ Based on manufacturing time ○ Operational equivalents hours (Net Operating Hours-NOH).
8.0	**F & G System**			
8.1	Sensors elements failure	Poor maintenance (lack of calibration program)	Process safety failure due to miss information (absence of accurate Detection, Notification and Alarm conditions)	Follow manufacturer Operational and Maintenance program. Periodic inspections. Replacement program: ○ Based on manufacturing time ○ Operational equivalents hours (Net Operating Hours-NOH).
8.2	Open wire failure	Poor maintenance	Process safety failure due to miss information (absence of accurate Detection, Notification and Alarm conditions)	Follow manufacturer Operational and Maintenance program. Periodic inspections. Replacement program: ○ Based on manufacturing time ○ Operational equivalents hours (Net Operating Hours-NOH).

ID	HAZARD OR RISK	CAUSE	POSSIBLE CONSEQUENCE	MITIGATION MEASURE
8.3	Notification elements failure (beacons and horns)	Poor maintenance, output bulb or coils burn out	Process safety failure due to miss information (absence of accurate Detection, Notification and Alarm conditions)	Follow manufacturer Operational and Maintenance program. Periodic inspections. Replacement program: ○ Based on manufacturing time ○ Operational equivalents hours (Net Operating Hours-NOH).
8.4	Misoperation (malfunctioning)	Poor maintenance (lack of calibration)	Process safety failure due to miss information (absence of accurate Detection, Notification and Alarm conditions)	Follow manufacturer Operational and Maintenance program. Periodic inspections. Replacement program: ○ Based on manufacturing time ○ Operational equivalents hours (Net Operating Hours-NOH).
9.0	**Operation**			
9.1	System components NOT responding	Misoperation (operational procedures not being followed). Instrument air pressure too low	Process Shutdown	Follow manufacturer Operational and Maintenance program Follow operational manual Follow interlock manual
9.2	Miss/false reading	Instrumentation lack of maintenance/calibration program	Process safety failure, followed by a process shutdown	Follow manufacturer Operational and Maintenance program. Periodic inspections. Replacement program: ○ Based on manufacturing time ○ Operational equivalents hours (Net Operating Hours-NOH).
10.0	**Control System**			

ID	HAZARD OR RISK	CAUSE	POSSIBLE CONSEQUENCE	MITIGATION MEASURE
10.1	PLC Failure	Lack of maintenance (inappropriate operating surrounding)	Process safety failure, followed by a process shutdown	Follow manufacturer Operational and Maintenance program. Periodic inspections. Operational redundancy (hot standby system or a Remote Terminal Unit (RTU) backup) Replacement program: ○ Based on manufacturing time ○ Operational equivalents hours (Net Operating Hours-NOH).
11.0	**Electrical System**			
11.1	Power failure	Power plant, main feeder or protection and control devices damage	Process safety failure, followed by a process shutdown System shutdown	Follow manufacturer Operational and Maintenance program. Periodic inspections. Alternate back up power Replacement program: ○ Based on manufacturing time ○ Operational equivalents hours (Net Operating Hours-NOH).
12.0	**Fire Protection System**			
12.1	Water source NOT available	Operational or force majeure problem	Process safety failure, followed by a process shutdown, risk to personnel and property	Follow manufacturer Operational and Maintenance program. Periodic inspections. Replacement program: ○ Based on manufacturing time ○ Operational equivalents hours (Net Operating Hours-NOH).
12.2	Pump failure	Mechanical problem Poor maintenance	Process safety failure, followed by a process shutdown, risk to personnel and property	Follow manufacturer Operational and Maintenance program. Periodic inspections. Operational redundancy Replacement program: ○ Based on manufacturing time ○ Operational equivalents hours (Net Operating Hours-NOH).

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ID	HAZARD OR RISK	CAUSE	POSSIBLE CONSEQUENCE	MITIGATION MEASURE
12.3	Diesel fuel failure (if the case)	Internal combustion engine problem or fuel shortage (runout).	Process safety failure, followed by a process shutdown, risk to personnel and property	Follow manufacturer Operational and Maintenance program. Periodic inspections. Operational redundancy: Redundant fire pump (electric) depending on requirements of Emergency Supply Power Protection Systems (ESPPS) according to Articles 700, 701 and 702 of the NEC-2014 (National Electric Code), Replacement program: ○ Based on manufacturing time ○ Operational equivalents hours (Net Operating Hours-NOH).
12.4	Power failure (electrical if the case)	Power plant, main feeder or protection and control devices damage	Process safety failure, followed by a process system shutdown	Follow manufacturer Operational and Maintenance program. Periodic inspections. Replacement program: ○ Based on manufacturing time ○ Operational equivalents hours (Net Operating Hours-NOH) Redundant fire pump (diesel fuel) with a capacity of at least 8 hours reserve fuel, depending on requirements of Emergency Supply Power Protection Systems (ESPPS) according to Articles 700, 701 and 702 of the NEC (National Electric Code), NFPA 110 (Emergency and Standby Power System); and Section 15 NFPA handbook (Water supply for Fixed Fire Protection).
12.5	FM and UL certified pump (Unique diesel pump failure if the case)	Internal combustion engine problem or fuel shortage (run out).	Process safety failure, followed by a process shutdown, risk to personnel and property	Follow manufacturer Operational and Maintenance program. Periodic inspections. Operational redundancy: NOT necessary if the pump is rated and certified FM and UL. Replacement program: ○ Based on manufacturing time ○ Operational equivalents hours (Net Operating Hours-NOH).

ID	HAZARD OR RISK	CAUSE	POSSIBLE CONSEQUENCE	MITIGATION MEASURE
12.6	Dry powder and CO2 extinguishing system failure	Poor maintenance	Process integrity failure due to fire and not being able to response	Follow manufacturer Operational and Maintenance program. Periodic inspections. Operational redundancy Replacement program: ○ Based on manufacturing time ○ Operational equivalents hours (Net Operating Hours-NOH). Accidental impact or visible structural damage
13.0	**Personnel**			
13.1	Operator fatigue	Fatigue/Tiredness	Human induced fails	Perform downloads operation during the day as long as possible, and always have a redundant operator, and supervisor.
13.2	Lack of supervision	Human error	Operative failure not detected in time by the absence of the Operator and/or Supervisor	Maintain at least one Shift supervisor and one operator per shift, or as stated by the company police.
13.3	Personal Protective Equipment (PPE) not being used	Lack of stock or PPE in bad condition	Personal injury, LTAs, Fatality	Maintain PPE in good condition Make sure personnel is trained on using PPE Follow SIG policy
13.4	Alcohol and Drug	Human behavior	Personal injury, LTAs, Fatality	Follow SIG policy

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APPENDIX 5: OPERATIONAL AND PROCESS SAFETY RECOMMENDATION

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OPERATIONAL AND PROCESS SAFETY RECOMMENDATION

Operational and process safety is key to guarantee the plant integrity and mission continuity. The levels for Individual and Societal Risk appear to be low, it means that BNOCL, as found and the recommended for it to be enhanced, is considered to be a safety industrial site. In the manual operation mode of the facility, a few weak points were determined. Based on present condition, manual operation mode of the facility and experience derived from the Oil and Gas industry; a few key topics might be pointed to be taken into consideration:

