Environmental and Social Impact Assessment Report (ESIA) – Appendix 10

Project Number: 50330-001
February 2018

INO: Rantau Dedap Geothermal Power Project (Phase 2)

Prepared by PT Supreme Energy Rantau Dedap (PT SERD) for Asian Development Bank

Rantau Dedap Geothermal Power Plant, Lahat Regency, Muara Enim Regency, Pagar Alam City, South Sumatra Province

Critical Habitat Assessment

Version 13

January 2018

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FINAL REPORT

Supreme Energy

Rantau Dedap Geothermal Power Plant, Lahat Regency, Muara Enim Regency, Pagar Alam City, South Sumatra Province

Critical Habitat Assessment

January 2018

Reference: 0383026 CH Assessment SERD

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1 INTRODUCTION

1.1 PURPOSE OF THE REPORT

This report outlines the results of the assessment of impacts to critical habitat relating to the PT Supreme Energy Rantau Dedap (SERD) Geothermal Project (the 'Project').

There is an existing body of work compiled as part of the Project that includes information relevant to the impact to biodiversity values. Specifically this includes the following documents:

- Environmental, Social and Health Impact Assessment (ESIA DRAFT FINAL) 250MW Rantau Dedap Geothermal Powerplant (Phase 1-92MW) South Sumatra, Indonesia, December 2016 (Greencap, 2017).
- Final Report of Study of Endangered Species at Rantau Dedap, PT Supreme Energy Rantau Dedap (SERD) Muara Enim Regency and Pagar Alam City, South Sumatra Province, February 2015 (Greencap, 2015).
- Biodiversity Action Plan (Draft Final), PT Supreme Energy Rantau Dedap (PT SERD) Lahat Regency, Muara Enim Regency and Pagar Alam City, South Sumatra Province, November 2016 (Greencap, 2017).
- Critical Habitat Assessment Report (Draft Final), PT Supreme Energy Rantau Dedap (PT SERD) Lahat Regency, Muara Enim Regency and Pagar Alam City, South Sumatra Province, November 2016 (Greencap, 2017).
- ERM biodiversity assessment (flora and fauna) of brine pipeline and transmission line (ERM, 2017).
- ERM ecosystem services assessment for SERD (ERM, 2017).
- ERM aquatic ecosystem assessment for SERD (ERM, 2017.

The primary purpose of this report is to document an assessment of impacts to biodiversity in accordance with Asian Development Bank (ADB) Safeguard Policy Statement (2009) and International Finance Corporation (IFC) Performance Standard (PS) 6, in particular a Critical Habitat assessment (According to Paragraphs 16-19 of the PS).

Section 3 summarises the baseline biodiversity values associated with the Project Footprint and Area of Influence (***Figure 1.1***).

The '*Project Area*' is defined as the direct disturbance footprint of the project infrastructure and is approximately 124.5ha, including roads, well pads and pipelines. An additional area will be cleared for construction of the transmission line, with some sections of vegetation suppressed rather than cleared underneath the power lines.

The Project '*Area of Influence*' (AoI) is defined as the area encompassed by a five kilometre (km) buffer from the Project Area and is approximately 22,162 ha. The buffer distance has been assigned in order to consider impacts that may occur in the Project Area surrounds. The AoI for the extent of transmission line that lies outside the Project Area is defined by a 100 m

buffer. This is a smaller extent than the Project Area AoI of 5 km as the main impacts from the transmission line are anticipated to be edge effects which are reasonably estimated to be experienced up to 100 m from the either side of the extent of the transmission line. While a summary of baseline conditions is provided in this report the focus of *Section 3* is identification of the '*Priority Biodiversity Values*' in order to assess impacts to Critical Habitat. Priority biodiversity values are values that are considered candidates for consideration for Critical Habitat status.

*Section*s *1* and *6* document the impact assessment and application of the mitigation hierarchy in accordance with the ADB Safeguard Policy Statement and IFC PS6.

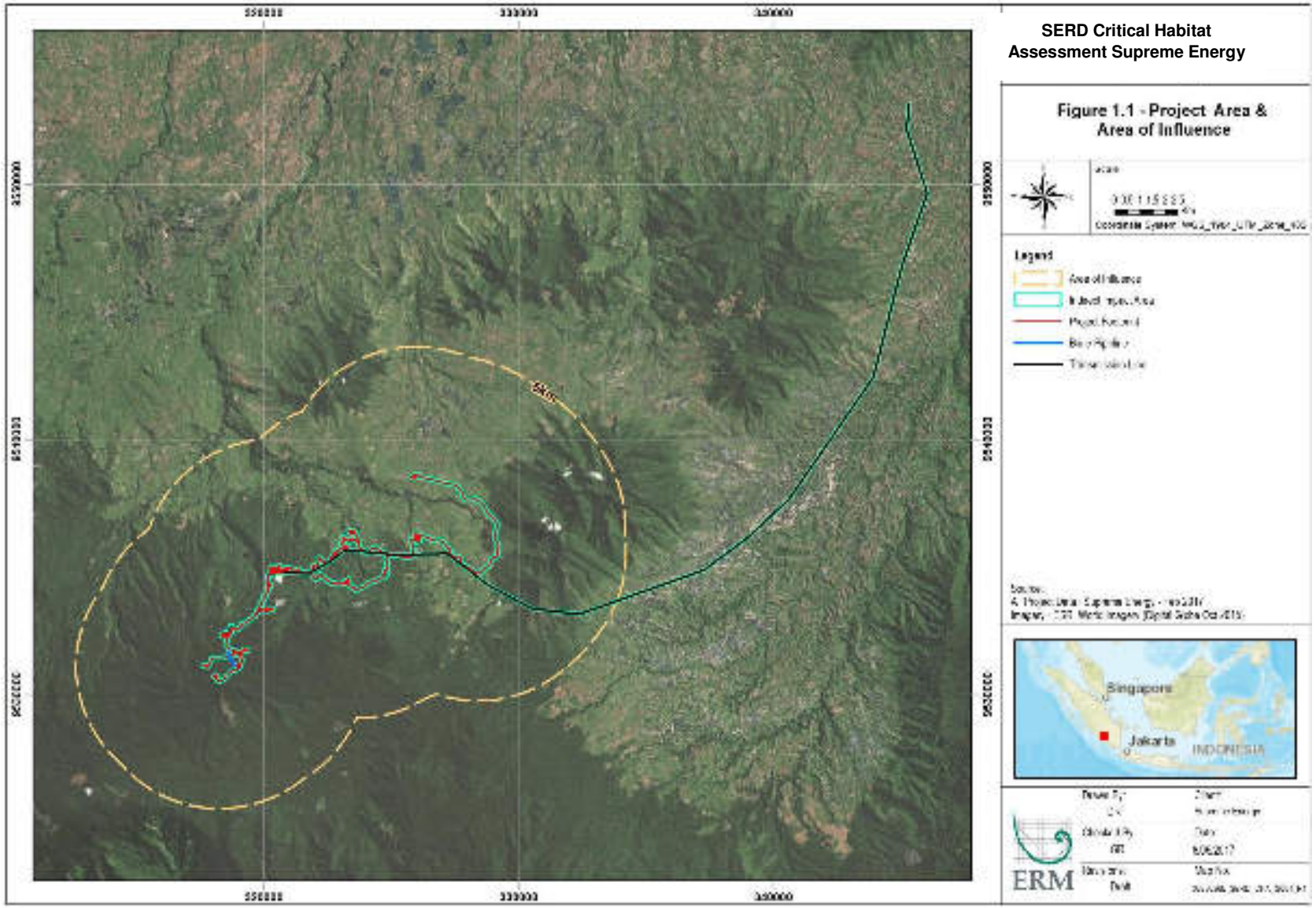
1.2 QUALIFICATIONS

The Project that has included a sequence of disturbance events to biodiversity values since exploration activities that commenced in January 2013. In order to identify the impact the biodiversity for the complete Project, data available regarding the values prior to this disturbance has been utilised where appropriate. This approach aims to develop an understanding of the baseline characteristics of the site prior to exploration such that impacts to habitats and ecosystems could be predicted retrospectively (when considering exploration activities).

The assessment of potential impacts related to terrestrial biodiversity in this Chapter is based on the environmental baseline data collected by Greencap and reported in draft documentation; desktop sources (as referenced); and judgements made based on available data, professional knowledge and previous experience of ERM from other projects within the vicinity.

From the data available from studies undertaken for other projects within Sumatra there is a high likelihood of endemic species occurring within the Project Area. Therefore there is a possibility that a number of endemic species may not have been recorded within the Project Area by previous studies. To overcome this gap, management measures have been developed to implement a precautionary approach a requirements to conduct pre-clearance surveys and assessments prior to the next phase of construction. This approach aims to detect conservation significant endemic flora prior to disturbance and allow for avoidance, translocation or seed harvest to be undertaken.

Figure 1.1 Project Area and Project Area of Influence



2 PROJECT DESCRIPTION

PT Supreme Energy Rantau Dedap (SERD) plans to develop a Geothermal Power plant project at the geothermal field in Rantau Dedap, South Sumatra ('the Project'). The concession is located approximately 91km south of Muara Enim, 225km to the southwest of Palembang, the capital city of South Sumatra Province and 100km southeast of Bengkulu, the capital of Bengkulu Province.

The development plans broadly comprise construction and operation of geothermal power units, construction of supporting infrastructures, and electricity distribution. These activities have potential to cause environmental impacts.

All activities of the development during construction and operation described below and the spatial areas impacted are defined as the Project Area for the purposes of this report. The Project Area is defined spatially in ***Figure 2.1***.

2.1 PROJECT HISTORY AND STAGING

Following award of the Rantau Dedap concession in December 2010 and grant of a Mining Area Licence in 2011, the exploration program commenced. Initially, the activities undertaken included topographic survey, civil engineering study, heat loss survey and geo-scientific interpretation, and these were completed in 2012.

In November 2012 the Project entered into a Power Purchase Agreement (PPA) with Perusahaan Listrik Negara, defining the contractual rights and obligations of the parties during exploration phase, construction phase and operation phase. At this stage, among other activities, land was acquired including approximately 82ha of Protected Forest Area and 10ha of other land, and access roads were built within the protected areas.

Civil and infrastructure work commenced in January 2013 and in February 2014 the exploratory drilling program began.

With the completion of the pre-feasibility and feasibility studies and then Front End Engineering Design (in 2016) the next stage of the Project will be the full development, including additional well drilling and construction of the steamfield, power plant, pipelines and other supporting infrastructure.

The Project life is expected to be 30 years though there may be opportunity to continue. Five years prior to the end of the Project life a decommissioning plan will be prepared to restore the area.

2.2 PROJECT CONFIGURATION

The main project components of the Rantau Dedap Geothermal Power Plant are described below and shown in ***Figure 2.1***.

2.2.1 *Production Wells, Injection Wells, and Wellpads*

The total estimated well requirement for operation of the full capacity 250MW power plant is 48 production wells (across eight wellpads). The 98.4MW Phase 1 dual flash power plant requires 18 production wells and four injection wells, situated on six to seven wellpads. The completed exploration phase activities have developed four wellpads (and six wells).

Injection (or reinjection) wells are required to discharge brine and condensate back into the formation. The injection wells will be located downhill, at the existing Wellpad B and Wellpad E.

The geothermal drilling process will use water-base mud (WBM) to prevent boreholes from collapsing during drilling and also to protect the environment. Water demand for drilling is matched by surface water and/or collected runoff water, amounting to up to 30 – 100 l/sec. A permit was obtained to source the surface water from the Cawang Tengah/Kiri Rivers.

2.2.2 *Pipelines*

The pipeline network consists of an above-ground Steam Gathering System as well as the freshwater supply.

The pipeline route will follow existing roads or dedicated corridors to facilitate easier and lower-impact construction and maintenance. Cut and fill will be necessary in some pipeline sections to stabilise slopes and manage safe operation conditions.

Drainage channels will be built parallel to the pipelines in addition to inspection roads. At some sections, structures to cross roads, rivers, or other features are to be built.

There will be a brine pipeline constructed between Separator Station near Wellpad E to Wellpad B.

2.2.3 *Soil Disposal*

There are two soil disposal areas located in the new well pad areas. Over excavated soil is expected only for the new roads to Wellpads L, M and N. Other planned earthworks are equal cut and fill balances.

2.2.4 *Power Generation*

Steam and brine are separated from the flow from wells at separator stations. Brine will be reinjected into the formation, while the separated steam will then enter a scrubber to purify the steam from impurities such as silica.

The purified steam then enters a turbine where it drives the turbine shaft to produce mechanical energy and a generator converts this mechanical energy into 11kV electricity. This is then run through a step-up transformer unit and channelled to the GIS substation in the power plant area.

2.2.5 *Switchyard and Transmission Line*

The PT SERD switchyard is located within the power plant area. The interface between PT SERD and the PLN network is at the high voltage gantry of the switchyard, which is used for connection to the PLN transmission line.

The switchyard is the end point of connection at a voltage of 150 kV to the PLN transmission and distribution network. From this switchyard, a transmission line will be constructed. (Note: PT SERD is not seeking finance for the transmission line however it has been included here to consider potential impacts of the whole Project as an associated facility).

The total length of the PLN transmission line between the PT SERD switchyard and the PLN 150 kV Substation at Lumut Balai is 39.1km, where it connects with electricity supply from another company and to the regional grid. The length of the proposed transmission line within the PT SERD project area is 12.4km and the remaining 26.7km being outside the project area.

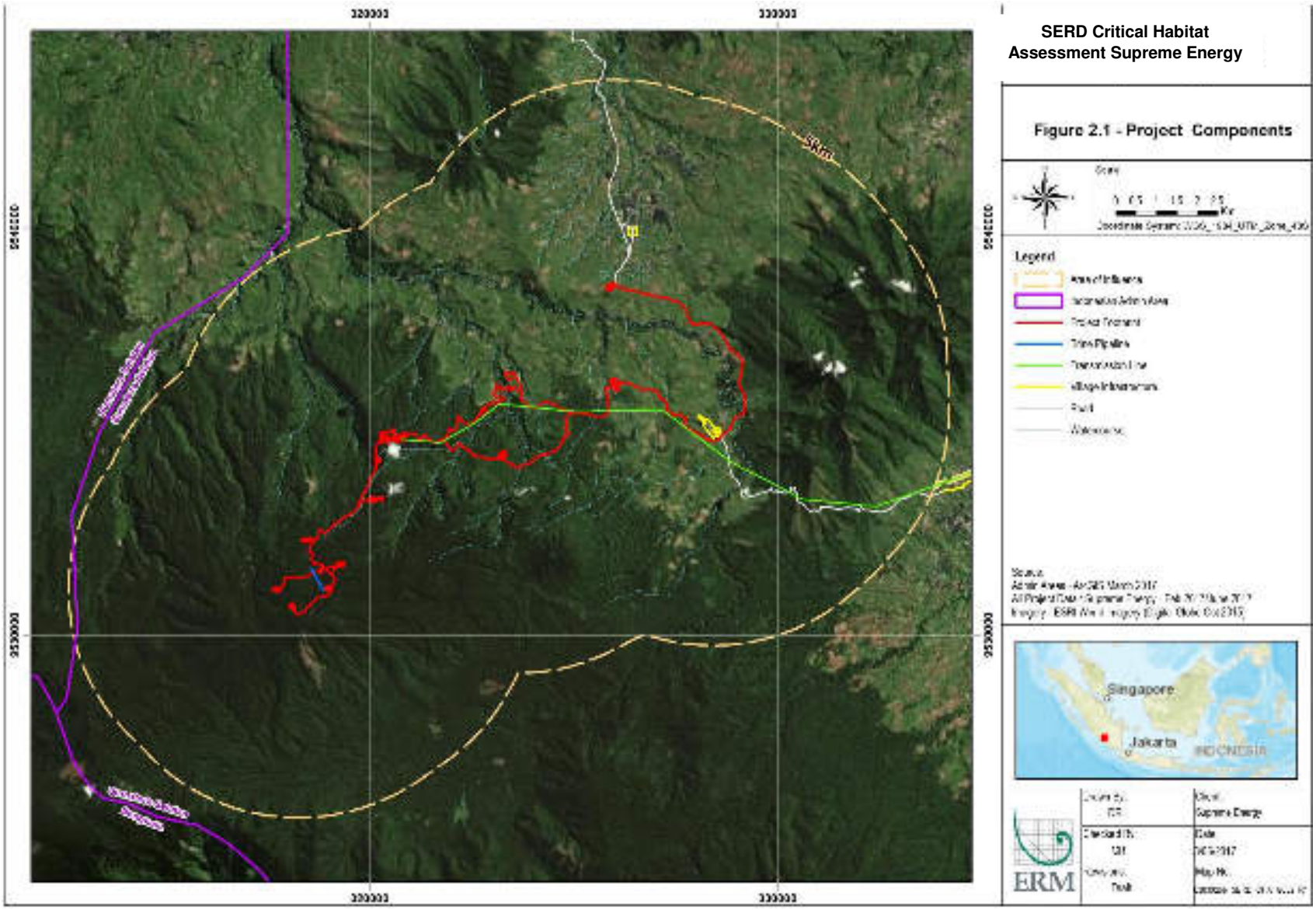
2.2.6 *Access Roads*

The total access road requirement is 52.5km. During the exploration activities 42.5km of access and connecting roads have been built with the additional 10km to be constructed in the next phase.

2.2.7 *Additional Facilities*

PT SERD will build facilities for a domestic water supply and treatment plant, waste water treatment, chemical storage, warehouse, workshop, firefighting system, open storage areas, project administration building and accommodation block.

Figure 2.1 Project Components



3 BASELINE BIODIVERSITY AND ECOSYSTEM SERVICES SUMMARY

3.1 BASELINE BIODIVERSITY VALUES

The Project site is largely located in the Muara Enim Regency of South Sumatra, at the slopes and foothills of the Mount Patah range approximately 25 kilometres (km) to the southeast of the city of Pagar Alam (***Figure 3.1***). A small portion of the Project Area lies within the neighbouring Lahat Regency.

The Project is located within the Bukit Barisan highland, known for its rich biodiversity. There is a range of land uses in the region however the forested mountains of the Barisan Range dominate the wider landscape. The area is remote and relatively undeveloped with steep terrain. It is reported that most of the area has only walking trails or no access ways.

3.1.1 *Definition of Area of Influence*

ERM has defined the Area of Influence (AoI) of the Project as all contiguous forested habitats within 5km of the Project Area Boundary. This area has been defined based on the likely habitat utilisation of the species detected from previous surveys and for species likely to occur within the area. Some species may move beyond the AoI (such as for migration or breeding), however the defined AoI is likely to represent the area likely to be impacted by the Project.

3.1.2 *Biodiversity and Ecosystem Service Survey Summary*

3.1.2.1 *2014 – 2016 Field Surveys (Greencap)*

Greencap (2017) summarised the key field studies undertaken to describe the baseline biodiversity values associated with the Project. This included:

- Baseline Biodiversity Study in January 2014 – an assessment undertaken before the exploration stage where sampling locations focussed on capturing study of representative ecosystem types.
- Biodiversity Study September 2014 - January 2015 – an assessment undertaken during the exploration stage consisting of camera traps and rapid observation methods for the purpose of identification and mapping of endangered species in the Project Area and surrounds;
- Biodiversity Study July – October 2016 – an assessment undertaken after the exploration stage focussing on Well pad L, M, N and X. The study employed rapid assessment methods and camera traps. The survey consisted of flora plots at Well pads L, M, N and X to collect data on density and abundance of flora species of different strata. Mammal observations were completed along 1,000 m long, 50 m wide strip width line transects and supplemented by camera trapping, small animal trapping, mist netting, concentration counts and community interviews. Bird surveys were completed on transects (6:00 – 11:00) and adopting concentration counts. Camera traps and mist nets were used in combination with line transects. The latter was also used for bird surveys.

Reptiles and amphibians were detected using night visual encounters and line transects. In addition habitats were classified as natural and modified habitat using land cover information, remote sensing techniques and spatial analysis.

The locations of surveys undertaken by Greencap are shown in ***Figure 3.1***.

3.1.2.2 Flora and Fauna Surveys (ERM 2017)

In 2017, Supreme Energy commissioned additional field surveys along the routes for the transmission line .and the brine pipeline route between Separator Station near Wellpad E to Wellpad B. Local flora and fauna specialists undertook these surveys from 9 to 15 May 2017. The surveys comprised the following activities:

- Flora survey: The flora survey was conducted from 9 to 15 May along the transmission line and the brine pipeline route between Separator Station near Wellpad E to Wellpad B. The routes were surveyed as transects and all flora observed within a 40 m corridor were recorded. Parameters recorded include the conservation status of flora species (IUCN Red List and Indonesian Law for Protected Species, Government Decree no. 7/1999), endemicity and invasiveness. The GPS locations of endemic and protected species were recorded. A list of flora species and a landcover map were generated.
- Fauna survey: The fauna survey was conducted from 10 to 14 May and sampling was focused at the areas around the first 54 (out of 116) towers of the transmission line and the brine pipeline route between Separator Station near Wellpad E to Wellpad B. Surveyors walked along the transmission line route and recorded species encountered through visual or auditory detection. Both indirect and direct observations of fauna were recorded. The GPS locations of protected species and the habitat types in which they were observed in were recorded. Surveys were conducted from 7am to 4pm.

The survey reports are appended in *Annex B*. The survey transects and locations are detailed in these reports.

3.1.2.3 Ecosystem Services Assessment (ERM 2017)

ERM was contracted to conduct an ecosystem services assessment of the SERD concession. This assessment was undertaken as required by the SERD Biodiversity Action Plan to satisfy the requirements of the Asian Development Bank (ADB) Safeguards Policy Statement (SPS). The survey and assessment was completed in November 2017.

ERM used the World Resources Institute Guidelines (WRI 2013) for the assessment. ERM conducted ecosystem screening assessment in order to determine the likely ecosystem service values that could be potentially important to affected communities within 5km of the SERD concession area. This assessment was done using existing sources of data, including information obtained during the scoping visit in October 2017 and consisted of

initial interviews with SERD representatives as well as with local community representatives in the following villages: Tunggul Bute, Rantau Dedap, and Talang Pisang.

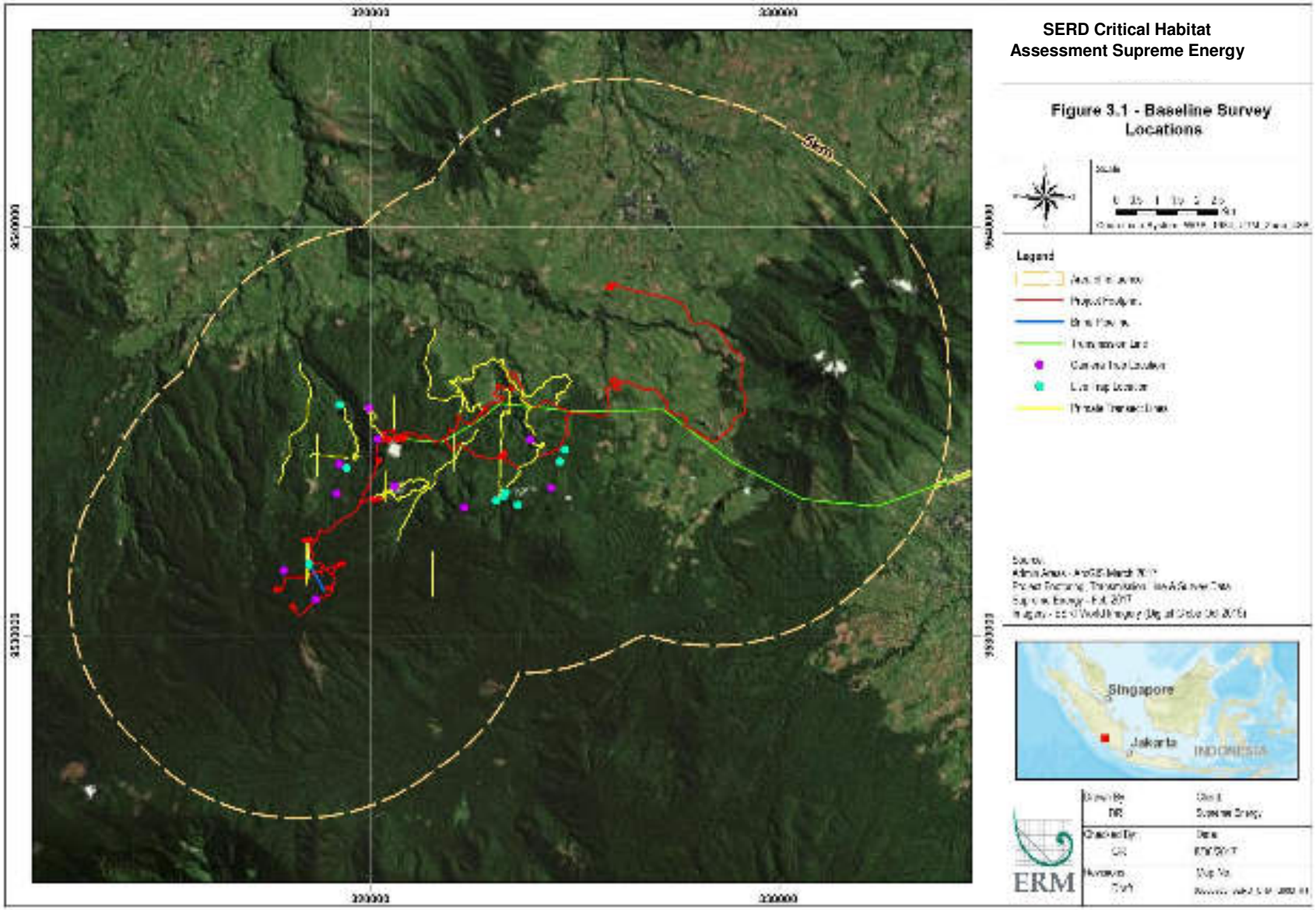
Further details on the ecosystem service assessment can be found in *Section 3.3* below. A copy of the Ecosystem Service Assessment can be found at *Annex D*.

3.1.2.4 Aquatic Ecosystems Assessment (ERM 2017)

ERM contracted Dr Dewi Imelda Roesma (Biology Department, Faculty of Mathematics and Natural Sciences, Andalas University) to undertake a "*Fish and Macroinvertebrates Rapid Assessment*" for the SERD Project Area. Surveys were conducted in December 2017 of eight (8) sites within and outside of the SERD Project Area. The study focussed on macroinvertebrates and fishes within the project area to identify any conservation significant species, including endemic or migratory species (and potentially Critical Habitat triggers).

Further details on the aquatic ecosystems assessment can be found in *Section 3.3* below. A copy of the "*Fish and Macroinvertebrates Rapid Assessment*" can be found at *Annex E*.

Figure 3.1 Baseline Survey Locations (Greencap, 2016)



3.1.2.5 Consultation

Public consultation in relation to the SERD project has included the following:

- In May 2017, SERD undertook a public consultation in Palembang with Universities, experts, government officials, NGOs and the general public; and
- In October 2017, ERM undertook specific consultation regarding ecosystem services with local people in and around the SERD concession.

ERM has undertaken consultation in relation to the assessment and management of aquatic biodiversity values in West and South Sumatra. This consultation was undertaken in March 2017 with:

- Dr Maurice Kottelat: freelance taxonomist specialised in biodiversity surveys of aquatic habitats and Chair of the committee on taxonomy for ichthyology of the International Commission on Zoological Nomenclature; and
- Dr Dewi Imelda Roesma: Biology Department, Faculty of Mathematics and Natural Sciences, Andalas University, Padang, West Sumatra, Indonesia

ERM undertook consultation with government officials, NGOs and the community in relation to biodiversity offsets in April 2017:

- Indonesian Forestry Department, Palembang; and
- Watershed Management Department, Palembang.

SERD undertook consultation regarding biodiversity offsets with the following organisations in May 2017:

- Universitas Sriwijaya;
- Palembang Environmental and Forestry R&D Agency;
- Environmental Agency Kota Pagar Alam;
- Forum Gajah;
- Forum Harimau Kita;
- Protection Forest Watershed Management Board Musi;
- Conservation and Natural Resources Agency South Sumatra;
- Energy and Mineral Resources Agency;
- GIZ BIOCLIME; and
- KPB SOS.

3.1.3 Geospatial Assessment

ERM undertook a spatial assessment using a Geographical Information System (GIS) clearing of vegetation within the AoI from Project related and non-project related activities from 2014 to the present (2016). Supreme advised that minor exploration activities occurred prior to work commencing on the project in 2013.

Land classes within each site were developed based on a review of existing baseline information, satellite imagery and field observations. An assessment of the distribution of Natural Habitat (as defined by ADB SPS) within the Project AoI was also undertaken to inform the impact assessment.

It should be noted that the spatial analysis undertaken in the CHA has used actual data from remote sensing. Information contained within the Environmental and Social Impact Assessment (ESIA) (GreenCap 2016) may differ given these areas were predicted areas.

3.1.3.1 Data sources

The United States Geographical Service's (USGS) archive of Landsat satellite imagery was reviewed for the period from 2008 to January 2017 to identify the best available imagery in annual time steps. The primary constraint on image quality is the presence of cloud. Cloud free images were identified for 2014, 2015 and 2016.

Only Landsat7 was available prior to 2014 and due to the functional issues with Landsat7, combined with persistent cloud results, a minimal range of imagery was identified that could have been analysed. No cloud free imagery was available for 2012 and 2013. The images selected and notes on the imagery selected are provided below in ***Table 3.1***.

Table 3.1 Landsat Satellite Imagery Selected for Analysis

Image	Path	Row	Image Date	Notes	Satellite	Status
1	125	63	06-Aug-16	Cloud Present	Landsat8	Utilised - cloud masked
2	125	63	03-Jul-15	Largely Cloud free over AoI	Landsat8	Utilised
3	125	63	16-Jul-14	Largely Cloud free over AoI	Landsat8	Utilised

3.1.3.2 Land Clearing Assessment

A number of indices were tested for suitability to map bare ground in the AOI, including the Normalised Differential Vegetation Index (NDVI) and the Bare Ground Index (BGI), however it was found that the following index was most effective: Landsat8 (Band 4 – Band 2) / (Band 4 + Band 2); and Landsat5 andLandsat7 (Band 3 – Band 1) / (Band 3 + Band 1). Threshold values were set for each time step resulting in a binary image (cleared or not cleared). These images were corrected for cloud cover and converted to polygons for area calculations and mapping in GIS.

The total cleared area was calculated for 2014 as a baseline to define non-project related clearing. Subsequent area changes in clearing were calculated for each subsequent year. The cleared land was classified as: Project related clearing and Project induced clearing, being clearing not associated with direct project activities.

Assessments of the imagery were made within the AoI and also within 500m of the Project area boundary. The 500m buffer from the Project area boundary was chosen in order to define an area that may have been made accessible from project related activities. Following a field inspection in April 2017, it was observed that clearing within the 500m buffer is generally contiguous with the Project Area and hence would likely be the area most impacted by project induced clearing during the period.

3.1.3.3 Natural Habitat Mapping

Natural and Modified habitat was mapped based on the extent of natural vegetation mapped in 2011 by the Indonesian Government (Ministry of Forestry, 2011). Image interpretation was combined with previously mapped Modified Habitat areas from 2013 and the combined cleared area mapping to generate Natural Habitat dataset. The malfunction of the LandSat7 satellite and the lack of cloud free imagery for 2012/13, the Natural Habitat assessment was not based on remote sensing analysis. Remote sensing undertaken on imagery from 2015 also did not adequately differentiate coffee plantations and other landuses.

3.2 BASELINE BIODIVERSITY VALUES

3.2.1 Project Area Overview

The Project Area is part of the Bukit Besar highlands in South Sumatra, amidst an area dominated by volcanic mountains, namely Bukit Besar, Bukit Mutung and Mount Anak complex. The elevation of the Project Area ranges between 1,000 m and 2,600 m above sea level (asl). The land uses in the activity location are listed as coffee plantations, dryland agriculture and settlements. Forest ecosystems present within the Project Area include primary montane and primary and secondary submontane forests.

The Project ANDAL reports there are several waterbodies associated with the Project, in particular the Cawang River, Asahan River, Puyang Lake, Deduruk Lake and Endikat River. The rivers are tributaries of the Lematang River (97.5 km in length) and the Lematang Watershed (7,380 km^2).

Majority of the Project footprint overlaps with the Bukit Jambul Gunung Patah Protection Forest (Hutan Lindung). The Project is located 60km from Bukit Barisan Selatan National Park (BBSNP), which is a nationally protected (IUCN Category II) and globally recognised important habitat area (IBA and KBA).

3.2.2 *Vegetation and Habitats*

Vegetation within the Project Area is represented by coffee plantations, secondary submontane forest, primary submontane forest and primary montane forest. The montane and submontane forests were classified as highland montane and lowland montane respectively. A number of CITES-listed orchid species were found from these forests collectively however none of these were nationally protected or listed on the IUCN Red List. One Critically Endangered species, *Dipterocarpus sp.* was recorded within the Project Area.

The ANDAL Study conducted vegetation sampling from three locations in the Project Area. The first location, lowland montane forest and coffee plantations, featured a vegetation type dominated by *Actinodaphne* sp., *Cyathea* sp., *Anisophylla disticha* and *Lycopodium* sp.1. The second location featuring lowland montane forest was dominated by *Barringtonia* sp., *Michelia alba*, *Acronychia porter* and *Begonia* sp.1. The last location, featuring highland montane forest, was dominated by *Cryptocarya* sp., *Acronychia porter* and *Dryopteris* sp. (ESC, 2016).

Field studies conducted for the 2016 ANDAL report that the coffee plantation, lowland montane and highland montane forest habitats were suitable for a variety of mammal, herpetofauna and bird species. These include a number of IUCN-listed Critically Endangered species and endemic species.

The 2017 studies along the transmission line and brine pipeline found that vegetation concurred with the 2016 ANDAL field studies in terms of the types of vegetation present in the Project Area. The study recorded 1 VU species, 1 Indonesian Protected species and 2 Sumatran endemics.

Based on IUCN species profile information and results of field studies, the primary and secondary forest is suitable habitat for a number of threatened species (flora and fauna) through provision of food and prey resources, nest sites and forest space for seasonal, arboreal and terrestrial movement and protection from predators.

Details on the priority flora and fauna values associated with these habitats are outlined in *Section 3.4 Priority biodiversity and ecosystem service values*.

3.2.3 *Biodiversity Values Specific to the Transmission Line and Brine Pipeline (ERM May 2017)*

The vegetation along the transmission line comprises primary montane rainforest, secondary forest, shrub and coffee plantations. This was largely in line with findings from the 2016 ANDAL. Along the brine pipeline, vegetation was found to be montane rainforest. A total of 108 species of vegetation was recorded. *Dacrycarpus imbricatus* was the dominant tree species at montane rainforest habitats.

1 IUCN-listed VU species, *Saurauia cauliflora* and 3 endemic species, *Vanda foetida, Anaphalis longifolia* and *Amorphophallus beccarii*, were identified from the study area.

Thirty Five (35) invasive species were identified throughout the survey area, including *Austroeupatorium inulaefolium*, *Musa acuminata*, *Pteris tripartita* and *Clidemia hirta*. Invasive species were mostly found within disturbed habitats, at open forest canopy areas and near coffee plantations.

Eleven (11) mammal species, 36 bird species and 6 amphibian species were found from the transmission line and brine pipeline. In particular, the mammal survey yielded 5 IUCN Red-Listed species of which 2 species; the Sumatran Surili (*Presbytis melalophos*) and Siamang (*Symphalangus syndactylus*) are listed as EN. Four (4) groups of Sumatran Surilis were observed, with each group consisting of 2 to 5 individuals. Individuals were found from primary and secondary forest habitats at both transmission line and brine pipeline locations. Five (5) groups of Siamangs were observed, with each consisting of 2 to 4 individuals of the same family unit. Similarly, the Siamangs were found from both transmission line and brine pipeline locations. They were also observed to be habituated to humans as the forest was frequently visited by people. These two species were also recorded from the 2016 Greencap surveys.

One (1) endemic bird species, the Sunda minivet (*Pericrocotus miniatus*) was recorded. It was noted to be fairly common in forested areas and tolerant of edge habitats. The Sunda minivet was also observed during the 2016 Greencap surveys.

3.2.4 Results of Aquatic Ecosystem Survey (ERM December 2017)

An assessment of aquatic ecosystem values was undertaken in December 2018. The assessment focussed on fishes and macroinvertebrates at eight (8) sample locations within the SERD Concession and surrounds. The location of the SERD sampling sites is shown in *Figure 3.2* below.

The results of the survey indicate that the species of fish detected are relatively common with *Glyptothorax platypogon* (IUCN NE) being the most abundant at the sampling sites. Other species identified in lower abundance included *Tor tambroides* (IUCN DD), *Xiphophorus hellerii* (introduced) and *Glyptothorax platypogonides (*IUCN NE*)*. Further assessment is currently being undertaken regarding the taxonomy of *Barbodes cf. banksi* and *Tor sp.* identified at SERD 8 (Endikat Hilir River). Regarding the *Barbodes cf. banksi*, the species in this genus are relatively widespread and hence it is unlikely that this species is a restricted range species.

No endemic fish species were identified during the survey. The species *Tor tambroides* (IUCN DD) is considered migratory.

The list of fish species identified at the SERD site is shown in ***Table 3.2*** below.

Table 3.2 Fish Species identified at SERD (December 2017)

No.	Scientific name	Common name	Status	Locality
A.	**Family : Cyprinidae**			
1	*Barbodes* cf *banksi* (Herre, 1940)	Spotted barb	NE	SERD-1, SERD-7, SERD-8
2	*Tor douronensis* (Valenciennes, 1842)	Semah mahseer	NE	SERD-1, SERD-7
3	*Tor tambroides* (Bleeker, 1854)	Thai mahseer	DD	SERD-8
4	*Tor* sp	-	-	SERD-8
B.	**Family: Poeciliidae**			
1	*Xiphophorus hellerii* Heckel, 1848	Green swordtail	NE (introduced)	SERD-1
C.	**Family: Sisoridae**			
1	*Glyptothorax platypogon* (Valenciennes, 1840)	Brauner Gebrigwels	NE	SERD-1, SERD-4, SERD-8
2	*Glyptothorax platypogonides* (Bleeker, 1855)	Spotted barb	NE	SERD-1, SERD-4

Regarding macroinvertebrates sampling, the stream ecosystem in the SERD region is relatively undisturbed. The number of genera of each river is high with relatively ranges from 23-34 genera. The number of individuals range from 91 to 295 individuals and the genera diversity index ranges from 1.92 - 2.94. This indicates that the site is considered as "moderate" health and the water quality is classified as "clean".

The presence of genera in each of the sample location varies. Genera found in all streams are the *Centroptilum, Neoperla, Hydropsyche*, and *Pseudocloeon*. *Anthocha, Baetis, Phagocata* are not found at one sample location (SERD-1). The predominant macroinvertebrate genera are: *Centroptilum, Pseudocloeon, Nemouraelmis, Stenelmis, Simulium, Anthocha, Neophylax, Hydropsyche* and *Psychomya*

3.2.5 Land Clearing Assessment

3.2.5.1 Background land clearing in Sumatra

Relevant baseline clearance rates are available from the Government of Indonesia (Direktorat Inventarisasi Dan Pemantauan Sumber Daya Hutan) for clearance in Sumatra for the period 2013/2014 (Indonesian Forestry Department, 2015). ***Table 3.3*** provides details on the clearing rates within Sumatran Provinces within 2013/14 (12 month period).