- Besides the LNG Satellite Plant operation control room; a remote monitoring and/or control point with a redundant communication system is usually recommended.
- The control, communication shall be equipped with two power sources. The electrical system has to be designed according to areas classification.
- Each vaporizer or group of vaporizer has to be equipped with a remote activated Shut Off Valve (ESDV).
- A manual or automatic pump to remove rain water from the dike containment has to be installed.
- Consideration to furnished the operation control room with positive pressure and the provision an elevated air intake with a gas sensor is recommended.
- The system control Programmable Logic Controller (PLC) has to be listed UL/FM. Taking into consideration the size of the facility; an instrumented independent PLC for the Safety Instrumented System (SIS) may not be necessary.
- A grounding system in the LNG transfer area need to be installed. An interlock system may be provided to stop cargo transfer if the grounding system fail/disconnect.
- A low temperature indicator/interlock is recommended at the vaporizers out let. Downstream gas metering piping is not usually suited for cryogenic loads, it means that under certain value, the system should alarm and stop gas send out if the temperature limit setting is reached.
- Overflow protection by mean of pressure setting is necessary at vaporizer outlet. After the plant is set to normal operation; the overflow protection indicates that an open flange or piping section is present.
- Vaporizers inlet line has to be furnished with Pressure Safety Valves (PSV)
- A piping arrangement and hoses draining system is mandatory. It will allow for hoses safety connection/disconnection.
- An Emergency Shut Down (ESD) system is mandatory

BNOCL LNG PLANT GOOD OPERATIONAL PRACTICE

- Control process variable and alarms system
- Maintain the level of fluid containment in vessels, equipment and piping via adequate corrosion allowance limits
- Control over pressure in the process system via adequate pressure safety valves
- Control all ignition source under control inside the plant. Naked light, open flame or other activities that may generate an ignition source have to be strictly prohibited. Facility entrance with portable cell phones, cameras and other none approved electronics devices is not permitted. Any of the above mentioned equipment have to be listed (intrinsically safe or explosion proof).
- Emergency Shut Down with different drive level is requested.
- Ensure the safety instrumented system including the ESD valves (may not be required for BNOCL LNG Plant)
- Stablish and maintain a preventive inspection maintenance on site, specially to the control and F&G system.
- Exercise periodic test as per manufacturer recommendation to all system in the plant. Special attention should be given to manual valves, F&G system and to the pressure safety and relief system.
- Implement an integrity program to all equipment in the facility

APPENDIX 6: FIRE PROTECTION RECOMMENDATION

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FIRE PROTECTION RECOMMENDATION

At no point fire protection in a plant is something you want to use. Nevertheless, it is required to have the system on site and functional than requiring it under an emergency and not having it available. The FRA study was meant to assess risk, which were found to be at a low level. Even though, the following fire protection measure and equipment may be required.

- LNG spill to be collected in suited containment area with appropriate low temperature detection (part of the F&G System).
- LNG primary and secondary containment areas. All containment areas are supposed to be designed according to NFPA 59A, Art. 5.3.2.
- If concrete is used, it should be capable to withstand the effects of the LNG low temperatures due to spills, and the effects of high temperatures due to fires.
- A F&G system with the capability to detect, alarm and notify shall be in place
- Fire wall between tanks is not mandatory, for the LNG Satellite plant was considered as an entire compact system (all five possible hazard scenarios were considered to be a single Isolated Process Segment-ISP). Even though, it is management option to build this extra level of protection if so wished.
- Lightning protection as part of the electrical system is required
- Fire and Gas (F&G) system with visual and audible alarms with the possibility to detect heat, cold temperature and gas leak is mandatory to be in place as per NFPA 59A, Art. 12.4.
- Water spray protection according to Density/Area Curves of NFPA 13 based on "*Hazard Locations*". For LNG, taking into consideration its vapor pressure, flashpoint, and specific gravity; the density may vary between 0.2 gpm/ft2 and 0.5 gpm/ft2 (8.1 to 20.4 L/min/m2).
- In the case of BNOCL, for exposure protection of vessels and equipment cooling, a density of 0.25 gpm/ft^2 (10.2 L/min/m^2) should provide sufficient cooling to limit an exposure fire's heat input to the vessels walls. Fire monitors with the characteristics of providing a requested cooling flow between 250-500 gpm/min are required.
- The crude oil tanks are not part of this study, but radiation effects on anyone of the side will affect the other. This makes a water curtain between the LNG plant and the crude oil tanks farm being necessary.
- Water requirement as per NFPA 59A, Art. 12.5. Sometime the water requirement might be difficult to obtain, in that case, a compensation with dry chemicals may be required according to the LNG storage capacity.
- Fire protection system with redundant fire pump and availability of water as stated by NFPA 59A is mandatory. In the case of the water based fire protection, a single listed FM/UL fire pump may be enough.
- Suited portable, stationary and wheeled type fire extinguishers are necessary around the transfer and process area. In the plant control room and the fire extinguisher must be clean agent.

- According to hazard area for BNOCL LNG plant, location of at least 2 portable fire extinguisher of 30 pounds (13.6kg) around the transfer area (one near each container), at least two wheeled type 150 pound (68kg) with hose reels and a 500 pound (227 kg) skid mount with hose reels. The 500 pound (227 kg) may be substitute by the equivalent using wheeled units.
- Control room and motor control center (MCC) must be furnished with clean agent or equivalent. 20 pound (9.1 kg) Carbon dioxide (CO_2) self-expelling unit is recommended.
- Since the impoundment area is very near the vaporizers and transfer area, it is expected that a worst case scenario (an entire container) the radiant heat flux (kW/m^2) will affect process equipment, including stationary ISO containers.

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APPENDIX D ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN




Prepared For:

Inter-American Development Bank

LNG RE-GASIFICATION PLANT EXPANSION
Environmental and Social Management Plan
Woodbourne, St. Patrick Barbados

August 2016

Environmental Resources Management (ERM)
1776 I St, Suite 200
Washington, DC 20006

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LIST OF ACRONYMS

BNOCL	Barbados National Oil Company Limited
EA	Environmental Assessment
EHS	Environmental, Health, and Safety
ESCR	Environmental and Social Compliance Report
BNOCL	Barbados National Oil Company Limited
ESMP	Environmental and Social Management Plan
ESR	Environmental and Social Responsibility
HSSE	Health, Safety, Security, and Environment
HSSEO	Health, Safety, Security, and Environment Officer
Km	Kilometers
LNG	Liquefied Natural Gas
Mcfpd	Thousand cubic feet per day
NFPA	National Fire Protection Association
NG	Natural Gas
NPC	National Petroleum Corporation
SCADA	Supervisory Control and Data Acquisition

1.0 OBJECTIVE AND SCOPE

1.1 OBJECTIVE OF THIS ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

This Environmental and Social Management Plan (ESMP) establishes the framework for the proper implementation of mitigation measures during the construction and operation of the proposed Woodbourne Liquefied Natural Gas (LNG) Re-gasification Expansion Project. This Plan will guide National Petroleum Corporation (NPC) and its contractor to manage, mitigate, and avoid adverse effects to environmental and social receptors located within the Project area of influence.

1.2 BACKGROUND AND DESCRIPTION OF THE PROJECT

The National Petroleum Corporation (NPC) and the Barbados National Oil Company Limited (BNOCL) are evaluating various strategies/options to manage the shortfall in NG supply particularly during the Christmas season — a critical period for the tourism sector. To manage the NG shortfall, in the short-term, NPC is contemplating the expansion of the existing BNOCL LNG regasification plant, commissioned in December 2015, located near Woodbourne, Saint Philip, in the Parish of Christ Church, Barbados.

The existing plant re-gasifies liquefied gas to NG and has the capacity to receive three iso-containers simultaneously. Iso-containers are 40 feet long, with the capacity to hold approximately 9,000 gallons of LNG and are delivered to the plant via trucks from ships landed at the Bridgetown Port facility. The plant, located approximately 30 kilometers (km) from the Port, was built to meet the National Fire Protection Association (NFPA) standard 59A (standard for the production, storage, and handling of LNG). At the plant, LNG is re-gasified and processed to NG using ambient air vaporizers. The NG is injected into NPC's existing distribution system. Currently, this plant can handle three iso-containers per week with a capacity up to 460 thousand cubic feet per day (mcfpd).