Table 3.3 ***Clearing within Sumatra Provinces, 2013/14***

Province	Deforestation (ha/yr)				Total Forest Area (ha)	% Rate of Loss
	Primary Forest	Secondary Forest	Planted Forest	Total Forest Loss		
Sumatera Utara	88.7	5556.9	494.8	6140.4	1,714,900	0.36%
Sumatera Barat	233.3	3847.3	975.3	5055.9	1,778,100	0.28%
Jambi	5423.5	18,025.3	30417.3	53,866.1	1,276,700	4.2%
Sumatera Selatan	**152.6**	**4127.4**	**-752.7**	**3527.3**	**1,346,800**	**0.26%**

The background clearing in 2013/14 for the Sumatera Selatan province (relevant to the Project Area) is 0.26% annum.

3.2.5.2 *Land Clearing within the SERD Concession*

Field inspections conducted in April 2017 indicated that coffee plantations have been established within the Protection Forest area adjacent to the Project Area and within the SERD Concession area for an estimated 15 years (2002) and continue to be established within the vicinity of the Project.

The results of the GIS assessment of the clearing assessment are shown in ***Table 3.4***. It should be noted that the remote sensing assessment has not accurately differentiated between forest cover and coffee plantation within the AoI. This is due to the low resolution of LandSat data (30x30m resolution). This has resulted in the assessment not differentiating between changes in forest cover and changes in coffee plantation extent. The assessment therefore is likely to overestimate the area of clearing of forest cover.

Table 3.4 ***Land Clearing Assessment Results***

Date	Clearing within 500m of Project Footprint (Ha)	Cumulative clearing (Ha) within 500m of Project Footprint	Project Related clearing (Project Area) (Ha)
Prior to 2014	313.08	313.08	82
To July 2015	93.95	329.98	0
To July 2016	16.9	423.93	0

For the period prior to 2014, there was 313.08ha cleared within 500m of the Project Area, most of which was within Protection Forest area for the purposes of coffee plantations and was unrelated to Project activities. Approximately 82ha of land was cleared within the Project Area.

By 2015, 93.95 ha were cleared and an additional 16.9 hectares was cleared by 2016 equalling a total of 110.95ha. The average annual rate of clearing over the 2 year period (2015 – 2016) was therefore 55.42ha (110.95/2). Given the area of forest within the 500m buffer of the project areas was approximately 2626ha (estimated 2015 extent), the induced clearing equates to 2.27% of this area ([59.63/2626]x[100/1]=2.27). Considering the average background induced clearing rate within Sumatra Selatan Province is 0.26% per annum, the

clearing rates for the Project AoI are considerably above background rates (2.27%per annum).

Visual interpretation of the imagery shown in ***Figure 3.2*** identifies that clearing within the 5km AoI as outlined has been relatively even in lower slopes and clearing has been associated with previously cleared areas. The installation of gates in 2015 has reduced access to the site and clearing has substantially reduced within the Concession area.

It is difficult to determine what clearing may have been project induced prior to 2015. Imagery also is not available to determine the amount of clearing prior to 2014 during the time of project exploration and the beginning of construction. Visual interpretation of the image suggests that there was minor clearing along the roads, especially near to the northern portion of the road loop. The estimated area of induced forest clearing along this section prior to 2014 is 5.5 hectares and should be considered as a residual impact due to the project.

No recent clearance for the establishment of coffee plantations or other agricultural activities was observed in areas of forest during ERM's 2017 site visit. The assessment of land clearing within the Project Area and AoI is shown in ***Figure 3.3***. Photographs from ERM's field assessment are shown in ***Photographs 3.1*** to ***3.2*** below.

Photograph 3.1 Coffee Plantation within the SERD Concession, established prior to 2013 (ERM 2017)

Photograph 3.2 Access Restrictions within the SERD concession (ERM 2017)

Figure 3.2 Aquatic Survey Sampling Locations

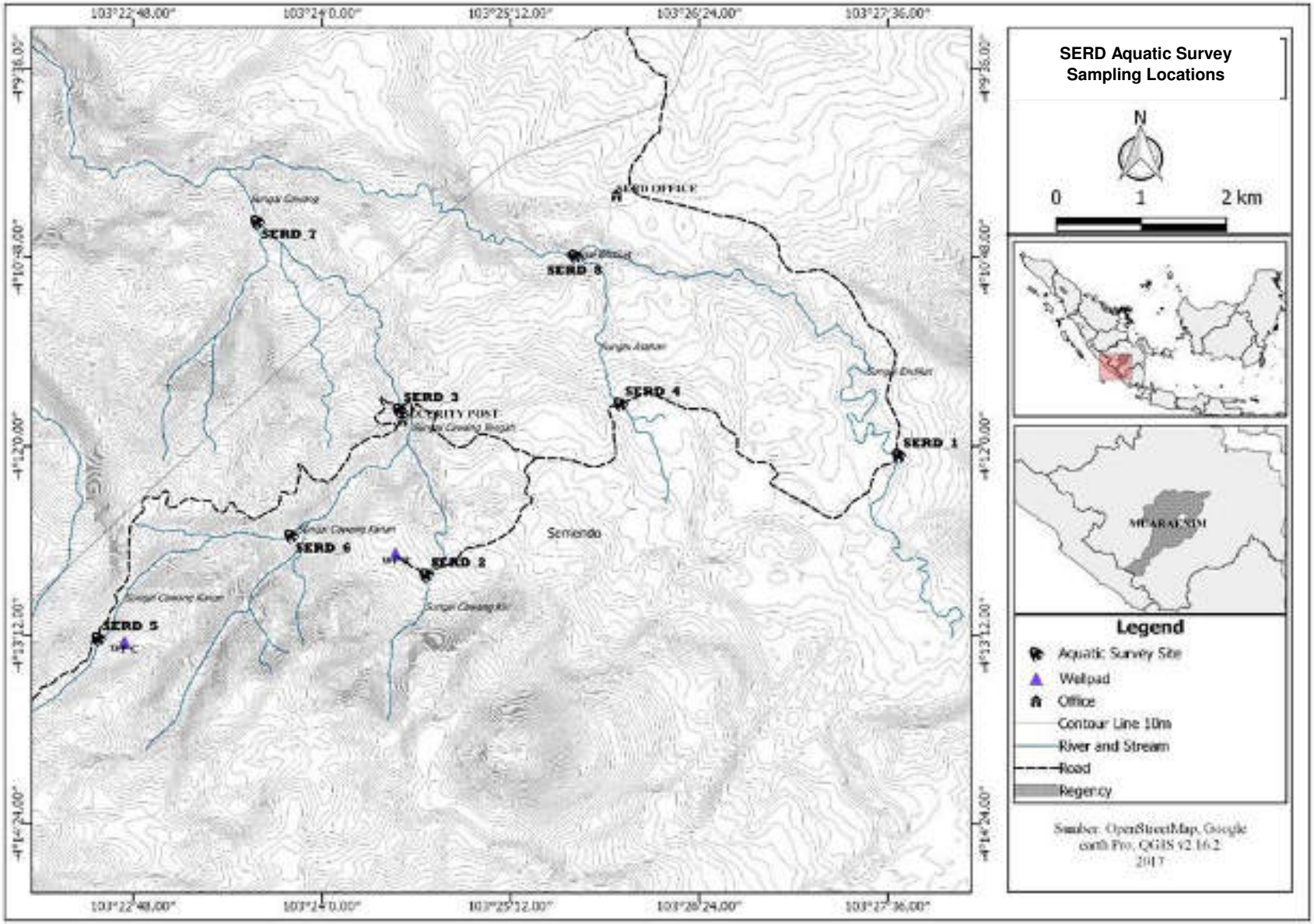
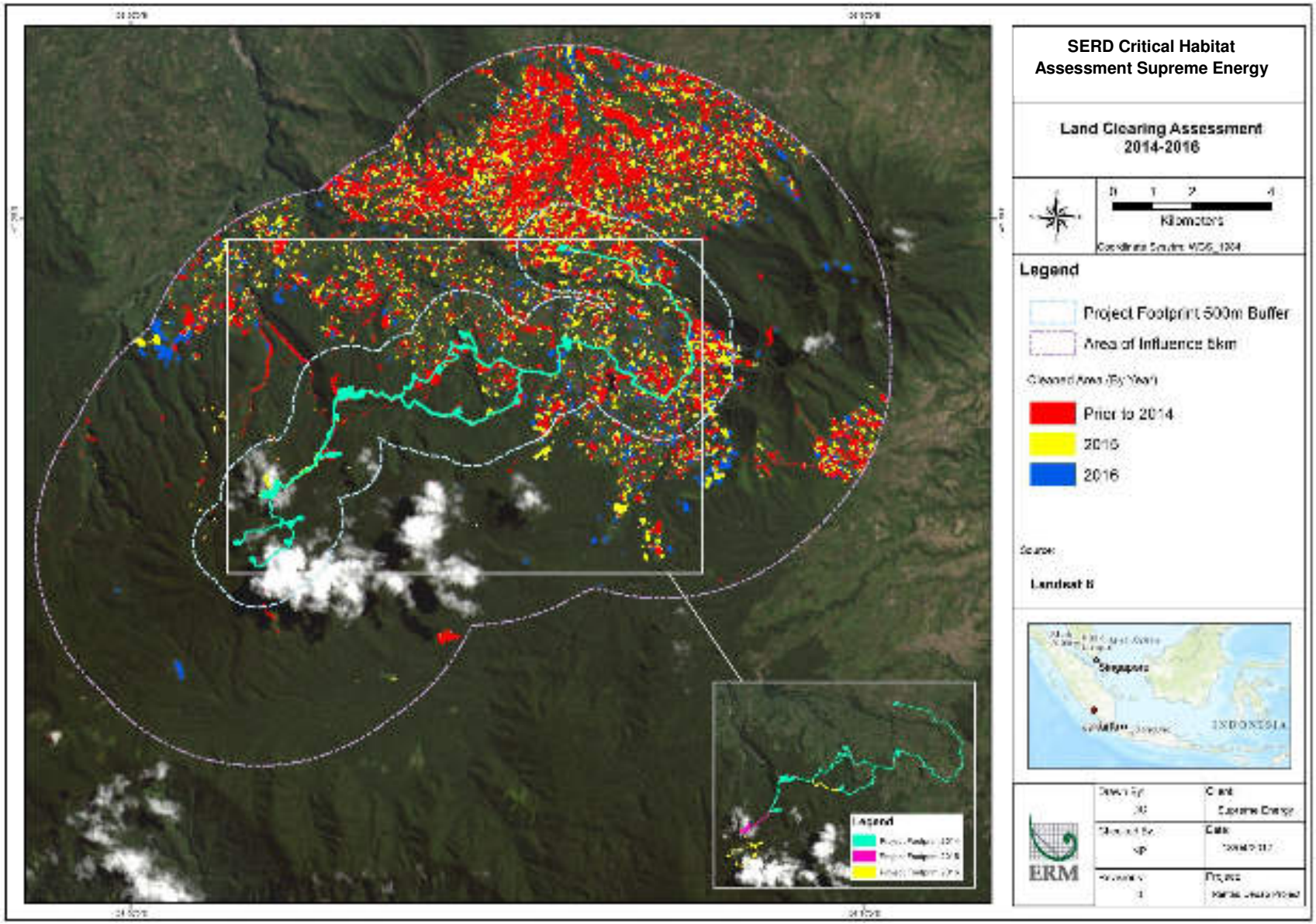


Figure 3.3 Land Clearing within the Project Area and AoI



3.2.5.3 *Land Classes*

Landcover types have been mapped using GIS for the Project Area and AoI. The landcover assessment used data available from the Indonesian Department of Forestry and other data available from GreenCap. Each landcover type has been classed as Natural Habitat or Modified Habitat according to the definition of Natural Habitat within the ADB Sourcebook. The following land class types within the Project Area have been identified and described in ***Table 3.5***. ***Figure 3.4*** shows the extent of land classes within the Project Area (note that only limited data was available for this assessment).

Table 3.5 Land Classes within the Project Area

Land Class	Description
Plantation	These area areas used for plantations; in the context of the project, plantations are mostly used for coffee cultivation.
Semi-rural/Urban	These are areas where human settlements have been established or land cleared for buildings. This includes areas that have been cleared for the establishment of plant facilities.
Freshwater habitat	This habitat can be found within the rivers and streams within the Project Area.
Montane forests	This habitat is found within and around the Project Area.

3.2.5.4 *Natural Habitat Mapping*

The spatial assessment Natural Habitat and Modified Habitat is based on the land class assessment undertaken for the Project Area and AoI. Remote sensing of satellite imagery to determine Natural Habitat extent was not available for the time period 2012-2013 due to LandSat7 satellite faults and lack of cloud free imagery.

Given an understanding of the species assemblages within each habitat/land class, natural-modified habitat classifications have been assigned as shown in ***Table 3.6***.

Table 3.6 Natural and Modified Habitats within the Project Area and Project AoI

Land Class	IFC PS6 Habitat Classification	Justification
Plantation	Modified	These areas are cultivated and retain little of their natural ecological function.
Semi-rural/Urban	Modified	Contains human settlements. Retains little natural ecological function.
Freshwater habitat	Natural	Majority of freshwater habitats within the Project Area and AoI remain natural and possess their original ecological function.
Montane forests	Natural	Continues to support assemblage of CR and EN species, including large mammals. Expected to retain natural ecological function.

The assessment was completed using the calculation of the footprint using remote sensing of the actual project area and may differ from the predicted areas contained within the ESIA.

The areas are shown in ***Table 3.7*** below. ***Figure 3.5*** shows the distribution of Natural Habitat and Modified Habitat areas within the Project Area and AoI.

Table 3.7 Natural and Modified Habitat within the Project Area and Area of Influence

	Area of Influence		Project footprint*	
	ha	%	ha	%
Natural Habitat	19810.66	89	72.63	53.90
Modified Habitat	2352.09	11	57.37	46.10
Total	22162.75	100	124.50	100.00

Note: * Includes the total area of all main Project components, Brine Pipeline and Transmission Line

Figure 3.4 Land Classes within the Project Area and Area of Influence (from GreenCap 2017)

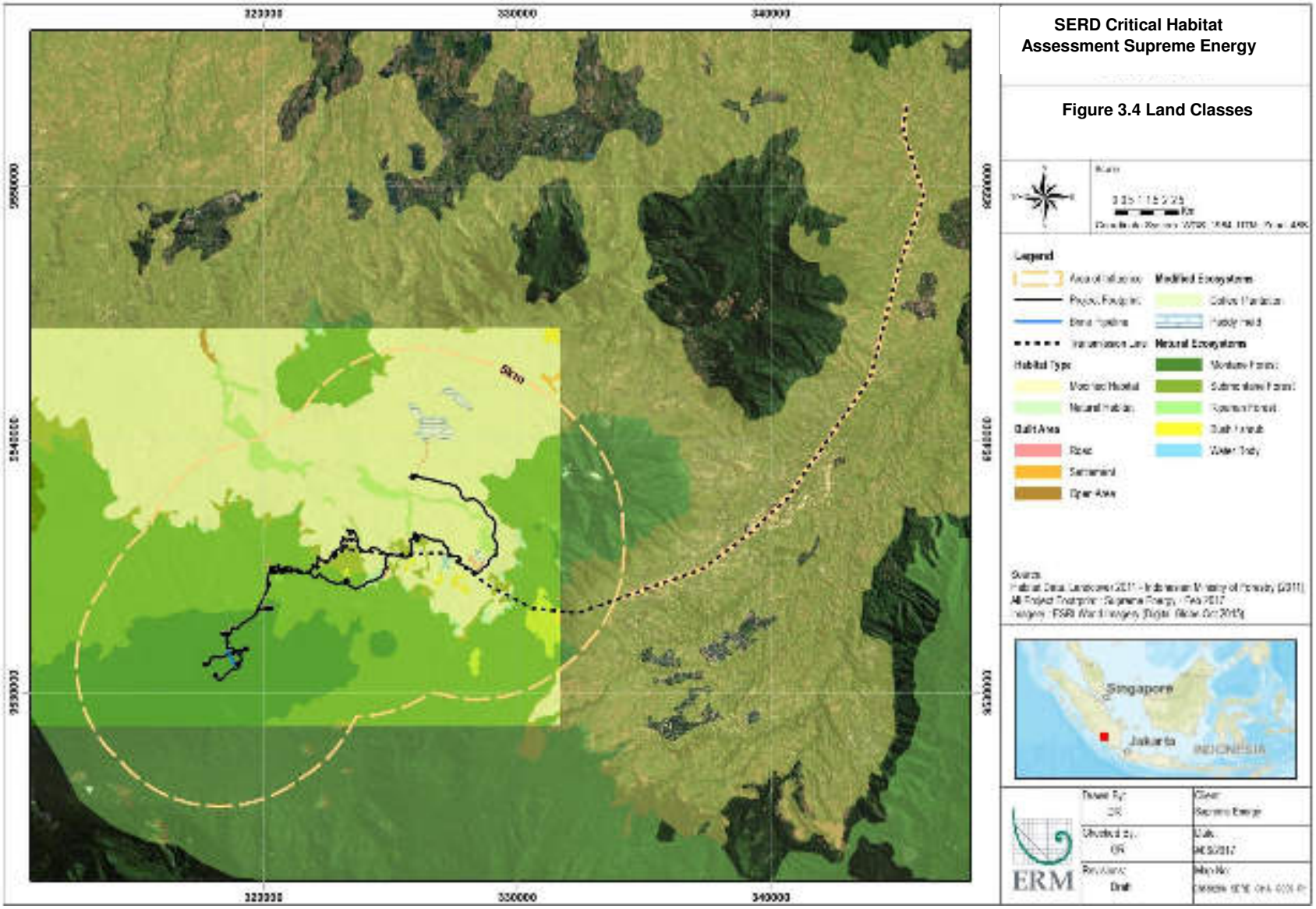
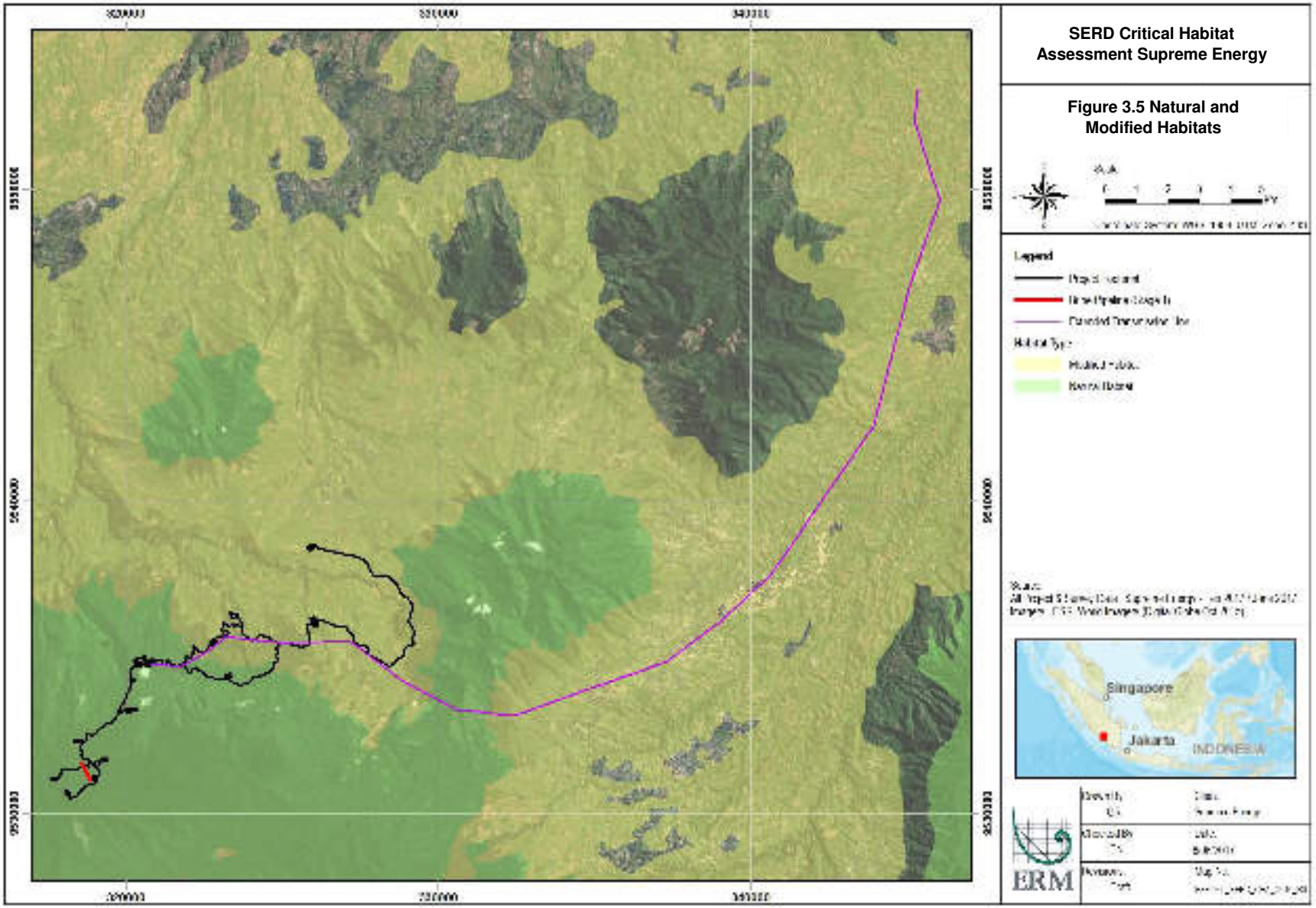


Figure 3.5 Natural Habitat and Modified Habitat within the Project Area and Area of Influence



3.3 ECOSYSTEM SERVICES BASELINE VALUES

This Section assesses the likely impacts to Ecosystem Services that may occur as a result of the development of the Project. The purpose of the assessment is to identify:

- Priority Ecosystem Services in the Project area;
- Potential and existing impacts to Priority Ecosystem Services; and
- Outline measures to avoid, minimise and mitigate impacts to Priority Ecosystem Services.

Ecosystem services are defined as the benefits that people, including businesses, derive from ecosystems (IFC 2012). These services are substantial and varied, underpinning basic human health and survival needs as well as supporting economics activities, the fulfilment of people's potential, and enjoyment of life.

In order to provide a uniform basis to assess the status of all major global habitat across all of the word's bioregions, the United Nation's Millennium Ecosystem Assessment (UN 2005) combine diverse Ecosystem Services typologies into a consistent classification scheme.

There are four categories of ecosystem services defined in Millennium Ecosystem Assessment as outlined in IFC Performance Standard 6:

- Provisioning Services; these services that can be extracted from ecosystem to support human needs. This term is more or less synonymous with the term " Ecosystem Goods" that was used in some prior classification schemes, including such tangible assets as fresh water, food, fibre, timber and medicinal plants;
- Regulating Services; the benefit obtained from an ecosystem's control of the natural environment, including of the regulation of surface water purification, carbon storage, and sequestration, climate regulation, protection from natural hazard, air quality, erosion and pests;
- Cultural Services; non-material benefits including diverse aspect of aesthetic, spiritual, recreational, and others cultural value; and
- Supporting services; the natural process essential to the maintenance of the integrity, resilience, and functioning of ecosystem, thereby supporting the delivery of all other benefits. They include soil formation, nutrient cycling, and primary production.

The IFC PSs require projects to assess and preserve the benefits from ecosystem services. The IFC also requires that the environmental and social risks and impacts identification process considers a project's dependence on ecosystem services. A fundamental component is to apply the mitigation hierarchy to determine measures to limit impacts on ecosystem services. ERM has utilized the World Resources Institute (WRI) Guidelines: *Weaving Ecosystem Service into Impact Assessment* to guide the approach used to assess ecosystem services in relation to the project.

Information used in this assessment is based on an ecosystem services assessment undertaken by ERM in October 2017. The results of the assessment are shown in *Annex D* and summarised below.

3.3.1 Community Surveys

ERM undertook the following consultation as part of ecosystem services assessment:

- Consultation meetings with internal SERD representatives (environment, social and management).
- Consultation with 15 local village representatives living in close proximity to Supreme Energy site location in Rantau Dedap from selected communities (3 villages); and
- Household survey questionnaires were used to gather data from the communities around SERD site locations to solicit their opinions on both the positive and negative aspects of the Project development. The data is relevant to understanding current socio-economic conditions in the Area of Influence of the Project, historical impacts associated with SERD project activities as well as potential issues associated with the on-going activities of the Project.

The topics addressed in the household surveys included:

- Basic household information (Individual);
- Group discussions focussed on the livelihoods of coffee small business women group; and
- Socio-economic system survey as a quantitative assessment of the level of reliance on natural resources by affected communities and the linkage between the subsistence economy and the livelihoods of affected communities.

Prior to conducting household surveys, an introductory meeting was convened in the host community to introduce the purpose of the consultation.

3.4 DATA COLLECTION

Data was collected through community meetings, household surveys and face to face discussions with stakeholders. Community meetings were arranged by Supreme Energy representatives in collaboration with the village leaders and other village representatives. The meetings provided an opportunity to gather feedback on SERD activities.

A total of fifteen (15) village representatives had discussions on their socio-economic conditions across three (3) villages with particular focus on the livelihoods of women and farmers. The details the surveys conducted are in ***Table 3.8***.

Table 3.8 Details of surveys conducted in project area.

Date	Name of Villagers	Occupation	Villages
06-10-17	Jutawan; H. Tawil; H. Ismail; Coffee small business woman's group	Village head; community leaders	Tunggul Bute
	Markun	Head of village	Rantau Dedap
07-10-17	Edi Prayitno	Religious leader	Talang Pisang
	Kaluri	Farmer/ traditional healer	Talang Pisang

In addition to conducting face-to-face interview with local villagers, ERM also conducted field observations. The field observations include the presence of Pamsimas (Indonesian Government program in clean water access and sanitation for local communities), rivers and site visits to Supreme Energy project activities.

Data was collected on screened in ecosystem services relevant to the community. Information was collated on:

- Type of ecosystem services used by the local community;
- Sources (locations), amounts utilised and availability of alternatives;
- Condition and trends in resource availability;
- Cultural and supporting ecosystem services;
- Screened ecosystem services for erosion, and;
- Non-use value of biodiversity

The results of the field surveys and ecosystem service prioritisation are shown in ***Table 3.9***.

Table 3.9 Results of Ecosystem Services Prioritization

Ecosystem Services	Trends and Sustainability	Beneficiaries	Importance to Beneficiaries	Irreplaceability	Potential Alternatives	Priority?
Provisioning Services						
Food: wild-caught fishes, shellfish, and aquaculture	The populations of wild-caught fishes appears to be in decline	All villages and villages within AoI of Rantau Dedap project area	Low	High	Communities in Rantau Dedap project have ready access to alternative protein sources such as chicken	Low
Food: wild meat	The populations of wild animal (deer) caught for meat appears to be in decline.	All villages and villages within AoI of Rantau Dedap project area	Medium	High	Communities in Rantau Dedap Village have ready access to alternative protein sources such as beef, fish, and chicken.	Low
Food: cultivated crops	The amount of main crops planted (coffee) and harvested within the Project AoI (Rantau Dedap) appears to be in fluctuating (decrease in wet season and increase in dry season)	All villages within AoI of Rantau Dedap project site location	High	Moderate	Besides crops from the community coffee plantation, the local people can plant other alternative plants such as vegetables	Low
Food: herbs and plants	The amount of herbs and plants available to the community from their farm/ plantation or house yard areas within the AoIs appears to be in stable.	All villages within AoI of Rantau Dedap project area	Medium	High	Replacements for herbs and plants collected are readily available within nearby markets or planted in local people farm/plantation or house yard	Low
Food: livestock farming	The amount of livestock farming available to the community from the local villager who lives in Rantau Dedap, Bapak Masrul Rohim who owns approximately 64 "garut" goats and they are increasing. The goats are sold during Islamic festive e.g. Eid Mubarak. While other villagers do raise cows and chicken in small amount.	All villages within AoI of Rantau Dedap project area	Medium	High	There alternatives for local villagers who own small amount of cows and chicken which they are for own consumption or to be sold to the market or their neighbors when needed.	Low
Biomass Fuel	Local villagers do not utilize biomass fuel for their daily cooking fuel from their livestock. Cow and chicken dung are utilized for crops fertilizer.	All villages within AoI of Rantau Dedap project area	Medium	High	Local villagers obtain organic fertilizer from seller who live outside villages (fertilizer store)	Low

Ecosystem Services	Trends and Sustainability	Beneficiaries	Importance to Beneficiaries	Irreplaceability	Potential Alternatives	Priority?
Timber and wood products	The amount of timber available to local people has been decreasing. There is a restriction from local government official (forestry) by establishing the local regulation/law to prohibit people entering forest. To overcome such issue, the timber and wood are planted in local villagers' farm or plantation.	All villages within AoI of Rantau Dedap project area	Medium	High	Potential alternatives exist for use by the villages such as bricks and cement which they can get from house building store in the city (outside Rantau Dedap) as road condition to and from the store is currently is in good condition. If the local people still need timber and wood for building houses, they buy it from house building store outside Rantau Dedap.	Low
Non- Timber Forest Products (NTFP)	Wild honey availability has been decreasing at AoI of Rantau Dedap	All villages within AoI of Rantau Dedap project area	Low	Moderate	Potential alternatives for use by villagers such as buying the honey from local market or supermarket.	Low
Freshwater	Currently, local communities utilize Deduruk small Lake and Endikat River for micro-hydro development and hygiene activities. If Rantau Dedap project utilizes local river or lake, it may likely impact to the river quantity and quality.	All villages within AoI of Rantau Dedap project area	High	Moderate	Spring water (Pamsimas program) and deep well are available for hygiene, cooking and drinking; however river water is still used for micro-hydro development.	High
Regulating Services						
Erosion regulation	The forest in Rantau Dedap project may provide stability to the slopes to reduce the chance of land slips and erosion	Supreme Energy has taken erosion management to prevent impacts of the affected villages downstream.	High	Moderate	Careful management of soil surfaces and river will be required to limit damage caused by erosion and mass movement (equipment mobilization).	High
Recreation and tourism	Sebidang Rindu waterfall. It is a nature creation and the water is not decreased even in the dry season.	Villagers who live in Tunggul Bute located within AoI of project area in Rantau Dedap (2 km)	Medium	Low	Local villagers very rarely visit the waterfall due to the location distance and access to the location is difficult.	Low
Cultural Services						
Spiritual, Religious or Cultural value	The availability of sacred sites (Puyang Lake and Belerang Hill) and they are considered as haunted places as well. Puyang Lake is located nearby well pad B, C, E, and I. While Belerang Hill is located in other district. Those places are nature and local villagers keep those two places sustainable.	All villages within AoI of project area in Rantau Dedap	Low	High	Local villagers embrace Islam and such sacred sites have never been visited by local villagers. In addition, Puyang Lake is located in Supreme Energy well pad, and there is likely a restriction to enter by the project in the future.	Low Low

Ecosystem Services	Trends and Sustainability	Beneficiaries	Importance to Beneficiaries	Irreplaceability	Potential Alternatives	Priority?
Ornamental resources	The coconut leaves are available in the villagers' farm/plantation as the coconut trees grow wildly.	All villages within AoI of Rantau Dedap project area	Low	High	Currently, local villagers very rarely use the coconut leaves for certain event, e.g. wedding party. Due to the influence of lifestyle modernization, local villagers decorate the certain event using trinkets made from colorful paper that is sold in the accessories shop for wedding party.	Low

3.4.1 *Priority Ecosystem Services*

The following priority ecosystem services shown in ***Table 3.10*** have been identified and will be assessed against the impact assessment procedures.

Table 3.10 Priority ecosystem services

Priority Ecosystem Service	Description
Freshwater	Evidence suggests that freshwater is used by local people from within the Project Area and AoI for irrigation system and micro-hydro development. The project may restrict or impact this activity. Impacts from the project activities may likely impact downstream due to utilization of river water, especially during the dry season due to decrease of water flows.
Erosion regulation	Evidence suggests that Rantau Dedap Project area of AoI has regulating erosion on slopes and riparian areas in the vicinity. The careful efforts in erosion control can provide stability to the slopes to reduce the chance of land slips and erosion. The land clearing and other related project activities might potentially change the river sedimentation and occurrence of erosion.

3.4.2 *Mitigation and management of priority ecosystem services*

To reduce the impacts on the priority ecosystem services, ERM proposed mitigations. At the mitigation stage, ERM identifies options through the mitigation hierarchy to enhance or at least maintain: (1) the well-being affected beneficiaries derive from ecosystem services and (2) the performance the project derives from ecosystem services at acceptable levels.

ERM has determined that the application of mitigations applicable to biodiversity values contained within this assessment is sufficient to reduce the impact to these ecosystem services to negligible or minor. As a result, no residual impacts have been identified on ecosystem services that require additional mitigation and offsetting. The proposed mitigations are outlined in ***Table 3.11***.

Table 3.11 Proposed Ecosystem Service Mitigations

Priority Ecosystem Services	Affected Stakeholder	Predicted Impacts on Ecosystem Service Benefit	Mitigation Measures (minimization)
Freshwater	Local villagers	Reduced water quantity and quality due to water utilization* by the SERD project where local villagers use the freshwater for hygiene activities and development of micro-hydro power.	- Freshwater use impacts can be reduced by utilizing dry cooling or by using non-freshwater sources as a cooling medium. A non-freshwater sources such as utilization of groundwater; - Freshwater use impacts can be reduced by utilizing groundwater source for washing and bathroom facilities
Erosion Regulation	Local villagers	Sediment carried in waters drained from roads and also soil sedimentation includes damage to provisioning value streams or rivers.	- Road and trail construction will not block drainage systems or water courses. Culverts or other suitable crossings will be installed in drainages, and roads will be drained or water barred as necessary to prevent erosion; - All roads planned for permanent or long-term use will be adequately gravelled or paved; - Roads, well pads, building and associated structured will be located and designed to require minimum earth movement for their construction; - All disturbed areas will be seeded, mulched, and fertilized for adequate protection from rain and run-off. Where feasible, native vegetation will be included in the prescription to restore the natural setting and to take advantage of normal ecological relationships; - Adequate erosion control and drainage measures will be required on disturbed sites to minimize soil movement and sedimentation of water courses.

3.5 PRIORITY BIODIVERSITY VALUES

Specific to biodiversity values this assessment considered two key guideline documents:

- Asian Development Bank (ADB) Policy Paper June 2009 Safeguard Policy Statement; and
- International Finance Corporation (IFC) Performance Standard (PS) 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources January 2012 and associated Guidance Note (January 2012).

The key features required for assessment by these guidelines include protected areas, natural and modified habitat, critical habitat, invasive species and ecosystem services. This section details these values based on the baseline information collated by Greencap (2016), the 2017 flora and fauna surveys conducted at the transmission line and brine pipeline, available desktop sources and geospatial analysis.

3.5.1 Legally Protected and Internationally Recognised Areas

Protected areas associated with the Project Area are discussed in this section and shown in ***Figure 3.6***.

3.5.1.1 Protected Areas

There are no IUCN category protected areas mapped within the Project Area or Project AoI. The desktop review identified the following Protected Areas within a 50 km radius of the Project Area:

- Bukit Barisan Selatan National Park (BBSNP), 60km southeast (IUCN Category II);
- Gumai Tebing Tinggi Wildlife Reserve, 25 km northwest (IUCN Category IV);
- Isau Isau Wildlife Reserve, 15 km northeast (IUCN Category IV);
- Bukit Rabang Grand Forest Park, 60km west (IUCN Category VI); and
- Kaur Marine Area, 100km southwest (IUCN Category VI).

3.5.1.2 World Heritage Areas (WHA)

There are no World Heritage Areas mapped within AoI or the Project Area.

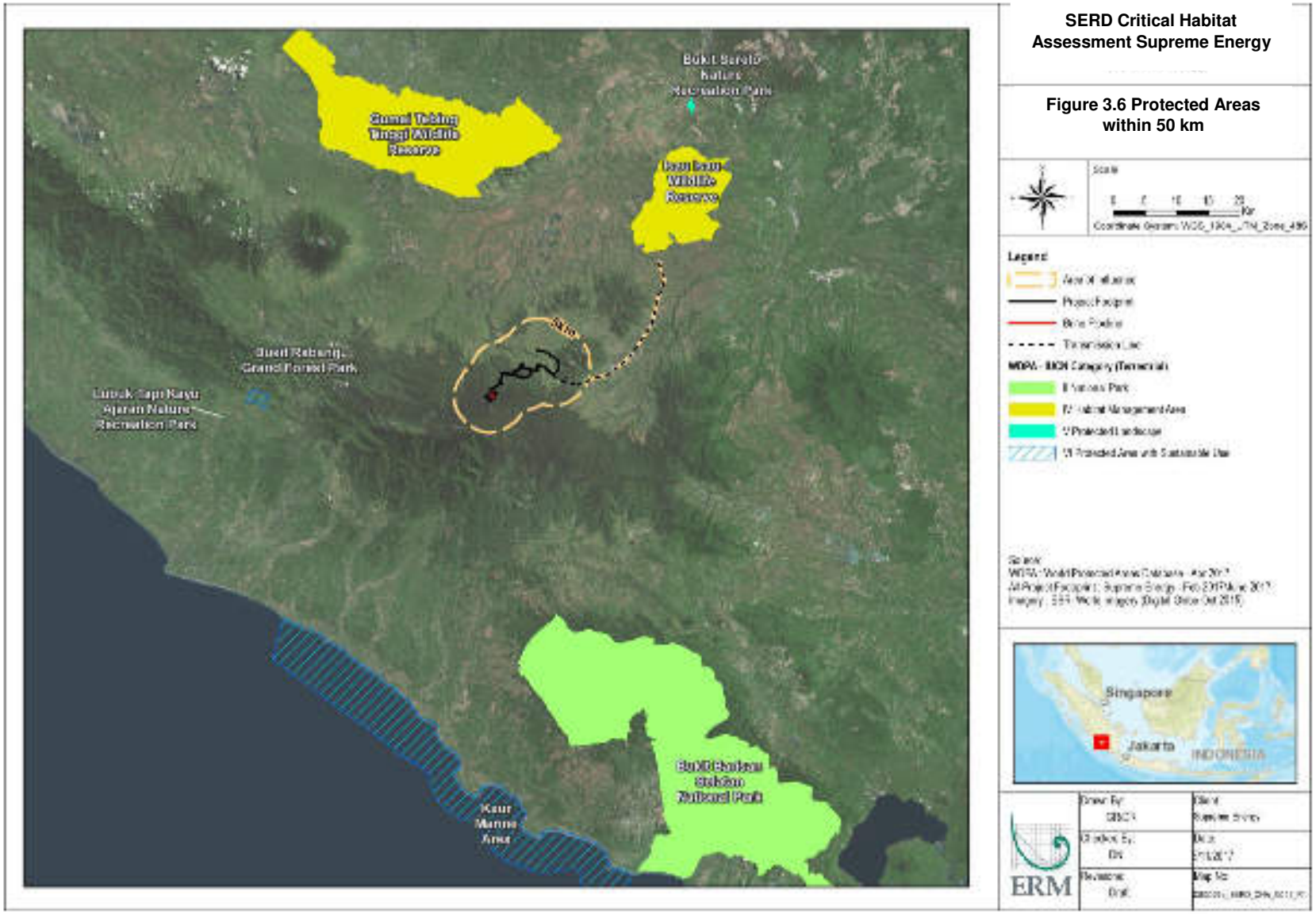
3.5.1.3 Key Biodiversity Areas

There are no Key Biodiversity Areas mapped within AoI or the Project Area.

3.5.1.4 Alliance for Zero Extinction (AZE) Sites

There are no AZE sites mapped within AoI or the Project Area.