The proposed Project contemplates the expansion and upgrades of the existing uploading LNG facility to increase the reception capacity of LNG iso-containers to seven, with a total capacity of 1 million mcfpd. The upgrades of the facility also include the installation of two storage LNG tanks (50,000 gallons each) and the construction of a new gas pipeline (6 inches in diameter) approximately 4 km long from a regulation station in Woodbourne to a connection near the Grantley Adams International Airport. All of the proposed upgrades to the

existing facility will be located within the existing plant footprint and no new land will be required or disturbed outside of the property. The pipeline will be installed within an existing pipeline rights-of-way corridor.

1.3 KEY IMPACTS

The proposed construction (expansion and upgrades) and operation of the LNG plan have the potential to affect the environmental and socioeconomics conditions of the project area. Potential negative impacts are negligible to minor, and include the following:

- Potential soil erosion during construction;
- Increase of dust and particulate emissions during construction;
- Noise during construction;
- Traffic disruption during construction (particularly, during construction of the NG pipeline);
- Risk of an accidental spill of LNG from storage tank rupture;
- Risk of an accidental spill of LNG from iso-container tank rupture during transportation from the port to the LNG facility; and
- Fire hazard.

The Environmental Assessment (EA) for the Project determined that the proposed expansion is not expected to have impacts on flora or fauna or cultural resources in the project area.

2.0 ENVIRONMENTAL POLICY, ORGANIZATION, AND RESPONSIBILITIES

2.1 ENVIRONMENTAL POLICY

BONCL's environmental, health and safety policy (http://www.bnocl.com/index.php?option=com_content&view=article&id=22&Itemid=34) states:

"*BNOCL is committed to sustainable development and to a healthy, safe and secure atmosphere forms the core of all their industrial activities. By implementing ergonomic solutions and reducing all risks within our work spaces and operating environments BNOCL ensure that the health, safety and welfare of their employees are optimized and recognize its linearity with maximum productivity.*

Cognizant of our responsibility to the environment and society within a sensitive operating environment; BNOCL engage in activities which reduce environmental impacts ensued during daily operations and embrace their surrounding community.

Therefore as good corporate citizens BNOCL recognize the importance of maintaining high health, safety, security and environmental standards.

These industrial standards are maintained through the following initiatives:

- *The implementation of a water quality monitoring program in 1997, in conjunction with the Barbados Water Authority and the Environmental Protection Department to ensure that the quality of the potable water extracted within the environs of our oilfields is maintained at the highest possible standards at all times.*

- *We also work closely with the Solid Waste Project Unit and other relevant authorities to eliminate indiscriminate dumping of garbage and construction waste within the environs of the oilfields. BNOCL also ensure that all obsolete chemicals are disposed of in accordance with the stipulations of the Environmental Protection Department.*

- *BNOCL encourage reuse and recycling of used materials at all levels of the operations.*

- *The safety of their employees, along with our company's integrity, is of great importance to us. Thus, health and safety training for their staff is conducted annually both in-house and off site to ensure that they are made aware of the workplace health, safety and environmental issues and standards.*

- *The company has formed and Environmental, Social, and Health and Safety (ESHS) committee which ensures employee contribution in the development of ESHS plans, policies, standards and guidelines.*

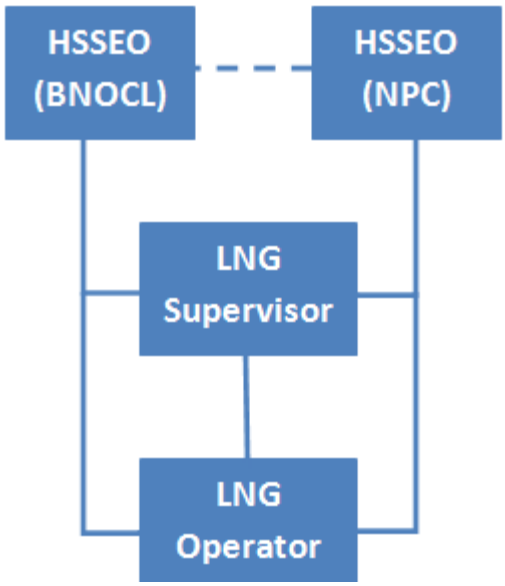
- *In light of the global and local energy challenges, we have been proactive in drafting a Business Energy Policy.*

- *BNOCL have engaged Guardsman Security to patrol and oversee the industrial site and fields 24/7.*

- *BNOCL maintain strong and viable relationships with all regulatory bodies to ensure that national and international requirements are met.*"

2.2 *LNG PLANT ENVIRONMENTAL, HEALTH, AND SAFETY (EHS) ORGANIZATION AND RESPONSIBILITIES*

The LNG Plant environmental, health, and safety (EHS) organization and responsibilities organigram is presented below:



Key:

HSSEO = Health, Safety, Security, & Environmental Officer

The proposed LNG Regasification plant expansion will be located within an existing BNOCL plant facility in Woodbourne and as a result must follow the general environmental, health, and safety (EHS) guidelines put in place by BNOCL. To this end, the plant will be overseen by the health, safety, security, and environment (HSSE) Officer from BNOCL; however, because currently the plant is operated by NPC and the entire process is new to BNOCL, all of the

procedures including emergency and EHS were developed and implemented by the NPC HSSE Officer. The developed procedures were shared with BNOCL HSSEO and incorporated and/or adjusted to comply with the existing BNOCL guidelines to ensure everyone was operating on the same level.

The NPC's EHS officer, together with the LNG Supervisor and Operator has the responsibilities of managing the EHS activities at the plant. Their responsibilities include:

- Ensure that all environmental, health, and safety policies and procedures are followed at the Plant.
- Ensure all personnel are trained in EHS and emergency response procedures.
- Ensure all safety equipment is inspected, tested, and calibrated according to the manufacturer's recommendations.

The day-to-day compliance with EHS policies and procedures at the Plant are under the responsibility of the LNG Plant Operator, who is also responsible for:

- Verify that all plant operations (e.g., truck unloading and regasification) are performed in compliance with environmental, health, and safety requirements.
- Inform all visitors and contractors of the evacuation routes and location of the meeting point.
- Determine the immediate response to any emergency.
- The LNG Operator may initiate the Emergency Shutdown Device; notify local authorities (Fire Service/Royal Barbados Police Force); and order a site evacuation.
- Comply with plant operation and health and safety requirements at all times.
- Ensure that the operational parameters for the plant process and equipment are within acceptable limits, taking remedial action when necessary.
- Ensure all data from monitoring equipment, including chart recorders and the supervisory control and data acquisition (SCADA) interface, is recorded and retained, and that readings are taken at appropriate intervals.
- Verify the operational status of and maintain all monitoring devices to ensure accuracy, and notify appropriate personnel should remedial action be necessary.
- Monitor the computer and the SCADA system for trends and alarms, responding to the same as necessary.
- Ensure proper operation of process equipment, including compressors and vaporizers, and liaise with the liquefied petroleum gas Plant

Operations as required to effectively regulate and optimize natural gas pressures and flow rates.
- Minimize the flaring of gas and plant downtime.
- Carry out basic repairs to controllers, valves and other process, control and monitoring equipment as per training.
- Assist designated maintenance personnel with repairs to all equipment in the plant.
- Keep the general surroundings free of combustibles and impoundment areas free of water.
- Perform visual and other inspections of equipment and piping as required by the operating plan to verify and ensure compliance with relevant safety standards.
- Maintain and test standby power and other back-up systems as set out in the operating plan.
- Liaise with the Production and Gas Plant arms of BNOCL and the National Petroleum Corporation to maintain an efficient supply of natural gas.
- Record all plant operational activities in the appropriate log.

The current organization effectively covers both the operational and EHS aspects of the plant construction and operation.