Figure 3.6 Location of Legally Protected and Internationally Recognised Areas within 50km of the Project Area



3.5.1.5 *RAMSAR Sites*

There are no RAMSAR sites mapped within the AoI or the Project Area.

3.5.1.6 *World Wildlife Fund EcoRegions*

The Project Area is located within the Sumatran Montane Rain Forests ecoregion. This type is recognised as part of the Global 200 ecoregions, those ecosystems represent the most outstanding and representative areas of biodiversity. (WWF, 2017)

The ecoregion is noted to represent the montane forests (>1000 m) along the Barisan Mountain Range. There are several large blocks of intact forest and numerous protected areas. Seven mammal and eight bird species are endemic to this ecoregion including mammals: North Sumatran leaf monkey (*Presbytis thamasi*), Sumatran flying squirrel (*Hylopetes winstoni*), Sumatran shrewlike mouse (*Mus crociduroides*), Sumatran mountain rat (*Rattus korinchi*), Sumatran mountain maxomys (*Maxomys hylomyoides*), Broad-nosed Sumatran maxomys (*Maxomys inflatus*) and Sumatran striped rabbit; and birds: Red-billed partridge (*Arborophila rubrirostris*), Salvadori's pheasant, Sumatran ground-cuckoo, Schneideri's pitta, Sumatran drongo (*Dicrurus sumatranus*) and Sumatran cochoa. (WWF, 2017)

Several other mammal species are found in the ecoregion including numerous primate species, siamang, dhole, Malayan sun bear, clouded leopard and Sumatran tiger (WWF, 2017).

3.5.1.7 *Tiger Conservation Landscapes*

In 2006, conservationists, scientists and NGOs jointly produced a document outlining the priorities for the conservation and recovery of wild tigers from 2005 to 2015. Two strategies for tiger conservation were identified: the protection of a few tiger populations within reserves, and the preservation of tiger landscapes. These landscapes, known as Tiger Conservation Landscapes, are defined as core habitats linked with corridors that 'allow the ecological requirements of wild tigers to be conserved'[1]. At the date of the publication, 76 TCLs have been identified of which 12 are located in Sumatra, occupying approximately 88,000 km^2. Following the publication of this report, there have been subsequent studies providing evidence of the presence of Sumatran tigers in forested areas outside the delineated TCLs. This includes a 10-year Conservation Strategy and Action Plan for the Sumatran Tiger (2007 – 2017) developed by the Indonesian Ministry of Forestry. The strategy states that there are at least 18 areas, including the 12 TCLs, where the Sumatran tiger can be found. Surveys of 8 of these areas have produced population estimates of a minimum of 250 individuals. A previous

[1] Dinerstein, E., C. Loucks, A. Heydlauff, E. Wikramanayake, G. Bryja, J. Forrest, J. Ginsberg, S. Klenzendorf, P. Leimgruber, T. O'Brien, E. Sanderson, J. Seidensticker and M. Songer. 2006. Setting Priorities for the Conservation and Recovery of Wild Tigers: 2005–2015. A User's Guide. WWF, WCS, Smithsonian, and NFWF-STF, Washington, D.C. – New York.

population estimate in 1992 reported 400 tigers from seven protected areas[2] and 100 tigers in unprotected areas. An IUCN summary of all population studies of the Sumatran Tiger from 1994 to 2007 conducted at various localities placed the total population at 441 to 679 individuals[3].

The DMU (1,477 km^2) falls within the Bukit Balai Rejang Selatan Tiger Landscape, occupying approximately 38% of the total TCL area of 3,884 km^2. This TCL is classified as a Class II landscape and of importance to tiger conservation strategy at a regional level[4]. Specific population information for the Sumatran Tiger in Bukit Balai Rejang Selatan TCL is not available. However the population size of tigers in Bukit Barisan Selatan National Park, which overlaps significantly with the southern part of the TCL, was reported to be 40 – 43 across an area of 3,650 km^2 (1.6 adults / 100 km^2) in 2003. While Bukit Barisan Selatan National Park does not fall within the DMU, it shares occupancy of the TCL with the DMU. Tiger densities at the National Park have thus been used to approximate tiger populations within the DMU.

With an estimated density of 1.6 adults / 100 km^2, the DMU would be capable of supporting a maximum of 23 tigers. This estimate should be viewed in consideration of the (i) age of the data – the density estimate was derived in 2003 and threats to tigers would have escalated since then, and (ii) unprotected status of the forests within the DMU, meaning there is likely a lack of enforcement of conservation measures. There is also a general trend of decreasing density at with increasing elevation[5] and it is noted that the project area consists of high elevation montane forest of 1,000 m to 2,600 m asl. This therefore suggests that the estimate of 23 tigers is highly conservative and optimistic. The location of the Tiger Conservation Landscape in relation to the Project Area is shown in ***Figure 3.7***.

3.5.1.8 Nationally Recognised Areas

The total Project Area is approximately 124.5ha. One hundred and fifteen (115) ha of the Project Area is mapped as Protection Forest and an additional 9.5ha is "Non-Forest Area". The extent of Forest Classifications under Indonesian classifications is shown in ***Figure 3.8***.

The Project Area is entirely mapped as within the Indonesian Government Forest Clearing Moratorium Area. It should be noted that this regulation does not apply to energy projects within Indonesia (Presidential Instruction No 6 year 2017 of The Moratorium of Permit Approval for Primary Forest and Peat-land).

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[2] These areas are: Gunung Leuser, Kerinci Seblat, Way Kambas, Berbak, South Bukit Barisan, Kerumutan and Rimbang.

[3] Linkie M, Wibisono HT, Martyr DJ and Sunarto S, 2008. *Pantera tigris* spp. *sumatrae*. The IUCN Red List of Threatened Species 2008. Retrieved from http://www.iucnredlist.org/details/summary/15966/0

[4] A Class II landscape is defined as one that contains sufficient habitat for 50 tigers and experiences moderate levels of threat that can be mitigated over the next 10 years. The TCL is considered of significance to the bioregional tiger conservation strategy as there is a moderate probability of persistence of tiger populations over the long term. The goal for a TCL of regional priority would be to be restored to Class I status (ie. Support at least 100 tigers with evidence of breeding and minimal to moderate levels of threat) in 10 years.

[5] Linkie M, Chapron G, Martyr DJ, Holden J and Leader-Williams N, 2006. Assessing the viability of tiger subpopulations in a fragmented landscape. Journal of Applied Ecology 43, 576-586.

3.5.1.9 *Indonesian Forestry Classifications*

The forest classifications for the Project Area have been defined under the Government of the Republic of Indonesia Forestry Law (No. 41 of 1999). The main forest class types include: Production Forest; Protection Forest; Converted Production Forest; and Nature Reserve.

The Study area is primarily classified as Protection Forest. Supreme Energy Rantau Dedap has been authorised to undertake activities within the Protection Forest and has been issued a permit under the Forestry Act, subject to conditions (Approval Number 27/1/IPPKH-PB/PMA/2017). A copy of the permit is shown in ***Annex C***.

It should be noted that the local community has historically and continues to clear Protection Forest within the vicinity of the Project Area for agricultural activities, including the establishment of coffee plantations.

The forest types and definitions as outlined in the Forestry Law are contained in ***Table 3.12***. The extent of forest classifications under the Forestry Law is shown in ***Figure 3.9***.

Table 3.12 Forest Classifications under the Indonesian Forestry Law (1999)

Forest Classification	Definition	Prohibited Actions
Production Forest	Production forest we mean forest area with main function to yield forest produces.	Forestry activities permitted
Protection Forest	Protected forest we mean forest area with main function to protect life buffer system to arrange water management, prevent flood, erosion, prevent brine water intrusion, and maintain land fertility.	Forest clearing activities prohibited unless authorised
Nature Reserve Forest	Nature reserve forest area we mean forest with typical characteristics, with main function to preserve bio-diversity and ecosystem thereof and also as life buffer system.	Forest clearing activities prohibited unless authorised
Non-Forest Area	Area that may be used for other purposes apart from forestry related activities	All activities permitted

Figure 3.7 Tiger Conservation Landscapes

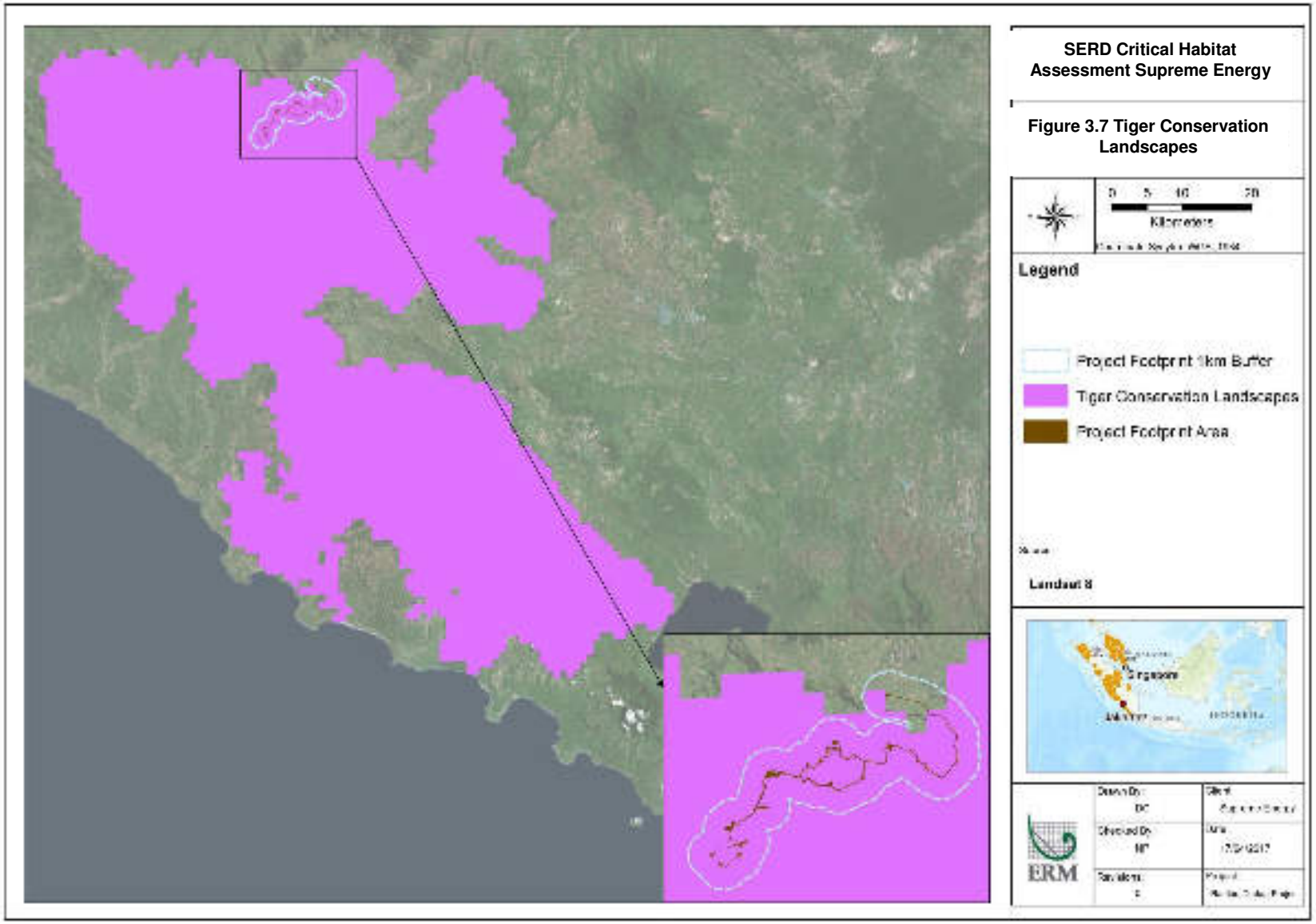


Figure 3.8 Indonesian Forest Moratorium Area

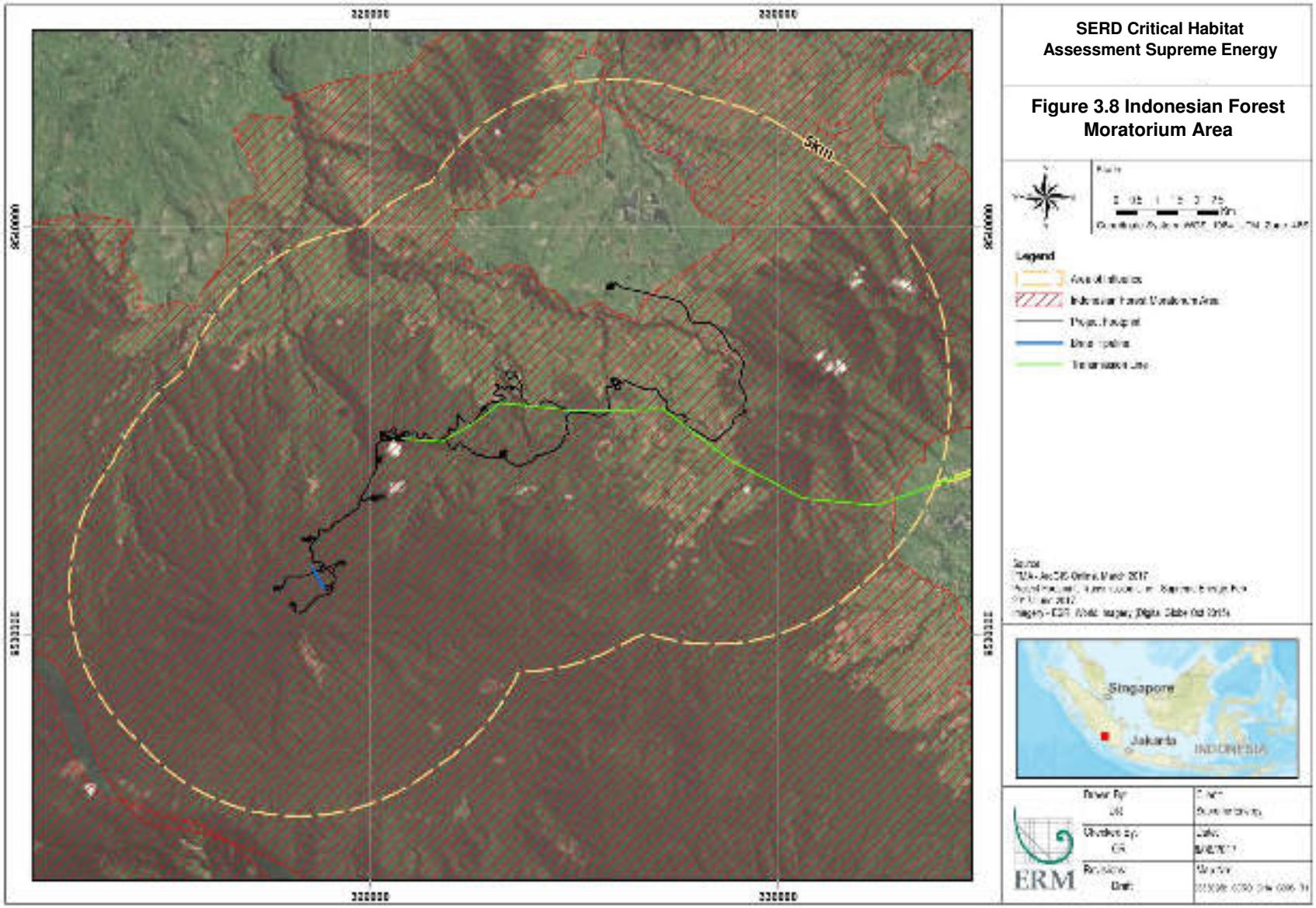
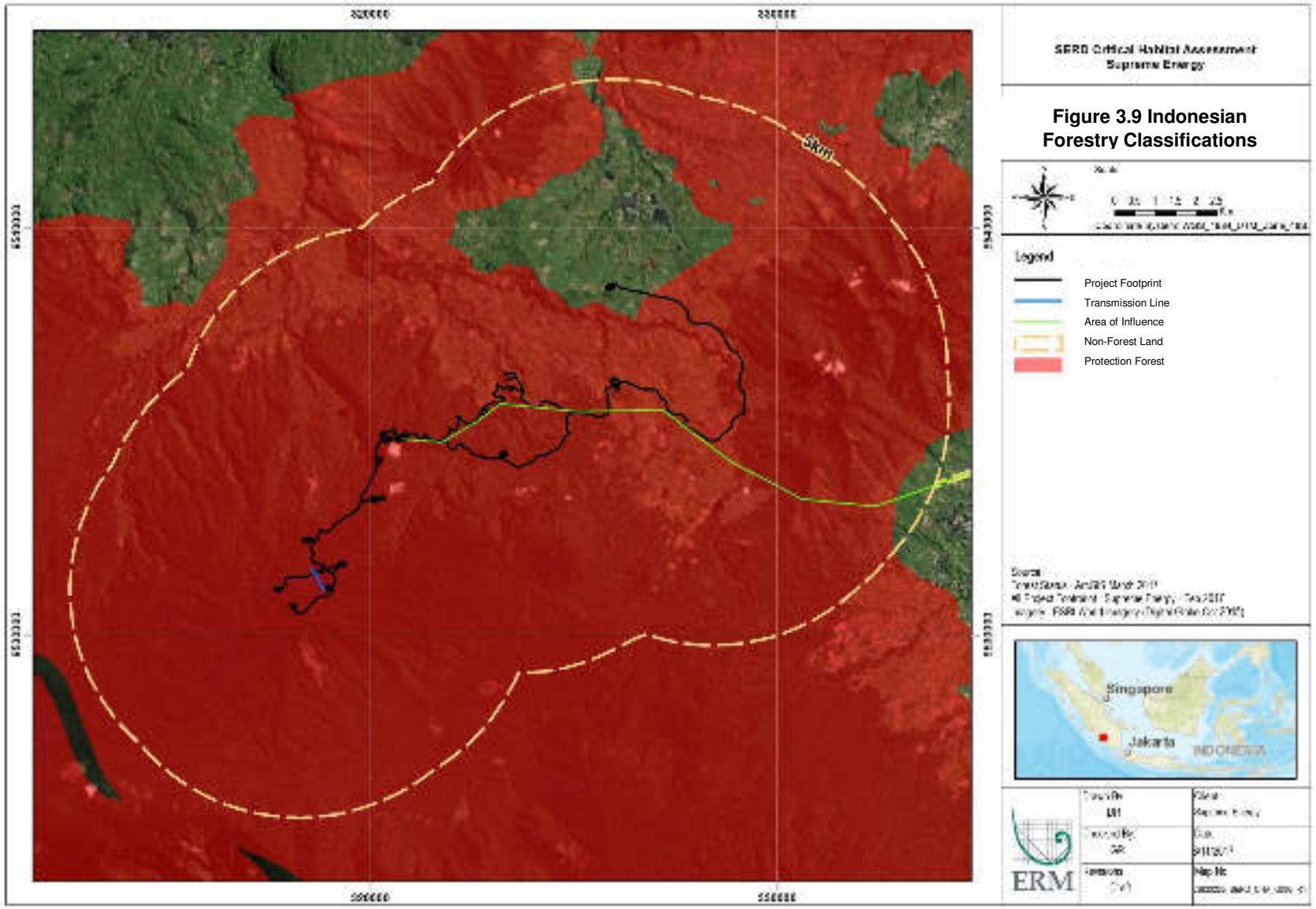


Figure 3.9 Indonesian Forestry Classifications within the Project Area and AoI



3.5.2 Threatened Species

Threatened species are identified as those listed on the IUCN Red List of Threatened Species and where relevant species are afforded equivalent conservation protection nationally. The IUCN Red List of Threatened Species provides taxonomic, conservation status and distribution information on flora and fauna that have been evaluated using the IUCN Red List categories and criteria. The criteria identify three categories of threatened species:

- Critically Endangered (CR);
- Endangered (EN); and
- Vulnerable (VU).