2.3 PROJECT CONSTRUCTION STRUCTURE

NPC/BNOCL will self-perform the construction of the new truck parking bays and the installation of the LNG storage tanks. Specific contractors and suppliers may be engaged to conduct or assist with some activities. Any contractor that may be engaged in the project will have to meet NPC's EHS requirements, which also reflect local Barbados requirements and industry standards for this type of small operation. For the construction of the NG pipeline, NPC is planning to subcontract the installation of the pipeline and has developed a set of technical specifications, including EHS, emergency, and traffic management guidelines which will be part of the contract (see Appendix D (A)).

2.4 ENVIRONMENTAL, HEALTH, AND SAFETY TRAINING

As part of NPC's standard operating procedures, all NPC/BNOCL staff that performs activities related to the LNG Plant operation will be trained in EHS policies and procedures and emergency plan and procedures. The HSSE Officer is responsible to ensure that training is up-to-date for all pertinent personnel. The EHS training includes the following:

- Properties of LNG:
    - Cryogenic temperature and its effects on living tissue.
    - Flammability range.
    - Characteristics of fires involving LNG.
    - Personal Protective Equipment Usage.

- Characteristics of Iso-containers:
    - Safety features in the design to deal with.
    - Physical damage from blunt force trauma: vehicular accidents, ship loading, etc.
    - Warm weather temperature.
    - Fire: fire breaks valves.

- Emergency response:
    - How to handle spills/leaks.
    - Classification of emergencies into controllable and un-controllable incidents.
    - Communication during emergency.
    - Roles of National Emergency responders as well as BNOCL staff.

- Safety guidelines to be followed during operation:
    - For example: access control, personal protection equipment requirements, and gas monitoring.

In addition, all drivers used to transport the LNG are trained and qualified to transport LNG by undergoing and pass a training course specifically designed for LNG transport drivers. The training is in accordance with U.S. Department of Transportation guidelines (Code of Regulations Title 49 – Transportation). The training includes LNG Safety and Handling and includes the training of the Port Authority drivers handling the containers. Topics covered in the training include:

- Vehicle Preparation and Inspection
- Driver Rules and Qualifications
- LNG at the Dock
    - General Dock Safety
    - Personal Protection Equipment
- Offloading/Loading
    - Preparation
        - Engine
        - Brakes
        - Wheel chocks
    - Material Handling and Transfer

    - Transfer
    - Completing Transfer
    - Disconnection
    - Post Loading Inspection
- Transporting by Ground
    - Driving Skills
    - Basic Rules
    - Special Rules for LNG
    - Inclement Weather
    - Distribution, Delivery, Industrial Usage
- Iso-tank
    - Offloading
    - Connection of Full containers

3.0 ENVIRONMENTAL MANAGEMENT PROGRAM

3.1 MITIGATION MEASURES AND MANAGEMENT CONTROLS

Projects impacts are negligible to minor. Construction activities at the LNG Plant will be limited to the existing fenced perimeter and will include the installation of concrete pads for the truck parking bays and to support the LNG storage tanks, as well as the installation of ancillary equipment, such as hoses and fire prevention equipment.

The 4-km long and 6 inches in diameter NG pipeline will be installed within existing rights-of-way, mostly within the paved portion of existing roads. The construction will temporarily disrupt traffic.

The number of trucks traveling from the Port to the Plant will increase to seven per week.

The negligible to minor impacts of the Project will be mitigated and managed with the application of industry-standard best practices. Table 3-1 summarizes these best practices. Any contractor or supplier that may be involved in the Project will be required to incorporate the proposed mitigation measures and management controls within their own working procedures and plans.

TABLE 3-1 ENVIRONMENTAL MANAGEMENT PROGRAM – PROPOSED MITIGATION MEASURES AND MANAGEMENT CONTROLS

Impact	Phase/Resource	Source of the Impact	Recommended Mitigation/ Management Measure or embedded Control	Responsible to Execute
Physical				
Increase dust and particulate emissions	Construction and operation/ Climate and Air Quality	• Wheel generated dust/surface disturbance during operation of diesel powered earth-moving construction equipment (e.g. bulldozers, graders, excavators, cranes, dump trucks) at the construction site. • Fuel combustion emissions from exhausts of iso-container trucks transporting LNG from the port to the LNG facility. • Construction workers commute vehicles (or company bus) to and from site.	• Reschedule earthwork activities during periods of high wind if visible dust is blowing off-site. • Provide dust suppression as needed. • Ensure that all construction equipment is maintained in accordance with manufacturer's specifications. • Stabilize disturbed areas as soon as possible.	HSSE Officer/ LNG Plant Operator and any contractor.
Potential increase of soil erosion and sedimentation	Construction/ Geology, Topography, and Soils	• Grading and recontouring required for installation of the new infrastructure to ensure proper drainage and stability.	• Implementation of soil erosion, storm water runoff, and sedimentation control measures, such as silt fences.	HSSE Officer/LNG Plant Operator.
Increase sedimentation; soil and contamination from spills	Construction/ Hydrology	• Sedimentation from construction activities. • Contamination from accidental spills (e.g., fuel and lubricants if handled on site). • Pipeline construction/ replacement activities involving crossings of ephemeral streams or drainage structures.	• Implementation of improved and effective soil erosion, stormwater runoff, and sedimentation control measures. • Exercise controls for inspecting equipment and Implement a Spill Prevention and Countermeasures Plan (SPCC).	HSSE Officer/Plant Operator.
Increase noise levels	Construction and Operation/ Noise	• Operation of earth-moving construction equipment such as bulldozers, front-end loaders, or dump trucks. • Vehicular traffic during construction. • Truck traffic during operation.	• Ensure regular inspection and maintenance of all vehicles and construction equipment in accordance with manufacturer's specifications. • Ensure that all equipment operating at the facility are maintained and operate in accordance with manufactures' specifications. • During construction, spot check noise levels at the facility and nearby receptors. • Employ best available work practices on-site to minimize occupational noise levels. • Select truck routes for construction traffic entering and leaving the site to ensure noise levels at noise sensitive receptors are kept to a minimum.	HSSE Officer and any contractor or supplier that may participate in the project.

Impact	Phase/Resource	Source of the Impact	Recommended Mitigation/ Management Measure or embedded Control	Responsible to Execute

Fire and explosion	Operation/ LNG storage or iso-container tank failure risk	• Accidental spill of LNG from a tank rupture.
		• Accidental spill of LNG from an iso-container/tank accidental rupture from a traffic accident.
			LNG Tank Rupture
			• Plant designed with embedded layers of protection:
			  • **Sitting and design –** designed to meet international standards (e.g., NEPA 59A – distance requirements from LNG plant, materials resistant to the cryogenic temperatures, and equipment anchoring/grounding against high winds and electricity);
			  • **Control and Monitoring –** detection equipment throughout the site (methane and flame detectors as well as various other sensors to detect any leaks and wind monitoring to determine the direction any potential vapors);
			  • **Prevention –** audible and visual alarms as well as automatic emergency shutdown valves;
			  • **Protection –** impoundment pit to contain any spilled LNG (fire response equipment and vapor control equipment – foam and water curtains);
			  • **Plant emergency response –** trained operators to ensure rapid response; and
			  • **Community emergency response –** emergency plan shared with the emergency services.
			
			• *Iso-containers Rupture*
			  • All personnel hired to transport the containers have been trained to US Department of Transpiration standard for LNG drivers;
			  • The route has been selected to ensure that only major roads that can handled the size and weight of the iso-containers are travelled;
			  • The transport of the LNG containers from the Bridgetown Port to the LNG Terminal
				LHG Plant Operator.