Five (5) additional categories of flora and fauna are included in the IUCN Red List however species categorized as CR, EN and VU are considered to be at a heightened risk of extinction and are awarded an elevated level of consideration under the IFC Performance Standards.

Species identified as endemic, restricted range, migratory and/or congregatory according to the relevant IUCN species profiles are also listed in order to assess against the IFC PS6 Critical Habitat thresholds.

Where species have not yet been evaluated by IUCN the protection status has been considered. Species listed as Protected under Indonesian law (and not evaluated by IUCN) are also considered 'threatened species' for the purposes of this assessment.

Threatened species that were identified specific to the Area of Influence and Project Area are shown in ***Table 3.13*** below. Where record locations are available they are shown in and ***Table 3.10*** to ***3.13***. Other threatened species identified through desktop review have been included as part of critical habitat assessment (***Section 3.5.4***).

Table 3.13 Threatened Species identified or likely to occur within the AoI

Scientific Name	Common Name	Type	IUCN Listing	Protected (Indonesia)	Endemic	Migratory/ Congregatory	Source
Dipterocarpus grandiflorus	-	Tree	CR				2016 Observation
Haemocharis integerrima	-	Tree	NA		x		2015 Observation
Rafflesia bengkuluensis	-	Parasitic	NA		x		Not recorded but identified with potential as part of baseline report
Taxus sumatrana	-	Plant	EN				2016 Observation
Saurauia cauliflora	-	Tree	VU				2017 Observation
Nepenthes rafflesiana	-	Shrub	LC	x			2017 Observation
Amorphophallus beccarii	-	Tree	NA		x		2017 Observation
Vanda foetida	-	Epiphyte	NA		x		2017 Observation
Apalharpactes mackloti	Sumatran trogon	Bird	LC		x		2016 Observation
Arborophila rubrirostris	Red-billed partridge	Bird	LC		x		2014 Observation and 2016 Observation, WWF Ecoregion species
Carpococcyx viridis	Sumatran ground-cuckoo	Bird	CR		x		WWF Ecoregion species
Cochoa beccarii	Sumatran cochoa	Bird	VU		x		WWF Ecoregion species
Dicrurus sumatranus	Sumatran drongo	Bird	NT		x		WWF Ecoregion species
Garrulax bicolor	Sumatran laughingthrush	Bird	EN		x		Not recorded but identified with potential as part of baseline report
Gallinula chloropus	Common moorhen	Bird	LC			x	2014 Observation
Halcyon chloris	Collared Kingfisher	Bird	LC	x			2017 Observation
Hydrornis schneideri	Schneider's pitta	Bird	VU		x		WWF Ecoregion species
Lophura inornata	Salvadori's pheasant	Bird	NT		x		WWF Ecoregion species
Motacilla cinerea	Grey wagtail	Bird	LC			x	2014 Observation
Muscicapa dauurica	Asian brown flycatcher	Bird	LC			x	2014 Observation
Myophonus melanurus	Shiny whistling-thrush	Bird	LC		x		2016 Observation
Padda oryzivora	Java sparrow	Bird	VU				2014 Observation and 2016 Observation
Pericrocotus miniatus	Sunda minivet	Bird	LC		x		2014 Observation; 2017 Observation
Pernis ptilorhynchus	Oriental honey buzzard	Bird	LC			x	2014 Observation
Polyplectron chalcurum	Bronze-tailed peacock-pheasant	Bird	LC		x		2014 Observation and 2016 Observation
Spilornis cheela	Crested-serpent Eagle	Bird	LC		x		2017 Observation
Trichastoma buettikoferi	Sumatran babbler	Bird	NT		x		Not recorded but identified with potential as part of baseline report
Ficedula hyperythra sumatrana	Snowy-browed Flycatcher	Bird	LC		x		2016 Observation
Arctictis binturong	Binturong	Mammal	VU				WWF Ecoregion species
Arctonyx hoevenii	Sumatran hog badger	Mammal	LC		x		2014 Observation; 2016 Observation
Capricornis sumatraensis	Sumatran serow	Mammal	VU				2016 Observation; 2017 Observation

Scientific Name	Common Name	Type	IUCN Listing	Protected (Indonesia)	Endemic	Migratory/ Congregatory	Source
Cuon alpinus	Dhole	Mammal	EN				2016 Observation, WWF Ecoregion species
Helarctos malayanus	Malayan sun bear	Mammal	VU				2016 Observation, WWF Ecoregion species; 2017 Observation
Hylobates agilis	Agile gibbon	Mammal	EN				Target species determined not to occur based on the field survey.
Hylopetes winstoni	Sumatran flying squirrel	Mammal	DD		x		WWF Ecoregion species
Manis javanica	Malayan pangolin	Mammal	CR				2016 Observation, WWF Ecoregion species
Maxomys hylomyoides	Sumatran mountain maxomys	Mammal	DD		x		WWF Ecoregion species
Maxomys inflatus	Broad-nosed Sumatran maxomys	Mammal	VU		x		WWF Ecoregion species
Muntiacus montanus	Sumatran mountain muntjac	Mammal	DD		x		2016 Observation
Muntiacus muntjac	Barking Deer	Mammal	LC	x			2017 Observation
Mus crociduroides	Sumatran shrewlike mouse	Mammal	DD		x		WWF Ecoregion species
Nesolagus netscheri	Sumatran striped rabbit	Mammal	VU		x		WWF Ecoregion species
Panthera tigris sumatrae	Sumatran tiger	Mammal	CR		x		2016 Observation, WWF Ecoregion species
Pardofelis marmorata	Marbled cat	Mammal	VU				2016 Observation
Presbytis melalophos	Sumatran surili	Mammal	EN		x		2014 Observation, WWF Ecoregion species; 2017 Observation
Pteromyscus pulverulentus	Smoky flying squirrel	Mammal	EN				Predicted to occur by threatened species report
Rattus korinchi	Sumatran mountain rat	Mammal	DD		x		WWF Ecoregion species
Rusa unicolor	Sambar	Mammal	VU				2016 Observation
Symphalangus syndactylus	Siamang	Mammal	EN				2016 Observation, WWF Ecoregion species; 2017 Observation
Tapirus indicus	Malayan tapir	Mammal	EN				2016 Observation, WWF Ecoregion species
Hylobates agilis	Agile Gibbon	Mammal	EN				2016 Observation, WWF Ecoregion species
Calamaria margaritophora	Stripe-necked reed snake	Reptile	DD		x		Not recorded but identified with potential as part of baseline report
Iguanognathus werneri	Spatula-toothed snake	Reptile	DD		x		Not recorded but identified with potential as part of baseline report
Ophiophagus hannah	King cobra	Reptile	VU				2014 Observation and 2016 Observation
Python reticulatus	Reticulated python	Reptile	VU				2014 Observation and 2016 Observation
Typhlops hypsobothrius	Sumatra worm snake	Reptile	DD		x		Not recorded but identified with potential as part of baseline report
Chalcorana crassiovis	Kerinci frog	Amphibian	DD		x		2016 Observation
Rhacophorus bifasciatus	-	Amphibian	NT		x		Not recorded but identified with potential as part of baseline report
Tor tamboides	Mahseer Fish	Fish	DD			x	2016 Observation

CR = Critically Endangered; EN = Endangered; VU = Vulnerable; DD = Data Deficient; Mig = Migratory; NA = Not Assessed

2014 Obs = Direct observations reported for biodiversity study (reported in Greencap, 2017); 2016 Obs = Direct observations reported for biodiversity study (reported in Greencap, 2017);

WWF Ecoregion species = key species noted for the Sumatran Montane Rain Forests Ecoregion.

3.5.3 Data Gaps in Existing Survey Data

From the data available from studies undertaken for other projects within Sumatra there is a high likelihood of endemic flora species occurring within the Project Area. Therefore there is a possibility that a number of endemic species may not have been recorded within the Project Area by previous studies.

To overcome this gap, management measures have been developed to implement a precautionary approach a requirements to conduct pre-clearance surveys and assessments prior to the next phase of construction. This approach aims to detect conservation significant endemic flora prior to disturbance and allow for avoidance, translocation or seed harvest to be undertaken.

Figure 3.10 Location of Critically Endangered Species records (Greencap, 2017)

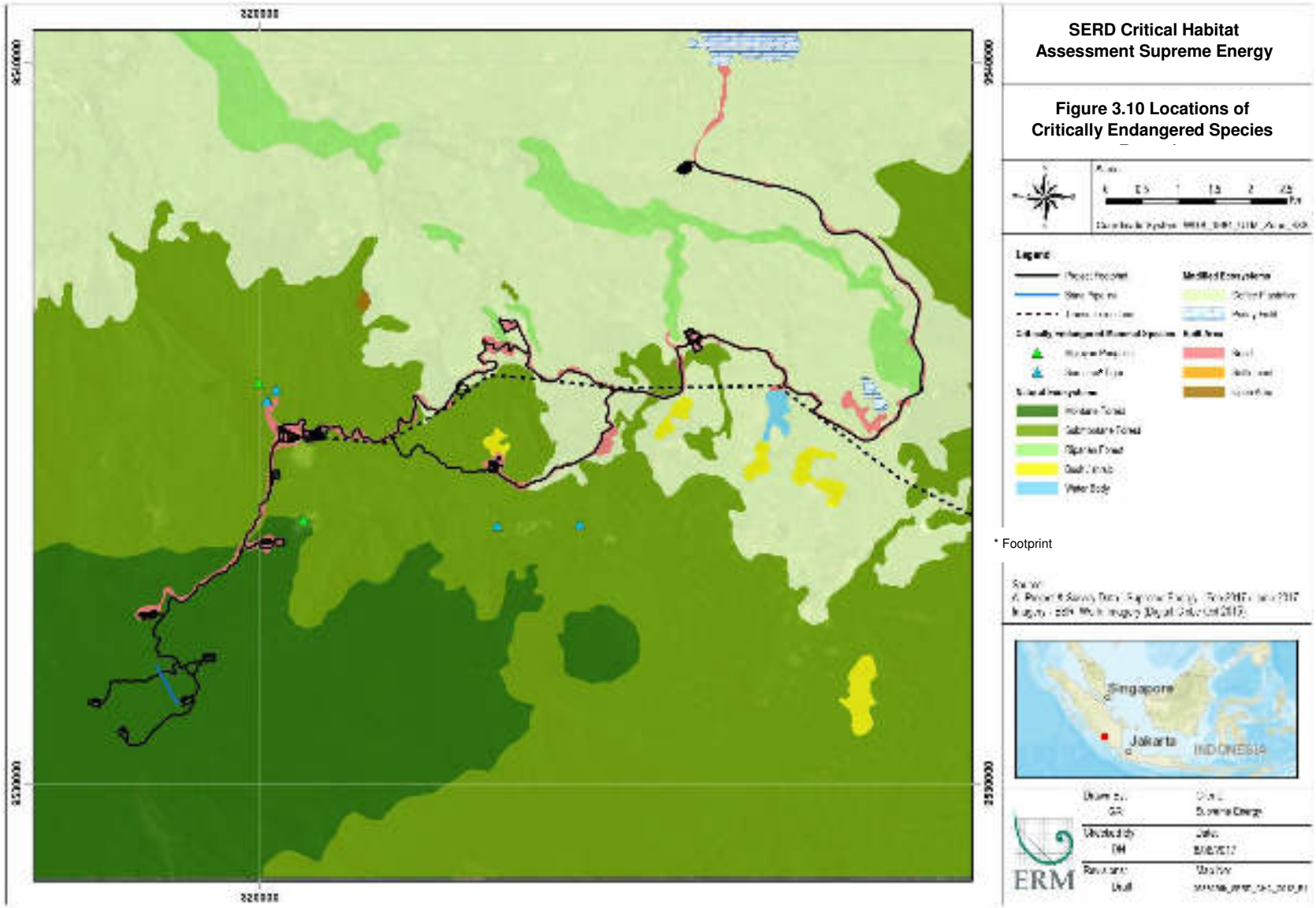


Figure 3.11 Location of Endangered Species records (Greencap, 2017)

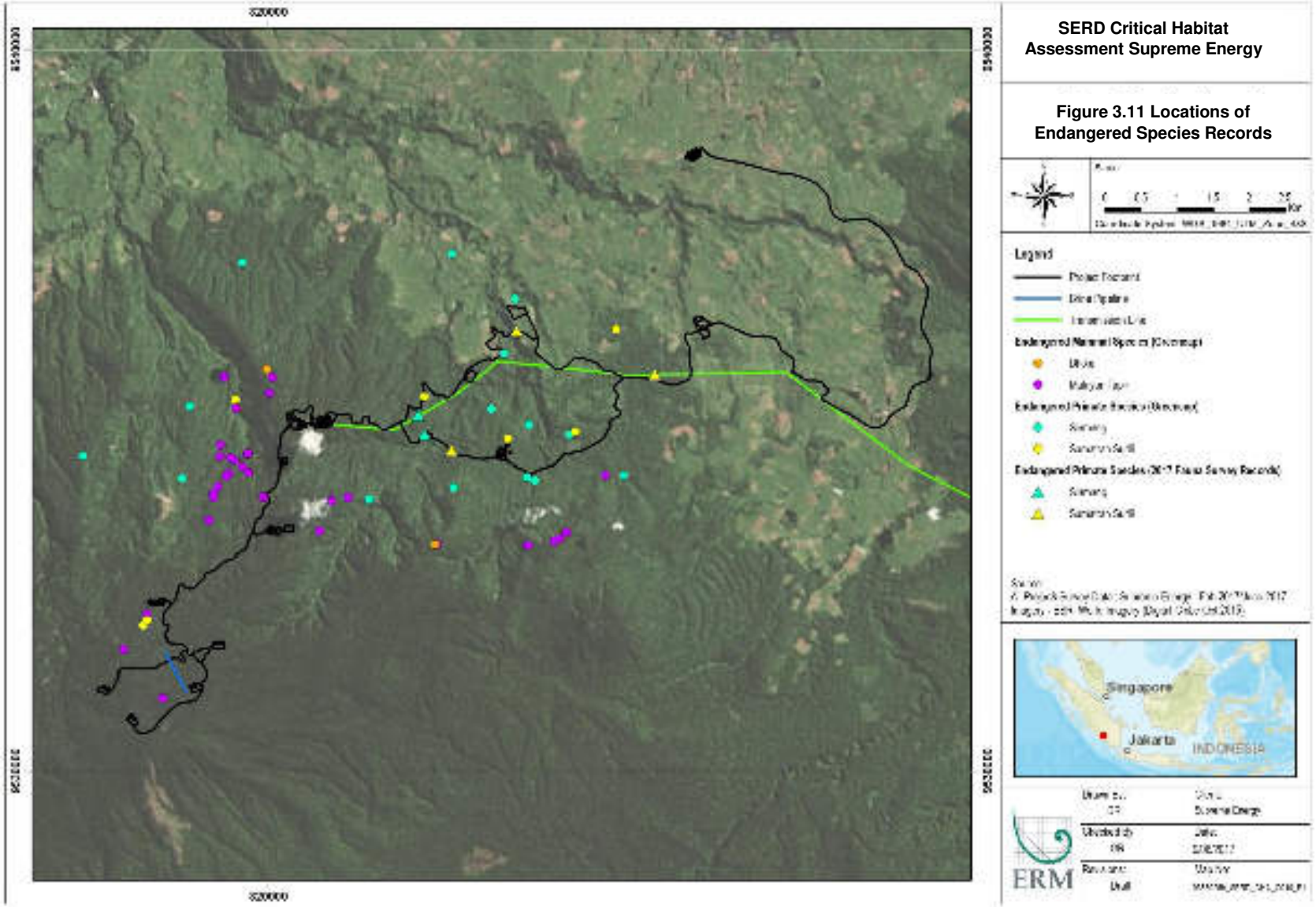


Figure 3.12 Location of Vulnerable Species records (Greencap, 2017)

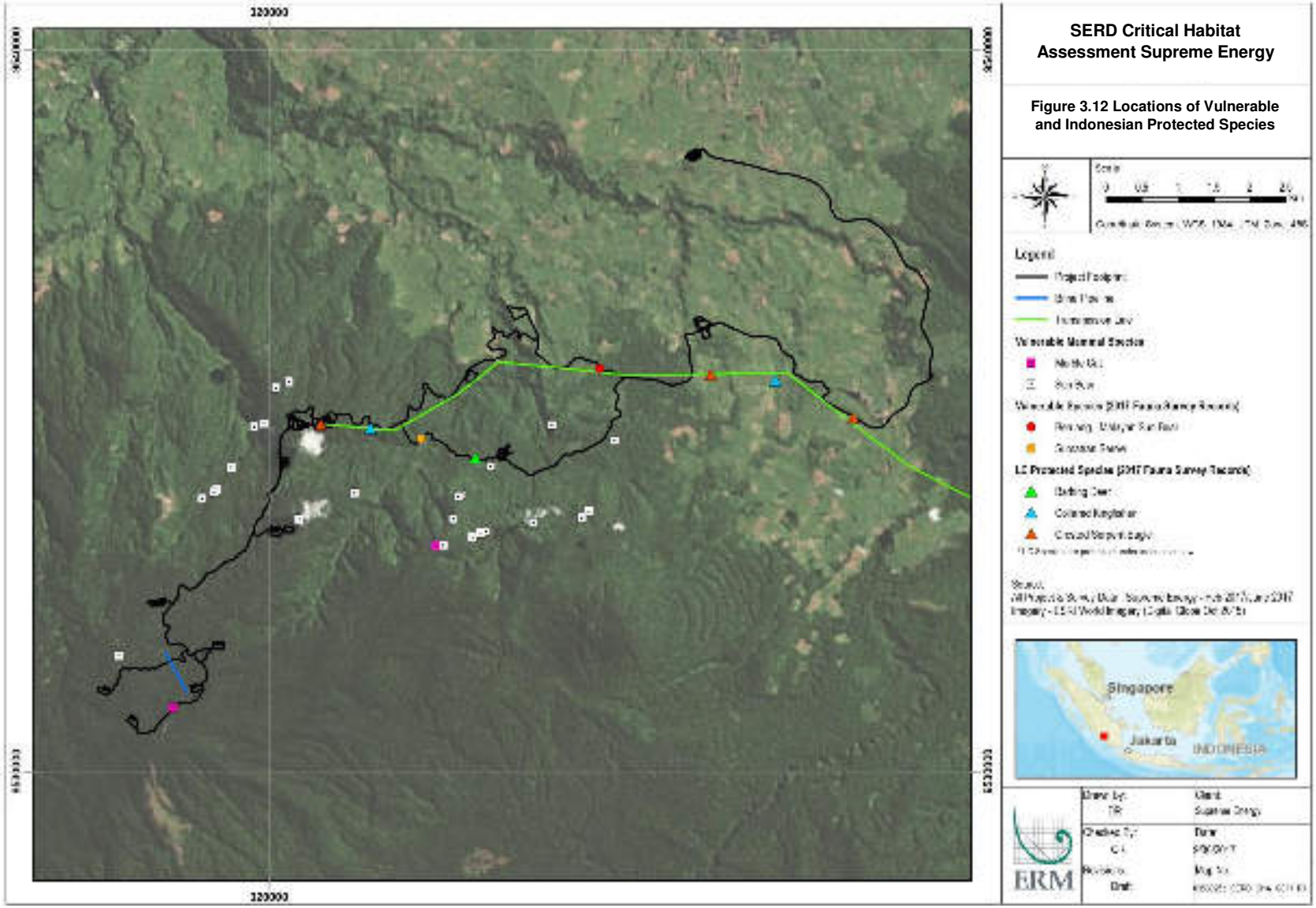
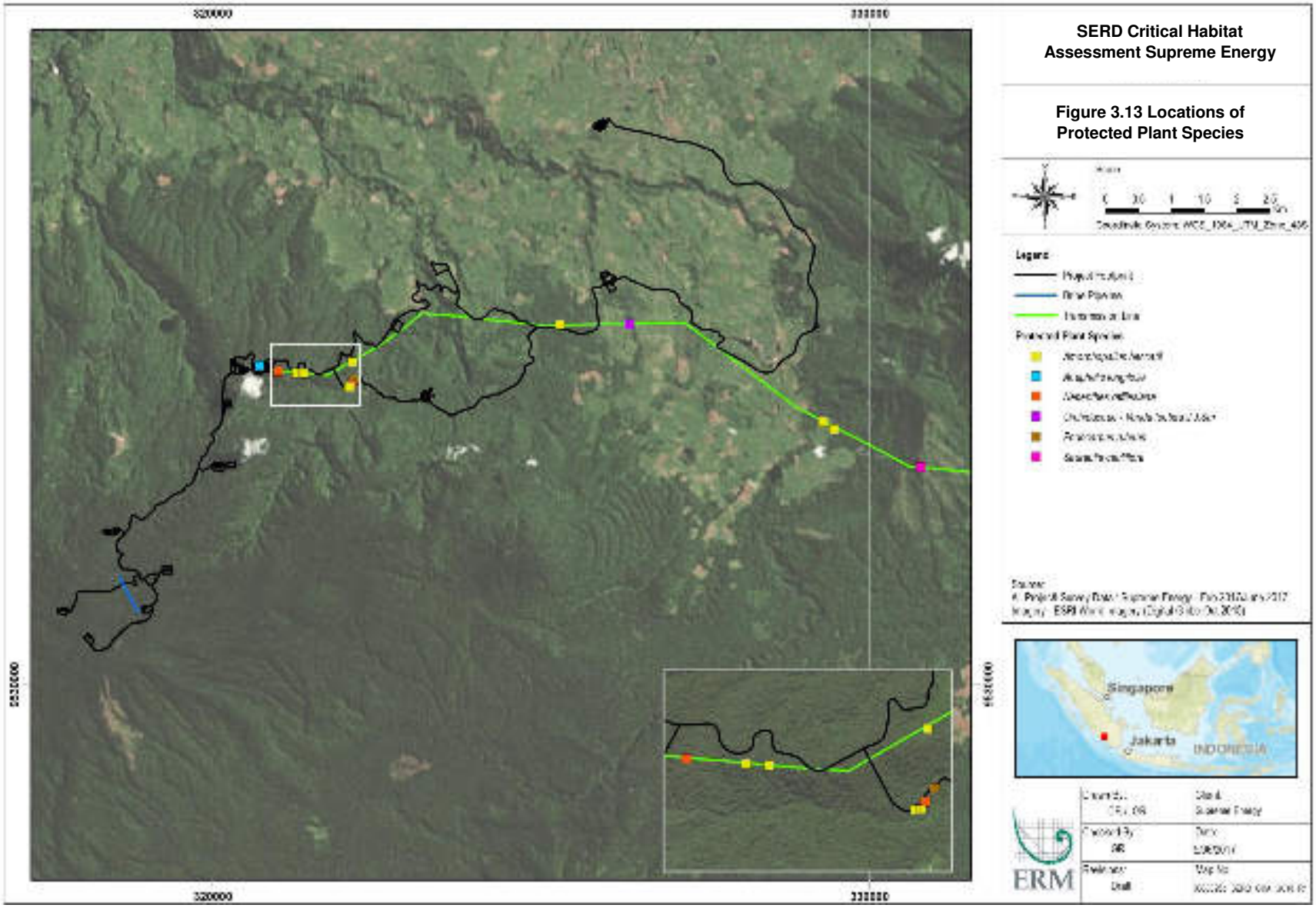