Impact	Phase/Resource	Source of the Impact	Recommended Mitigation/ Management Measure or embedded Control	Responsible to Execute
			will occur in off-peak hours (between 23:00 and 05:00) as the vehicles are oversized. Each convoy will be escorted by an out-rider and the Royal Barbados Police Force shall be notified to facilitate road closures to ensure that no other road users can be impacted by the containers. • Iso-containers have built in safeguards to protect against roadside accidents (insulated and double walled, all valves are recessed within the confines of the container frame, valve cluster encased within a steel cabinet, and remote monitoring – pressure values can be monitored remotely to alert personnel to any issues prior to the container arrival).	
Fire and explosion	Operation/ Fire hazard risk	• Accident release of LNG – LNG is classified as highly flammable gas.	• Distance requirements stipulated by NEPA 59A provide a buffer around the re-gasification facility where no ignition sources are present (no ignition sources within 100 feet of storage tanks, e.g., liquid fuel storage, motors, highways, and unrated electrical appliances). • Large wheeled dry powder fire extinguisher units (350 pounds) stationed around the transfer bay. • Fire water system (30,000 gallons tank and pump) used to cool surrounding infrastructure in the event of a fire. • Foam blocks in the impoundment pits to provide constant passive response (does not require operator intervention.	LHG Plant Operator.
Potential LNG spills	Operation/ Natural Disasters	• Hurricanes and natural fires	• Storage tanks will be built to withstand hurricane force winds and earthquakes. • Natural vegetation fires (flame detectors also detect fires external to the plant and result in a shutdown of operation).	LHG Plant Operator.
Social				
Potential nuisance to	Construction/Operation	• Construction activities and truck traffic during operations	• Establish grievance mechanism (see Section 5)	HSSE Officer

Impact	Phase/Resource	Source of the Impact	Recommended Mitigation/ Management Measure or embedded Control	Responsible to Execute
local residents			• Establish maintenance of traffic measures during NG pipeline installation to minimize traffic disruption.	
Benefits to the local and national economy	Construction and operation/ Socioeconomic	• Project induced economic activity will result from contracting of materials and services during the construction and operations phases including mechanical equipment, piping, building materials, civil construction works; telecommunications equipment, and other materials. • Increase availability of natural gas for economic development. • Increase employment.	No additional mitigation measures are proposed.	Not Applicable

3.2 MONITORING AND EVALUATION

During construction, NPC will have an EHS Monitor on site to verify that construction activities are conducted in compliance with this ESMP and applicable regulatory requirements.

The EHS Monitor will observe and verify the following:

- Erosion control measures and their effectiveness.
- Noise levels (spot-checks).
- Dust generation.
- Health and safety procedures.

At the end of construction, NPC will provide the IDB with a concise report summarizing the EHS performance during construction, detailing any events that may have been out of compliance and how it was managed and resolved.

During operation, NPC will provide semi-annual Environmental and Social Compliance Reports (ESCR) to the IDB. The ESCR will be a concise document, addressing the main potential impacts and risks of the project:

- Physical environment: report any event related to the physical environment, such unanticipated atmospheric releases or high levels of noise.
- Occupational health and safety: discuss the occupational health and safety performance and detail any event or incident, its causes and consequences, an analysis of root causes, and measures taken to prevent similar events in the future.
- Community grievances: provide details of community grievances including list of grievances, how grievances were solved, list of any pending grievances, and root causes of grievances.

4.0 EMERGENCY PLAN

To respond to emergencies at the LNG plant, including spills from the rupture of a LNG tank at the plant or from the rupture of a LNG iso-container during the transportation from the port to the plant, BNOCL has developed an emergency response plan to handle and mitigate any emergency. The emergency response plan is included in the EA report as Appendix B.

5.0 COMMUNITY COMMUNICATIONS AND GRIEVANCE MECHANISM

As part of the normal operations of the LNG Plant, BNOCL currently notifies the neighboring communities of any planned works that may impact them detrimentally and there is a mechanism that allows the public to register any complaints they may have regarding the operations of BNOCL. NPC currently has a 24 hour hotline that is advertised to the public (430-4099 or 430-4000). This is used to report all natural gas related complaints, including damages or gas escapes. During normal operating hours (Monday – Friday 08:00 – 16:00), the calls are answered by NPC Customer Service Department. The complaint is then logged under NPC work order system for follow up by NPC Technical Department. When the work order has been executed, it is logged as completed and the work done outlined.

If the call is received outside of normal work hours, it is answered by NPC 24 hour guard company who then logs them in a Duty Fitter Job Card Book which is passed to the Duty Fitter (after hours on-call personnel) for investigation. At the beginning of the following normal work day all jobs logged and rectified by the Duty Fitter are given to the Foremen for logging in NPC work order system. Any remedial works conducted is also logged with the corresponding work order. If the customer complaint is deemed to be outside of normal operating parameters then the Duty Fitter informs the foreman who will then escalate the problem to his superiors and the HSSE Officer if required.

NPC also has an arrangement with the Barbados Fire Service and Royal Barbados Police Force, by which they inform NPC of any natural gas related reports. NPC also informs these agencies whenever we are conducting work that may result in gas release or major inconvenience to communities so that they may respond accordingly if they receive a complaint/report from the public.

These communication and grievance mechanism effectively cover the proposed Woodbourne plant expansion project.

6.0 ESMP IMPLEMENTATION BUDGET

Table 6-1 provides a summary of the NPC's ESMP estimated budget, including EHS allocated for the different civil and electrical work activities.

TABLE 6-1 ESTIMATE BUDGET

Infrastructure/Activity	Estimated Costs ($USA)
Civil Works	
Impoundment area	9,863.49
concreting impoundment pit	22,192.85
trenching for water pipes	9,863.49
installation of drainage to impoundment pit	9,863.49
design & installation of blast walls	98,634.89
Electrical Works	
Retrofit the Control Room	7,397.62
Installation of one methane controller container	34,522.21
relocation of methane controller	
Installation of 2 methane detectors	
Relocation of Fire probe	
Installation of points for Cryogenic pumps	
Installation of point for 30 HP pump	
Installation of solenoids and UPES for water monitors	
Installation of power & controls for Gas Chromatograph	
Installation of systems for valve operation for tanks	
Materials	17,261.11
Total	**209,599.15**

APPENDIX D (A) NG PIPELINE CONTRACT SPECIFICATIONS

Reference: No.

Date:

Dear Sirs

Contract No:
Contract Name:

1. Kindly refer to your tender dated .....

2. We are pleased to confirm that the National Petroleum Corporation (hereinafter referred to as "the Corporation") has agreed to award you the contract, subject to prior receipt of permission from the relevant Ministry to undertake the reinstatement of natural gas main trench along .....

   2.1 **.....ft of pipe track**

   Reinstatement using hot mix asphalt

Rates

3. The Corporation accepted your tender for carrying out the completed works

   a) Reinstatement **$.....** per linear foot (vat exclusive)

   Total Cost **$..... (vat inclusive)**

Specifications

4. The Contractor shall take notice that:

   4.1 The contractual trench size is **14" x 30".** This size may vary according to site conditions. Any variation must be authorised as per the

attached "**Variation Order Form**" and must be agreed to and signed accordingly, between the Contractor and an authorised representative of the Corporation before any variation work is commenced.

4.2 The roadway must be reinstated in **the same type of material as that of the existing surface.** Backfilling and reinstatement must be in accordance with MPT's Specifications for Reinstatements of Small Openings/Crossings, Track and Signage as attached. As it relates to subsection h) under heading Other Mandatory Instructions, the Corporation specifies particularly that the selected materials, must be imported materials only and not excavated materials as indicated in that subsection.

4.3 The Ministry will indicate the maximum compaction density that the selected backfill can attain based on the quarry. See also MPT's specifications for Road Repairs (reference CTO/R.20 of January 30 1986 and CTO G.12 of June 29 1993).