Figure 3.13 Locations of Protected Plant Species



3.5.4 Critical Habitat

3.5.4.1 Critical Habitat Triggers

Critical habitat is defined under both the ADB Safeguard Policy and IFC PS6.

Critical habitats are areas with: "high biodiversity value, including (i) habitat of significant importance to Critically Endangered and/or Endangered species; (ii) habitat of significant importance to endemic and/or restricted-range species; (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species; (iv) highly threatened and/or unique ecosystems; and/or (v) areas associated with key evolutionary processes". In addition ADB Safeguard Policy includes areas having biodiversity of significant social, economic, or cultural importance to local communities as critical habitat. In this report this aspect will be collectively termed 'ecosystem services'.

Critical Habitat may not be limited to pristine or highly biodiverse areas but rather may include both modified habitat and natural habitats across the broader landscape that supports the biodiversity values that trigger the Critical Habitat criterion. Critical Habitats can therefore be a subset of both modified habitat and natural habitat.

Assessment for Critical Habitat is undertaken as a screening process against the criteria defined within IFC PS 6 Guidance Note. This involved GIS analysis and desk based data collection including a review of previous biodiversity studies.

Critical Habitat criteria are defined in PS6 Guidance Note 6 (GN6), Paragraphs GN69 to 97. ***Table 3.14*** provides detail of the qualifying requirements for Critical Habitat criteria 1 to 3 (i.e. thresholds), while details of the likely qualifying interests for Criterion 4 and 5 will be defined based on research and expert opinion.

Table 3.14 Criteria Habitat Criteria (IFC PS6 Guidance Note 2012)

Criteria	Tier 1[1]	Tier 2[1]
Criterion 1: Critically Endangered (CR) / Endangered (EN) species:	a) Habitat required to sustain ≥ 10 % of the global population of a CR or EN species /sub /species and where there known regular occurrences of the species and where habitat could be considered a discrete management unit for the species. b) Habitat with known, regular occurrences of CR or EN species where that habitat is one of 10 or fewer discrete management sites globally for that species.	c) Habitat that supports the regular occurrence of a single individual of a CR species and/or habitat containing regionally- important concentrations of Red-listed EN species where that habitat could be considered as a discrete management unit for the species/subspecies. d) Habitat of significant importance to CR/EN species that are wide-ranging and/or whose population distribution is not well understood and where the loss of such a habitat could potentially impact the long-term survivability of the species. e) As appropriate, habitat containing nationally/regionally important concentrations of an EN, CR or equivalent national/regional listing.
Criterion 2: Habitat of significant importance to endemic and/or restricted-range species;	a) Habitat known to sustain ≥ 95 % of the global population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species.	b) Habitat known to sustain ≥ 1 % but < 95 % of the global population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species, where data are available and/or based on expert judgment.
Criterion 3: Habitat supporting globally significant concentrations of migratory species and/or congregatory species;	(a) Habitat known to sustain, on a cyclical or otherwise regular basis, ≥ 95 % of the global population of a migratory or congregatory species at any point of the species' lifecycle where that habitat could be considered a discrete management unit for that species.	(b) Habitat known to sustain, on a cyclical or otherwise regular basis, ≥ 1 % but < 95 % of the global population of a migratory or congregatory species at any point of the species' lifecycle and where that habitat could be considered a discrete management unit for that species, where data are available and/or based on expert judgment. (c) For birds, habitat that meets BirdLife International's Criterion A4 for congregations and/or Ramsar Criteria 5 or 6 for Identifying Wetlands of International Importance. (d) For species with large but clumped distributions, a provisional threshold is set at ≥ 5 % of the global population for both terrestrial and marine species. (e) Source sites that contribute ≥ 1 % of the global population of recruits.
Criterion 4: Highly threatened and/or unique ecosystems; and/or	Criterion 4 has no tiered system although recent publication (Keith et al, 2013) may introduce this. This criterion must include one of the following a) the ecosystem is at risk of significantly decreasing in area or quality; b) has a small spatial extent; and /or c) contains unique assemblages of species including assemblages or concentrations of biome-restricted species. Highly threatened or unique ecosystems are defined by a combination of factors which may include long-term trend, rarity, ecological condition, and threat.	

Criteria	Tier 1[1]	Tier 2[1]
Criterion 5: Areas associated with key evolutionary processes	The criterion is defined by: a) the physical features of a landscape that might be associated with particular evolutionary processes; and/or b) subpopulations of species that are phylogenetically or morphogenetically distinct and may be of special conservation concern given their distinct evolutionary history. The latter includes evolutionarily significant units and evolutionarily distinct and globally endangered species.	

Note: [1] No Tier system is in place for Criterion 4 and Criterion 5.

With regard to Criterion 2, it should be noted that an endemic and restricted range species is defined by the IFC as one which possesses an extent of occurrence of 50,000 km^2 (C. Savy pers. comms). Plant species may qualify as endemic if has ≥95% of its global range inside the country or region of analysis.

The five criteria are 'triggers' in that if an area of habitat meets any one of the criteria, it will be considered Critical Habitat irrespective of failing to meet any other criterion[6]. Therefore, Critical Habitat can be determined through a single criterion or where a habitat holds biodiversity meeting all five criteria. This approach is generally more cautious but is used more widely in conservation[7]. Critical Habitat criteria therefore have two distinctive characteristics. First, components of biodiversity are essentially assigned to only two levels of conservation significance, those that trigger Critical Habitat and those that do not (Tier considerations being secondary to this primary Critical Habitat determination). Second, each criterion is applied separately and not in combination, meaning that the scores are not cumulative.

3.5.4.2 *Discrete Management Unit*

As part of the process in carrying out a Critical Habitat assessment it is essential that the spatial boundaries relevant to the assessment are clearly determined and defined (IFC, 2012). IFC PS6 recommends defining a Discrete Management Unit (DMU) which delineates the area of habitat to be considered for the assessment within which the biological communities and/or management issues have more in common with each other than they do with those in adjacent areas (IFC, 2012). A DMU may or may not have an actual management boundary (eg legally protected areas, World Heritage sites, KBAs, IBAs, community reserves) but could also be defined by some other sensible ecologically defined boundary (IFC, 2012).

Section 3.4.1.1 identifies that the AoI for the Project overlaps with a large tract of primary forest (and secondary forest) associated with Mount Patah. This area is considered to have potential to support a number of threatened and

[6] The Biodiversity Consultancy (TBC) (2013) Getting through PS6: Critical Habitat and its requirements. Case Studies from Guinea and Mongolia. Whitmore, T.C. (1984) Tropical Rain Forests of the Far East. Oxford University Press. Second Edition.

[7] McDonald-Madden, E. Gordon, A. Wintle, B. Walker, S. Grantham, H. Carvalho, S. Bottrill, M. Joseph, L. Ponce, R. Stewart, R. & Possingham, H. P. (2009). "True" Conservation Progress. Science 323: 43-44.

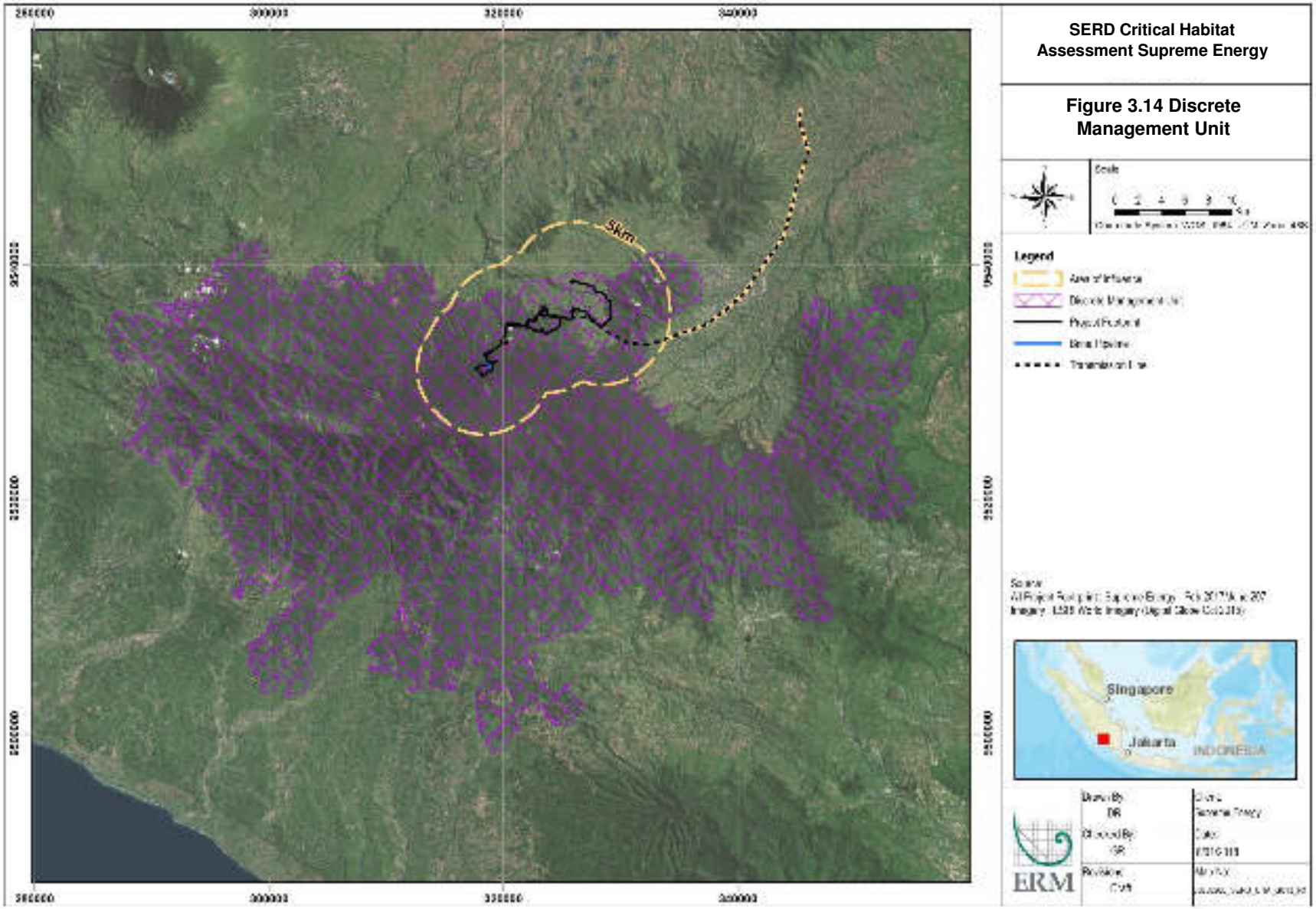
endemic species and given its association with the Project location is considered to be a management unit. In this instance the boundary of the DMU incorporates the mapped primary forest and secondary utilising land cover mapping sources. The location of the DMU in relation to the Project Area is shown in ***Figure 3.14***.

The area of impact and proportion within the DMU is shown in ***Table 3.15***.

Table 3.15 Area of Impact within the DMU

Land Cover Type	DMU (ha)	Project Footprint (ha)	Induced Clearing (ha)	Project footprint proportion of DMU (%)
Montane forests	82,400	25.06	5.50	0.0003%
Sub Montane	24,362	42.07		0.0017%
Riparian Forest	2689	2.24		0.0008%
Bush/scrub	18,249	12.85	-	0.0007%
Plantation	-	39.42	-	-
Semi-rural/Urban	-	2.34	-	-
Freshwater habitat	-	0.52	-	-
Total	127,700	124.50	5.50	0.0009%

Figure 3.14 Discrete Management Unit and AoI



3.5.4.3 Critical Habitat Candidate Species (Criteria 1-3)

For Criterion 1 to 3, this exercise considers if habitats from which candidate species are found in could qualify as Critical Habitat under the ADB Safeguard Policy and IFC PS6. Threatened species refer to species evaluated as CR or EN on IUCN status or have been conferred national protection status, are endemic or restricted range species, and are migratory or congregatory species (ADB, 2012). The evaluations were carried out in consideration of the threats facing these identified species and their habitat requirements.

Candidate species were identified from previous biodiversity studies and other relevant desktop information sources. The Critical Habitat candidates and assessment against thresholds are summarised in ***Table 3.16*** *Candidate Critical Habitat Species (Criteria 1-3) and Assessment*.

The assessment identified the following species with potential Critical Habitat associated with the Project Area:

- *Rafflesia bengkuluensis* – Criterion 2, Tier 2;
- *Vanda foetida* – Criterion 2, Tier 2;
- Malayan pangolin (*Manis javanica*) – Criterion 1, Tier 2;
- Broad-nosed Sumatran maxomys (*Maxomys inflatus*) – Criterion 2, Tier 2;
- Sumatran ground-cuckoo (*Carpococcyx viridis*) - Criterion 1, Tier 2e
- Sumatran tiger (*Panthera tigris sumatrae*) – Criterion 1, Tier 1; Criterion 2, Tier 2;
- Sumatran surili (*Presbytis melalophos*) – Criterion 1, Tier 1 and 2;
- Siamang (*Symphalangus syndactylus*) – Criterion 1, Tier 2;
- Malayan tapir (*Tapirus indicus*) – Criterion 1, Tier 2; and
- *Rhacophorus bifasciatus* – Criterion 2, Tier 2.

Table 3.16 Candidate Critical Habitat Species (Criteria 1-3) and Assessment

Scientific Name	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale
Dipterocarpus sp.		CR	x			IUCN notes this species is possible extinct. The distribution is reported to include India, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam from 0-600m asl. This species occurs in primary semi-evergreen and evergreen dipterocarp forest. The Project ESIA included reference to records of this species at a number of locations within the Project Area.	This species is considered possibly extinct. As part of the ESIA the species is reported as *Dipterocarpus grandifloras*, with common name Keruing. Keruing is a term used capturing the *Dipterocarpus* genus that covers 70 species spread across Southeast Asia. Similarly the altitudinal range for the species is reported to be from 0 to 600m asl however the Project Area is located above 1400m asl. Further investigation of the reporting of this species would be required to confirm if it should be considered a Critical Habitat candidate.
Haemocharis integerrima		NA		x		Occurs in undisturbed to slightly disturbed forests up to 100m. In secondary forest probably present as a pre-disturbance remnant. The distribution of the species is listed to include Sumatra, Java, Lesser Sunda Islands, Borneo (although only known from one collection) and Celebes.	The species information is not consistent with the requirement for a restricted range or endemic species, and as such is not considered a priority for critical habitat.
Rafflesia bengkuluensis		NA		x		This species is a parasitic plant endemic to Sumatra. It was discovered in Bengkulu province (2006). Kaur Forest, Penangkulan River and Sakaian Mayan forest area are locations where habitat is known and the species is known (AnataraNews.com, 2016).	There is little reported regarding the extent of occurrence for this species. As a result the precautionary approach may apply and there is potential that the forest of the DMU sustains at least >1% but < 95% of the global population (Criterion 2, Tier 2b). It may also sustain >95% of the global population however there is a lack of species data to confirm this (Criterion 2, Tier 1a). **The Project Area is considered to contain Critical Habitat for this species.**

Scientific Name	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale
Taxus sumatrana		EN				Stated to be a synonym of *Taxus wallichiana* (IUCN) but recognised as a standalone species on The Plant List v1.1[8]. Information from the World Botanical Associates was used for this assessment instead *Taxus sumatrana* is found from Sumatra, Thailand, Taiwan, Philippines, Sulawesi and Sumatra at elevations of 650 m to 3000 m. It appears widespread and especially within the project area, the dominant species.	Given the large range of the species, it is unlikely that 95% of the global population will be contained within the Project DMU. Therefore, it does not qualify as a CH candidate under Criterion 2. For purposes of assessment against Criterion 1, it is assumed that *Taxus sumatrana* is a confirmed synonym of *T. wallichiana* hence the status of *T. wallichiana* on the IUCN Red List was adopted for *T. sumatrana*. The species appears to have suffered less decline in Sumatra and found to be the dominant species in a number of vegetation plots surveyed in the Project area. It is not considered that the DMU will contain a regionally important concentration of *Taxus sumatrana* as the species is likely to be common throughout montane forest in the region. *Taxus sumatrana* therefore does not trigger CH under Criterion 1.
Nepenthes rafflesiana	-	LC				This species is protected under Indonesian law. Common lowland species in Borneo, it is rare in Sumatra and Peninsular Malaysia. It occurs in open areas to shady forest, from sea level to 1,000 m. Two individuals were found from the project area in the 2017 flora survey in primary forest habitat.	While protected under Indonesian law, the species does not appear to suffer from major threats. Given the wide geographical range of the species, habitats in the DMU are unlikely to contain numbers of *N. rafflesiana* that meet the thresholds of CH under Criterion 1. *N. rafflesiana* therefore does not trigger CH under Criterion 1.
Amorphophallus beccarii	-	NA				Endemic to Sumatra. 6 individuals were found from the project area in the 2017 flora survey within primary and secondary forest habitats. The species grows in open canopy at primary and secondary forest habitats.	This species is considered endemic based on IFC PS6 as more than 95% of its global range lies within Sumatra. The project DMU does not occupy more than 1 % of Sumatra, therefore numbers of *A. beccarii* found within the DMU are unlikely to meet thresholds to trigger CH under Criterion 2. *A. beccarii* therefore does not trigger CH under Criterion 2.