These sizes may vary according to site conditions. Any variation must be authorised as per the attached "**Variation Order Form**" and must be agreed to and signed accordingly, between the Contractor and an authorised representative of the Corporation before any variation work is commenced.

Payment Schedule

5. Claims for payment shall be made by the Contractor every two weeks. Such claims will be subject to verification by the Corporation. Payment by NPC upon verified claims will be made within **ten** working days of verification. Retention, which will be at the rate of 10%, will be released within 35 days of the expiry of the MPT's defects liability period, which is six months after the date of the MPT's certificate of satisfaction.

Responsibilities of Contractor

6. The Contractor is also required to

6.1 Request and ensure that **ALL UTILITY COMPANIES** indicate by way of marking out the location of mains/other utility infrastructure along the roadway within three days of trenching.

6.2 Undertake the excavation work with the use of manual workers, compressors, backhoes and/or other appropriate equipment.

6.3 Cut the edges of the trench to ensure they are clean and square and that the bottom of the trench is level.

6.4 Contact MPT's Traffic Manager if for any reason a section of the road has to be closed. An authorised representative of the NPC must be notified of any road closure. Where the road closure is planned, such notice to the NPC shall be in writing.

6.5 Excavate, where necessary, a minimum of 450 linear feet each week.

6.6 Limit the length of each section of open trench to 120 feet or if not practicable to a longer distance as agreed to on site between the Contractor and the Manager – Technical Operations of the Corporation or other officer or representative authorised by the Corporation.

6.7 Wherever feasible, locate the trench not less than one foot away from the slipper and curb of the road.

6.8 Ensure that in executing this work, bridges and culverts are not tampered with. Where drainage systems such as box drains and cross culverts are encountered the Contractor must trench under them and not tunnel through them.

6.9 Where, it is not practicable to tunnel under box drains and cross culverts the Contractor should stop within 10 to 15 feet of such structures, and divert the trench away from the structures as directed by the authorised representative of the Corporation.

6.10 Where difficulties are experienced in executing the work that affects drainage, the Contractor must contact the Drainage Engineer at MPT, and ensure that his instructions are executed. Executing the instructions may amount to a variation to the specification/works and must be authorised as detailed, in a **Variation Order Form** as per section 4.1 of this contract. The Contractor must notify NPC in writing of the Drainage Engineer's instructions in reasonable time before such instructions are carried out.

6.11 Repair all damaged paved and unpaved drains, curbs, pedestrian and vehicular infrastructure, sidewalks and other drainage infrastructure to the Ministry's standards.

6.12 Special care should be taken to keep the weep holes, water hydrants, valves and drains within the scope of work free from the excavated debris and other materials being used at the site.

6.13 Be responsible for the bridging of any open trench along the route, ensuring that access crossings are provided to residences and all businesses. Any bridging must be carried out in a manner that will ensure safe passage of vehicles and pedestrians over the bridges and cause a minimum of inconvenience to the public.

6.14 Be responsible for the lighting of the works and for providing flashing warning lights and such other warnings and notices as may be necessary to ensure the safety of users of the road. Such signs should be placed at appropriate points and at periodic distances beginning at 400 feet from the activity and again within 75 to 100 feet.

6.15 Place adequate warning signs at appropriate intervals to ensure vehicular and pedestrian traffic are aware well ahead of the scope of works, as well as at specific approaching intervals leading towards the scope of work and utilising both sides of the running trench. Where appropriate use stop and go signs manned by individuals. These signs should be clearly visible to the travelling public. The Corporation may require that the Contractor provide traffic control devices such as traffic lights to control the flow of traffic. Where traffic lights are necessary to control the flow of traffic the Contractor shall seek the approval of the Chief Technical Officer, Ministry Public Works and Transport for the erection of the same and notify the National Petroleum Corporation forthwith the approval of the Chief Technical Officer.

6.16 Undertake, to the satisfaction of MPT, the backfilling of all trenching carried out and the daily removal of all excess material. The Contractor must ensure that where reinstatement does not immediately follow backfilling, select material (free from all organic matter, mould and other impurities) must still be placed in the trench up to approximately one inch above the existing road surface. The backfill must be thoroughly compacted and executed in accordance with specifications outlined in section 4.2 of this contract.

6.17 Ensure that the final 18 inches of the trench being backfilled, must be backfilled and compacted using 50mm crusher run.

6.18 Control any dust, noise or other nuisance generated by the work. Any loose and fine material that is brought or accumulated on site by virtue of works must be covered or wetted to reduce any dust and nuisance caused.

6.19 Pay for any compaction tests that are required in the execution and completion of the works. The results of those tests must be to the satisfaction of MPT. Where failure of compaction tests occur, the Contractor must remedy the works within 1 week of notice of failure and make immediate contact with MPT for any retesting to occur. The Contractor must notify the Corporation of all results of the compaction test, by providing the Corporation with a copy of the results from MPT.

6.20 Have in effect valid public and employers' liability insurance which covers a period up to the date of expiry of MPT's defect liability period for reinstatement of public roadways. **Evidence of this insurance must be submitted to the Corporation at the time of the acceptance of the signed contract.** The defects liability period covers a period of six months after the date of MPT's certificate of satisfaction. The Certificate of Satisfaction from MPT shall be issued upon the Corporation's request which shall be made within two days of the satisfactory completion of the compaction test or satisfactory completion of reinstatement as appropriate. MPT will issue the Certificate of Satisfaction within ten days of the Corporation's request, assuming satisfactory completion of all works including tests.

6.21 Indemnify and keep indemnified the Corporation against all losses and claims for injuries or damage to any person or property whatsoever which may arise out of or in consequence of the carrying out of the work under the contract.

6.22 Ensure that where the works include excavation, backfilling and compaction only, the Contractor must make good of the public roadway upon which the works was executed, until all compaction tests have been passed to the satisfaction of the MPT, and having ensured that NPC has been furnished with a copy of the test results. Where the works include excavation, backfilling, compaction and reinstatement, the Contractor must ensure that his liability to make good of the public roadway only ends at the expiry of MPT's defects liability period for public roadways as referred to in subsection 6.21.

6.23 Undertake and provide to the Corporation pipeline lifting and handling services using manual and/or mechanical equipment as and when required to facilitate the execution and completion of the pipeline and

valve installation works as instructed by an appropriate officer or representative of the Corporation.

6.24 All contractors, contracted personnel and subcontractors agree that they are independent contractors and that at no time shall this contract be deemed to constitute a partnership or joint venture or agency or contract of employment and as such work on the understanding that NPC has no obligation to provide employment beyond the contracted job.

6.25 The contractors, contracted personnel and subcontractors further agree that they are solely responsible for the payment of all National Insurance payments, Inland Revenue PAYE payments, VAT payments and all other statutory taxes and or obligations arising out of the contracted job. Notwithstanding this clause the Contractor acknowledges that NPC has the right to supervise the performance of the Services to ensure compliance with NPC's policies and procedures for quality control reasons and to ensure compliance with all safety and environmental laws, regulations, guidelines and procedures and policies of NPC.

6.26 The contractor shall designate an individual to be responsible for upholding these rules and to communicate with the NPC representative designated for the contracted job. Whenever the individual changes, the NPC representative shall be informed. It is required that the designated individual provides a phone contact to the NPC representative and that the designated individual knows the cell phone number of the NPC representative.

6.27 All contractors, contractor personnel and subcontractors shall comply with all applicable governmental safety and health legislation.

6.28 No contractor employee is permitted to operate, adjust or tamper with any device used for safety, security or production without authorization of the NPC representative.

6.29 NPC management reserves the right to stop any job or remove any contractor, contractor employee or subcontractor from plant property/NPC work sites for violations of these rules or any other applicable safety or environmental rules, regulations or laws.

6.30 Vehicle engines shall be switched off for unloading tools or equipment.

Safety

6.31 Contractors are responsible for providing required Personnel Protective Equipment (PPE) as suitable and adequate for the particular contract

job and Contractor employees and subcontractors are required to adhere to all established and/or posted PPE requirements while on plant property/NPC work sites. It is a minimum requirement that all contractors shall wear industrial grade safety shoes at all times and ear defenders are required to be worn for certain activities.

6.32 All Contractor personnel shall comply with rules such as turning off cell phones in areas where gas may be present.

6.33 The Contractors shall ensure that their equipment is in good condition and that their personnel are trained in the proper use of the equipment.

6.34 Work areas where any unsafe conditions such as overhead hazards, excavations, trip hazards or metal sparks are likely during the work shall be properly blocked off with appropriate warnings and barricades to prevent persons from falling into open trenches as necessary by the contractor.

6.35 The Contractor shall ensure that their material or equipment does not restrict any emergency route at any time.

6.36 When the nature of the job presents a health or safety hazard or generates an irritant such as noise, dust, paint fumes etc., the contractor shall inform the NPC representative before work commences.

Accident Reporting

6.37 Accidents occurring on plant property/NPC work sites shall be reported immediately at once to the nearest NPC employee and a request that the NPC representative be contacted immediately shall be communicated.

6.38 All contractor injuries requiring medical assistance beyond basic first aid shall be investigated and reported in writing within 24 hours of the occurrence to the NPC representative.

6.39 In the event of chemical spills, damage to non-Contractor equipment or property or the creation of a hazardous or potentially hazardous condition of any kind, the contractor and/or his employees shall report it at once to the nearest NPC employee and request that the NPC's supervisor of works be contacted immediately.

Permits to Work

6.40 NPC requires that specific precautions are taken for work in the following categories of work and that the appropriate Permit to Work

(PTW) form is be completed in conjunction with the NPC representative.

- Confined Spaces
- Hot Work
- Energy Isolation
- Work at Height

Equipment and Tools

6.41 Contractors are expected to provide their own equipment.

Clean-up of Job Site

6.42 All jobs bid at the NPC site shall include removal of waste materials and cleaning of the site by the contractor at his expense, unless otherwise specifically negotiated in the contractual agreement.

6.43 All waste generated by contractors shall be placed in suitable marked containers. No contractor generated waste is to be disposed of in NPC dumpsters, without approval from the NPC representative.

6.44 It is the contractor's responsibility to properly dispose of all waste and hazardous materials generated in the course of the contracted job, including containers that contain or had contained any waste or hazardous materials. Such materials shall be removed from NPC property daily unless otherwise agreed by the NPC representative and shall be properly disposed of by the contractor in accordance with all applicable laws, rules and regulations.

6.45 Reference to NPC or any of its trademarks shall not be used in any documentation associated with the disposal of such waste and debris.

6.46 At no time shall any hazardous material enter any drain or well on NPC property. If this should occur, the contractor shall notify the NPC representative immediately.

6.47 Worksites shall be inspected by the NPC representative prior to final payment to ensure that the site is clean and all materials have been removed from the property. Final payment shall be withheld until such time as this has been confirmed. If this is not done within 48 hours of the completion of the job NPC shall take steps to have the area cleaned by a third party at the contractor's expense.

Contractor's Warranty

6.48 NPC relies on the skill and judgment of the Contractor and its employees and the Contractor warrants that its employees have the skill, judgement and expertise to execute and perform this Agreement.

General Conditions

6.49 Reporting for work under the influence of alcohol or drugs shall NOT be tolerated. NPC management reserves the right to remove any contractor or subcontractor employee from work sites who is believed to be under the influence of alcohol or drugs or is found to be in possession of illegal drugs.

6.50 NPC reserves the right for its Management and Supervisory personnel to remove from their work area any person who in their view are wearing inappropriate clothing, are unhygienic or are in any other way unsuitable for entry in the area.

6.51 The use of cigarettes, tobacco or other forms of similar substances is prohibited on an NPC site.

Time Schedule

7. The work **.....** is scheduled to commence on **.....** and to be completed by **.....**

8. The standard working hours of the Corporation are 7.30 am to 4.30 pm from Monday to Friday. The Contractor is required to comply with these detailed time schedules – to be worked out between the Contractor and the Manager – Technical Operations of the Corporation or other officer or representative of the Corporation. Where work is carried out outside of standard hours, one day's notice must be given to the Manager – Technical Operations of the Corporation or other authorised officer or representative of the Corporation. Where scheduled work is extraordinary, full notice as well as a schedule of works is expected to be submitted to the Corporation.

Liquidated Damages

9. The Contractor must sign and return to the Corporation the attached written confirmation that the Contractor will complete the works in the time specified. Where work is not completed by the agreed completion date, the Corporation may impose an amount of $1600 per day in respect of liquidated damages.

10. Should the Contractor fail to complete the works to the satisfaction of the Corporation, by the completion date, the contract may be terminated and another Contractor engaged. In such circumstances, the Contractor will be liable for any cost overruns resulting from the hiring of the new Contractor.

Acceptance

11. The Contractor must communicate acceptance of these terms and conditions by signing and returning the duplicate copy of this contract within two weeks, **and provide the Corporation, upon signature of the contract with the original or a certified copy of CERTIFICATE OF INCORPORATION, EVIDENCE OF PUBLIC AND EMPLOYERS' LIABILITY INSURANCE COVERAGE** to the Corporation's office situated at Wildey, St Michael. These certificates must be valid at date of signature of the contract.

Briefing

12. The Contractor will be briefed by the Manager - Technical Operations of the Corporation or other officer or representative of the Corporation on issues regarding any aspect of the work to be executed.

13. The terms and conditions of this contract embody in entirety what has been agreed to by the parties to this contract.

Signatures on behalf of
the National Petroleum Corporation: …….

Wosley Holder
Manager – Technical Operations (Ag)

…….

Mechelle Smith
Manager – HR & Administration

Signature on behalf of the Contractor: ……

Date of execution of Agreement:
……

MS/km

Enclosures

Contractor Name

To: National Petroleum Corporation
Wildey
St Michael

Contract Name

I confirm that …… will comply with the stipulated requirements in the contract and complete the required work by **……..**.

…….. ……..
Signed Dated

APPENDIX E APPLICATION FOR PERMISSION TO DEVELOP LAND

Specimen "K"

REVISED (2013)

Application No. .....

Land Registration No. .....

Date received .....

TOWN AND COUNTRY DEVELOPMENT PLANNING OFFICE

Town and Country Development Planning Act, Cap. 240

Application for Permission to Develop Land

(the attention of applicants is drawn to the directions appended to this form)

TO THE CHIEF TOWN PLANNER:

I/WE HEREBY make an *~~application~~ / outline application for permission to carry out the development described hereunder and on the attached plans and drawings.

(*Delete where inapplicable. See paragraph 4 of Directions)

(Signed) .....

FULL NAME & ADDRESS OF APPLICANT *(in block letters)*

(State whether Mr., Mrs., Miss) **WINTON GIBBS** .....

(Postal Address) **BARBADOS NATIONAL OIL COMPANY LIMITED** .....

WOUDBOURNE, ST. PHILLIP .....

Telephone Number **(246) 418-5200** .....

If signed by an Agent on behalf of the applicant:

NAME & ADDRESS OF AGENT **JAMES BROWNE** .....

NATIONAL PETROLEUM CORPORATION .....

WILDEY, ST. MICHAEL .....

Telephone Number **(246) 430-4000** .....

For office use only:

Officer's Comments: .....

Accepted by: ..... **Fee:** ..... **Receipt No.** .....

PARTICULARS OF APPLICATION

(the word "land" includes any buildings thereon)

(1) (i) Particulars of the applicant's interest in the land (e.g., free holder, lessee, prospective purchaser,) etc. .....

FREE HOLDER

.....

(ii) Is the land bound by any restrictive covenants? Yes ☐ No ☑

(iii) If the applicant is a prospective purchaser of lessee of the land, state whether the vendor or lessor has consented to the proposed development –

N/A

(2) Address or location of the land to be developed.	(2) **BARBADOS NATIONAL OIL COMPANY, WOODBOURNE, ST. PHILIP**
(3) Describe briefly the proposed development, including the purpose for which the land and/or buildings are to be used. If they are to be used for more than one purpose, give details.	(3) **RENTENTION AND COMPLETION OF AN OFFICE, L.N.G. PRODUCTION HOLDING AREAS AND PIPELINES.**
(4) (a) Area of site in square metres/hectares (b) Gross floor area metres/feet (c) Gross roof area metres/feet	(4) (a) **4004 square meters** (b) **29 square metres** (c) **29 square metres**
(5) (a) Where applicable state the number of lots to be created.	(5) **NOT APPLICABLE**
(6) State the purpose for which the land and/or buildings are now used, and if used for more than one purpose, give details.	(6) **PRODUCTION AND STORAGE OF LIQUEFIED PETROLEUM GAS.**
(7) (a) State whether the proposed development involves the use or construction of a vehicle access onto a road other than a Class IV road.	(7) (a) **VEHICULAR ACCESS WILL BE VIA AN INTERNAL INDUSTRIAL ROAD**
(b) State whether the development is on the coastline.	(b) **NO**
(8) Does the land form part of a sub-division plan approved or permitted by – (a) The General Board of Health; or	(8) (a) **NO**
(b) Chief Town Planner;	(b) **NO**
If so, state the reference number and date of approval or permission.	**NOT APPLICABLE**
(9) Where applicable state whether the development has been served with an enforcement notice?	(9) **NOT APPLICABLE**
If so, state the enforcement notice number and date.	**NOT APPLICABLE**
(10) If the land is to be used wholly or partly for industrial or commercial use, state:– (i) the nature of the proposed industry or business, including, if for industrial use, a brief description of the type of processes to be carried on;	(10) **YES IT WILL BE LIGHT INDUSTRIAL AND COMMERCIAL USE** (i) **STORAGE OF LNG; VAPORIZATION OF LNG; TRANSPORT OF NATURAL GAS VIA UNDERGOURND PIPELINE. FIRE CONTROL SYSTEMS**

(10) (ii) if for industrial use – (a) the amount and the means of disposal of any SOLID, LIQUID, or GASEOUS trade refuse or trade effluents.	(10) (ii) (a) **- ANY WASTE METAL WILL BE RECYCLED** **- OTHER MATERIALS WILL BE REMOVED FROM LAND**
(b) estimated water requirements in gallons per day.	(b) **A MAXIMUM OF 25 CUBIC METRES**
(c) estimated electricity requirements in Kilowatts.	(c) **UNKNOWN AT THIS TIME**
(d) estimated number of persons to be employed.	(d) **A MAXIMUM OF 5 PEOPLE**
(iii) If for industrial use – (a) Does the proposal involve use or storage of any hazardous material.	(iii) (a) **YES**
(b) If yes, state materials and approximate quantities.	(b) **24,000 GAL OF LNG**
(11) Where appropriate state – (i) Source of water supply – (a) existing.	(11) (i) (a) **MUNICIPAL MAIN**
(b) proposed.	(b) **MUNICIPAL MAIN**
(ii) Means of waste water and sewage disposal – (a) existing.	(ii) (a) **WELL**
(b) proposed.	(b) **WELL**
(12) Where appropriate state building materials – (i) Walls.	(12) (i) **SHIPPING CONTAINER**
(ii) Roof covering.	(ii) **N/A**
(iii) Roof supports.	(iii) **N/A**
(13) The amount of floor space involved: (a) the amount of retail floor space.	(13) (a) **NO RETAIL FLOOR SPACE INVOLVED**
(b) the amount of office floor space.	(b) **250 SQUARE FEET**
(c) the amount of institutional floor space.	(c) **NO INSTITUTIONAL FLOOR SPACE INVOLVED**
(d) the amount of warehouse floor space.	(d) **NO WAREHOUSE FLOOR SPACE INVOLVED**
(e) the amount of industrial floor space.	(e) **NO INDUSTRIAL FLOOR SPACE INVOLVED**
(f) the amount of floor space common to more than one use (e.g., service area).	(f) **NOT APPLICABLE**
(14) (a) Where applicable state the number of storeys/floors to be created.	(14) (a) **ONE (SINGLE STORY)**
(b) State the height of the proposed building(s) from the lowest point of the building(s).	(b) Feet **12** Metres **-**
(15) (1) For apartment/hotels or town houses, state the number of units proposed.	(15) (i) **NOT APPLICABLE**
(ii) For hotels and guest houses, state the number of bedrooms proposed.	(ii) **NOT APPLICABLE**
(16) For places of public assembly, state the maximum seating capacity.	(16) **NOT APPLICABLE**

DIRECTIONS TO APPLICANTS

1. Every application for permission under section seventeen of the Town and Country Development Planning Act, Cap. 240 shall be made on this form.

2. Where appropriate, full particulars should be given in answer to each question.

3. Each application shall be accompanied by –

(a) In the case of an application for permission to sub-divide land, four copies of a plan, drawn to an ordinance scale not less than 1:250m. Such plan shall show the position, boundaries and size of the proposed lots, the position and width of any road reserve and of any gutters, trenches or other means for taking water to be made or constructed over and through the land, and the levels for surface drainage.

(b) In the case of an application for permission to erect any building or carry out any building or engineering operations, or to change the use of any buildings, six copies of a plan drawn to a scale of not less than 1:200m in sufficient detail to show the layout and design of the proposed development in relation to any existing building on the land and to the boundaries of the plot on which it is situated, and the layout of any proposed, existing road, or other vehicular access.

(i) In all cases where the land slopes, the elevation indicating the slope shall be submitted.

(c) In all cases the area of each floor shall be indicated on the plans.

(d) In all cases, the same number of copies as required at (a) and (b) of a location plan to a scale of 1:2500m showing clearly the location of the property in relation to the nearest identifiable road junction or other land-mark. The names of all roads and such other descriptions as may be necessary to identify the property should be marked on the block plan.

(e) The appropriate fee in accordance with the Town and Country Planning (Fees) Regulations, 1970.

The orientation of the property shall be indicated by means of a North Point on each drawing or plan and the scale to which each drawing or plan is drawn shall be noted thereon.

4. Where an applicant so desires, he may make an outline application for permission to erect any building reserving for the subsequent approval of the Chief Town Planner on a further application any matters relating to the siting, design or external appearance of the building, or the layout of the land or the means of access thereto. An outline application need not be accompanied by the plans or drawings required by paragraphs 3(a) and (b).

Where this application involves the erection of a building –

(a) in the case of development for erection of a house – nearer than two metres; and

(b) in the case of all other classes of development – nearer than three metres;

from any side or rear boundary of the plot to which the application relates it must be accompanied by the following statement or statements signed by the owner or owners of any conterminous plot affected by the encroachment.

I/We, (Mr./Mrs./Miss) ..... hereby consent to the proposals contained in this application, which involve the erection of a building in the manner proposed within the prescribed distance of the boundary of my land.

(Signed) (1) .....

(2) .....

(3) .....

In the case of any conterminous owner who objects to the proposed encroachment, a separate statement signed by that owner and stating the grounds of any objections should be obtained and attached to this application.

Should a statement of consent or objection for some reason not be obtainable, the applicant should notify this office in writing accordingly stating the reasons why the statement is not obtainable.