[8] http://www.worldbotanical.com/taxus_sumatrana_group.htm

Scientific Name	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale
Vanda foetida	-	NA		x		Endemic to Sumatra, 1 individual was found from the project area in the 2017 flora survey growing on a dead tree in a shrub-dominated area. The population of *V. foetida* appears to be small and can only be found in Pagar Alam, South Sumatra Province. Populations are fragmented and isolated by tea and coffee plantations, and are generally decreasing due to deforestation and exploitation[9].	This species is considered endemic based on IFC PS6 as more than 95% of its global range lies within Sumatra. The individual found falls within the known distribution range of the species. The Project DMU covers a large portion of secondary and primary forest habitats in the Muara Enim and Lahat regencies, and habitats surrounding Pagar Alam. It is likely that the DMU supports more than 1% of the global population of *V. foetida*. *V. foetida* therefore triggers CH under Criterion 2. **The Project Area is considered to contain Critical Habitat for this species.**
Apalharpactes mackloti	Sumatran trogon	LC		x		Species is native to Indonesia with an estimated extent of occurrence is listed by IUCN as 207,000km^2	Given the extent of occurrence is >50,000km^2 it would not be considered a candidate for Critical Habitat under the definition of endemic or restricted range.
Arborophila rubrirostris	Red-billed partridge	LC		x		Endemic to Indonesia. Estimated extent of occurrence is listed by IUCN as 192,000km^2	Given the extent of occurrence is >50,000km^2 it would not be considered a candidate for Critical Habitat under the definition of endemic or restricted range.
Carpococcyx viridis	Sumatran ground-cuckoo	CR	x	x		Species is only known from eight specimens and a recent series of sightings. It was un recorded since 1916 until an individual trapped in 1997 in Bukit Barisan Selatan NP (at 500m). Subsequent records include from NP and Wildlife Sanctuary to the north of the Project Area, a bird caught and additional sightings in Bukit Barisan Seletan NP. Habitat for the species, though poorly understood, is reported to occur in primary or little-disturbed forest with a relatively dense understorey. Specimen labels identify the species to inhabit foothill and lower montane forests from 300-1400 m asl.	In the wider landscape there is 19,810ha of natural habitat mapped (based on 2014 imagery) within the AoI. There are only a small number of sightings of the species, including a number of north and south of the Project Area in national parks. The DMU encompasses habitat consistent with known species preferences however there has been no evidence to date to suggest the species inhabits the DMU and as such no known regular occurrence of the species (Criterion 1, Tier 1a) or a regionally important concentration (Criterion 1, Tier 2c). There may be fewer than 10 DMU sites for this species however while there are no known or regular occurrences

[9] Rinyastuti R, Metusala D, Kumalawati DA and Daryono BS (2015) Genetic variation of *Vanda foetida* J.J.Sim; a rare and endemic orchid in South Sumatra based on RAPD analysis. Journal of Tropical Biology and Conservation 12: 99-112. Retrieved from https://www.ums.edu.my/ibtpv2/images/publication/JTBC/JTBC-VOL-12/08_JTBC12_021_11.pdf

Scientific Name	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale
						Threats to the species relate to deforestation and possibly susceptibility to bycatch through hunting. Endemic to Indonesia (Sumatra). Estimated extent of occurrence is listed by IUCN as 53,800km²	of the species within the DMU Criterion 1, Tier 1b is not considered to apply. While the population distribution is not well understood, the loss of the 72.63ha of natural habitat within the Project Area in the context of the DMU would not be considered likely to impact the long-term survivability of the species (Criterion 1, Tier 2d). Although there are no records of the species known from the DMU it is considered that the DMU contains habitat that may be nationally and/or regionally important concentration (Criterion 1, Tier 2e) of the species. Given the extent of occurrence is >50,000km² it would not be considered a candidate for Critical Habitat under the definition of endemic or restricted range (Criterion 2). **The Project Area is considered to contain Critical Habitat for this species.**
Cochoa beccarii	Sumatran cochoa	VU		x		Endemic resident in Sumatra. Estimated extent of occurrence is listed by IUCN as 161,000km²	Given the extent of occurrence is >50,000km² it would not be considered a candidate for Critical Habitat under the definition of endemic or restricted range.
Dicrurus sumatranus	Sumatran drongo	NT		x		Endemic resident in Sumatra. Estimated extent of occurrence is listed by IUCN as 658,000km²	Given the extent of occurrence is >50,000km² it would not be considered a candidate for Critical Habitat under the definition of endemic or restricted range.
Garrulax bicolor	Sumatran laughing thrush	EN	x	x		The species is known from montane forest up to 2000m asl. There is recent considerable decline in the population with five locations where the species is known at present. One of the location includes Bukit Barisan NP and Lake Ranau to the south of the DMU. The largest extent of remaining habitat is in the Aceh Province where the species is still relatively widespread. Endemic resident in Sumatra. Estimated extent of occurrence is listed by IUCN as 218,000km². The species was not recorded during field survey.	The DMU encompasses habitat consistent with known species preferences however there has been no evidence to date to suggest the species inhabits the DMU and as such no known regular occurrence of the species (Criterion 1, Tier 1a) or a regionally important concentration (Criterion 1, Tier 2c). The DMU is not linked to the national parks where the species is known via primary forest tracts. There may be fewer than 10 DMU sites for this species however while there are no known or regular occurrences of the species within the DMU Criterion 1, Tier 1b is not considered to apply. While habitat exists, the loss of the 72.63 ha of natural

Scientific Name	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale
							habitat within the Project Area in the context of the DMU would not be considered likely to impact the long-term survivability of the species (Criterion 1, Tier 2d). Given there are no records of the species known from the DMU it is considered unlikely the DMU contains a nationally and/or regionally important concentration (Criterion 1, Tier 2e). Given the extent of occurrence is >50,000km² it would not be considered a candidate for Critical Habitat under the definition of endemic or restricted range (Criterion 2). The Project Area is not considered to contain Critical Habitat for this species.
Gallinula chloropus	Common moorhen	LC			x	The species inhabit freshwater wetlands, requiring easy access to open water. The mapped distribution identified the species as resident. The species has an extremely large range and an extremely large population. The species was recorded during biodiversity surveys in an artificial lake near the village (Greencap, 2015).	While the species is noted to be migratory, in Indonesia it is considered to be a resident and as a result the migratory/congregatory species criteria (Criterion 3) do not apply. The Project Area is not considered to trigger Critical Habitat for this species.
Hydrornis schneideri	Schneider's pitta	VU		x		Endemic resident in Sumatra. Estimated extent of occurrence is listed by IUCN as 165,000km²	Given the extent of occurrence is >50,000km² it would not be considered a candidate for Critical Habitat under the definition of endemic or restricted range.
Lophura inornata	Salvadori's pheasant	NT		x		Endemic to Sumatra. Estimated extent of occurrence is listed by IUCN as 229,000km²	Given the extent of occurrence is >50,000km² it would not be considered a candidate for Critical Habitat under the definition of endemic or restricted range.
Motacilla cinerea	Grey wagtail	LC			x	The habitat for the species is reported to be fast-flowing mountain streams and rivers with riffles and exposed rocks or shoals, often in forested areas. Also found in lowland watercourses, artificial waterfalls, weirs, millraces and lock gates. Outside of breeding season it inhabits a wider variety of habitats including farmyards, sewage farms, forest tracks and town centres. IUCN maps Indonesia as extant (non-breeding) distribution. The species has an extremely	Although the DMU is forested and may provide habitat it is considered unlikely to sustain ≥ 95 % of the global population (Criterion 3, Tier 1a) or ≥ 1 % but ≤ 95% (Criterion 3, Tier 2b) given the large range of the species in combination with an extremely large population. The DMU is not considered to meet the BirdLife International's criteria A4 or Ramsar criteria 5 or 6. This species is not a congregatory, waterbird or seabird species and there is no evidence to suggest the DMU is bottle neck

Scientific Name	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale
						large range, extremely large population and is native to many countries. The species is a full migrant. The species was observed by Greencap during project surveys (Greencap, 2015).	site for migratory species (Criterion 3, Tier 2c). The species is not known to have a 'clumped' distribution and as such Criterion 3, Tier 2d is not considered to apply. Given that the species is not reported to breeding in Indonesia the DMU is highly unlikely to contribute ≥ 1 % of the global population of recruits (Criterion 3, Tier 2e). The Project Area is not considered to trigger Critical Habitat for this species.
Muscicapa dauurica	Asian brown flycatcher	LC			x	The species has an extremely large range and an extremely large population. It does not breed in Indonesia. The species is noted to be a common bird found in open woodland and cultivated areas. The species was recorded at Wellpad I during biodiversity surveys (Greencap, 2015).	These features are not uncommon in the disturbed areas of the lowland landscape locally and given that this species is a wide ranging species the survivability is unlikely to depend on the AoI. The AoI is not considered to sustain ≥ 95 % of the global population (Tier 1) given the large range in combination with large population. While habitat within the AoI may be suitable for the species it is not reported to breed in Indonesia. There is no evidence to suggest that the area would meet the BirdLife International criterion A4 or Ramsar Criteria 5 or 6. (Tier 2) The Project Area is not considered to trigger Critical Habitat for this species.
Myophonus melanurus	Shiny whistling-thrush	LC		x		Endemic to Indonesia. Estimated extent of occurrence 195,000km²	Given the extent of occurrence is >50,000km² it would not be considered a candidate for Critical Habitat under the definition of endemic or restricted range.
Pericrocotus miniatus	Sunda minivet	LC		x		Endemic to Indonesia. Estimated extent of occurrence 798,000km²	Given the extent of occurrence is >50,000km² it would not be considered a candidate for Critical Habitat under the definition of endemic or restricted range.
Pernis ptilorhynchus	Oriental honey buzzard	LC			x	Habitat for the species is noted as woodland, preferring broad-leaved forests up to 1,800 m. The species required forest although not necessarily old growth. Birds in the northern part of the range are noted to be migratory while further south the species is sedentary. Indonesia is in the southern part of the range and IUCN mapping shows Indonesia to	While the species is noted to be migratory, in Indonesia it is considered to be a resident and as a result the migratory/congregatory species criteria (Criterion 3) do not apply. The Project Area is not considered to trigger Critical Habitat for this species.

Scientific Name	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale
						support a resident population. The species has an extremely large range, very large population and is native to many countries. The species was observed by Greencap during project surveys (Greencap, 2015).	
Polyplectron chalcurum	Bronze-tailed peacock-pheasant	LC		x		Endemic to Indonesia. Estimated extent of occurrence 197,000km^2	Given the extent of occurrence is >50,000km^2 it would not be considered a candidate for Critical Habitat under the definition of endemic or restricted range.
Spilornis cheela	Crested-serpent Eagle	LC	x			Protected in Indonesia but otherwise widespread across a large geography and occurs in several habitats including rainforest, open savannah, mangrove swamps, plantations, tidal creeks etc. Tolerant of habitat disturbance[10].	While protected under Indonesian law, the species' large range and stable population would not qualify it as a candidate for Critical Habitat.
Trichastoma buettikoferi	Sumatran babbler	NT		x		Endemic to Indonesia. Estimated extent of occurrence 533,000km^2	Given the extent of occurrence is >50,000km^2 it would not be considered a candidate for Critical Habitat under the definition of endemic or restricted range.
Ficedula hyperythra sumatrana	Snowy-browed Flycatcher	LC				This record in the existing SERD ANDAL document appears to be a subspecies of *Ficedula hyperythra* listed as LC on IUCN. In the absence of further information clarifying the status of this subspecies, data for *Ficedula hyperythra* was used in this assessment.	*Ficedula hyperythra* has a large range with an estimated extent of occurrence at 15,700,000 km^2. Therefore, the species does not qualify as a restricted range species under IFC PS6 (range > 50,000 km^2). This species is hence screened out of the CH assessment.
Arctonyx hoevenii	Sumatran hog badger	LC		x		The species is endemic to Sumatra. The IUCN listed notes it is listed as Least Concern as the geographic range for the species is far too large to warrant categorization as Near Threatened based on those grounds and implausible that the population is small enough or ay any steep decline to warrant categorization as Near Threatened based on population.	While an extent of occurrence is not calculated the IUCN listing notes the species has a large geographic range and a stable population that does not appear to be at risk. While the species is endemic to Sumatra, the extent of occurrence is not considered to be <50,000km^2 and as such would not be considered a candidate for Critical Habitat under the definition of endemic or restricted range.

[10] LZ Han (2017) The Eagle Directory: Crested Serpent Eagle – *Spilornis cheela*. Retrieved from http://www.eagledirectory.org/species/crested_serpent_eagle.html

Scientific Name	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale
						The species is common in high montane zone of Kerinci Seblat NP as well as other areas. It has been recorded in Bukit Barisan NP. The species was recorded as widespread during biodiversity surveys (Greencap, 2017)	
Cuon alpinus	Dhole	EN	x			Species recently confirmed in several national parks along the Barisan Mountain range including Kerinci Seblat NP (to the north of the Project Area) and Bukit Barisan Selatan NP. IUCN lists over 10 areas where they have been confirmed in addition to listing distribution globally. The species is noted to be a habitat generalist occurring in a wide variety of habitat types including primary, secondary and degraded forms of forest. The species was recorded as part of Project biodiversity surveys (Greencap, 2015).	Highest populations of the species are noted in India, Thailand and Myanmar followed by Bhutan, Cambodia, China, Lao PDR, Malaysia and Nepal; and based on this the DMU habitat is not considered to sustain >10 % of the global population (Criterion 1, Tier 1a). While habitat within the DMU may be suitable for the species the area is not one of 10 sites globally with many sites noted globally for the species (Criterion 1, Tier 1b). There is no evidence to suggest there is an important concentration of the species within the DMU, including a nationally/regionally important concentration (Criterion 1, Tier 2c and Tier 2e). There is approximately 163 ha of the Project Area within the DMU that will be directly disturbed. It is not considered to be of sufficient extent to impact the long term survivability of the species (Criterion 1, Tier 2d). The Project Area is not considered to trigger Critical Habitat for this species.
Hylopetes winstoni	Sumatran flying squirrel	DD		x		The species is known from one type specimen only, recorded in the north of Sumatra. The taxonomic status requires evaluation and there is no information relating to population status or habitat preference.	There are currently no records of the species in the DMU and as such it is not known to sustain ≥ 95 % of the global population (Criterion 2. Tier 1a) or ≥ 1 % but ≤ 95% (Criterion 2, Tier 2b). As this species has only been recorded once in the north of Sumatra there is no evidence to suggest that the DMU or Project Area are important for the species. The Project Area is not considered to trigger Critical Habitat for this species.

Scientific Name	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale
Manis javanica	Malayan pangolin	CR	x			Habitat for the species is described as primary and secondary forest as well as cultivated areas (gardens, oil palm and rubber plantation), including near human settlements. While the species is found in a variety of habitats, primary forest is noted to support more individuals given a presence of greater number of older, larger trees with hollows suitable for sleeping and den sites as well as lower level of human activity. The species is widely distributed geographically. The IUCN listing profile notes a paucity of research on population density at local, national and global scales though notes populations in Singapore, Cardomom Mountains in Cambodia, Selangor and Negri Sembilan and Pasoh Forest Reserve and Kenyir Wildlife Corridor in Peninsula Malaysia, Sabah Sumatra, Java and Kalimantan. Home range size for the species has been estimated at 6.97 ha. The primary threat to the species is hunting and poaching. The species was recorded at 1,910m asl as part of Project biodiversity surveys (Greencap, 2015) and has been recorded in Bukit Barisan Selatan NP at 900m asl (Wirdateti *et al*, 2013 cited in Greencap, 2015).	Distribution data notes a wide geographic spread for the species and as such the DMU is unlikely to sustain >10 % of the global population and is not one of 10 or fewer discrete areas where the species is known (Criterion 1, Tier 1a and 1b). Primary forest habitats are noted to be preferred by the species and the Project captured photographs of the species at Wellpad D and Wellpad C. As a result the DMU would be considered to support a regular occurrence of an individual (Criterion 1, Tier 2c). While there is an overlap of the DMU with the Project Area, the direct disturbance of 72.63 ha of natural habitat would not be expected to impact the long-term survivability of the species (Criterion 1, Tier 2d). There is insufficient data to confirm if the DMU habitat contains a nationally/regionally important concentration of the species so a precautionary approach may be suitable (Criterion 1, Tier 2e) **The Project Area is considered to contain Critical Habitat for this species.**
Maxomys hylomyoides	Sumatran mountain maxomys	DD		x		This species is reported to be found in primary upper montane or moss forest, and possibly sub alpine or shrubland vegetation. The range is poorly understood however it is noted to be found above 600-800m. There is no information to identify if the species can persist in disturbed or modified habitat. The species distribution is mapped only in two patches within the Kerinci Seblat NP. It is known present in the Kerinci Seblat NP and is noted may be found in other protected areas.	The species distribution is mapped only in two patches and not within the DMU. As a result with would be considered unlikely that the DMU sustains >95 % of the global population (Criterion 2, Tier 1a); and in the absence of any known records in the DMU unlikely to sustain >1 % but <95 % of the global population (Crierion 2, Tier 2b). The Project Area is not considered to trigger Critical Habitat for this species.

Scientific Name	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale
Maxomys inflatus	Broad-nosed Sumatran maxomys	VU		x		This species is believed to be confined to lower and mid-montane elevations, inhabiting tropical evergreen forest. The species distribution is mapped across the mountains of the length of western Sumatra incorporating the national parks to the north and the DMU. The species is known to be present in the Kerinci Seblat NP and has been recorded between 900 and 1500m asl.	The species distribution is mapped across the mountains of the length of western Sumatra including to the southern extent DMU. Based on this distribution it is unlikely that the DMU sustains >95 % of the global population (Criterion 2, Tier 1a) however there is potential that the DMU sustains >1 % but <95 % of the global population in the absence of any detailed population information (Criterion 2, Tier 1b). **The Project Area is considered to contain Critical Habitat for this species.**
Muntiacus montanus	Sumatran mountain muntjac	DD		x		The IUCN notes there is little acknowledgement of the species' potential existence, and thus work apparently continues to assume that only one muntjac species is present on Sumatra. The listing cites '*it is thus impossible to ascertain even the species' relative status and distribution let alone, habitat and altitude use, other aspects of ecology, levels of potential threats, and resilience to such threats*.' The distribution of the species is uncertain though current distribution mapping does not include the DMU. There is also uncertainty associated with altitudinal distribution though it appears it is a montane species. The species was not recorded during biodiversity surveys for the Project (Greencap, 2017).	Further work would be required to clarify the taxon of montanus upon which it would be expected the uncertainty regarding distribution and habitat preferences may become clearer. Given the species was not recorded during field survey and in the absence of other information this species will not be considered a critical habitat candidate in this instance.
Muntiacus muntjac	Barking Deer	LC	x			Listed as LC on the IUCN Red List but protected by law in Indonesia. Associated with forest but occurs widely even in heavily degraded forest and in cultivated landscapes. It appears resilient to hunting and increases in numbers with logging and other forms of forest disruption.	While protected under Indonesian law, the species' large range and stable population would not qualify it as a candidate for Critical Habitat.

Scientific Name	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale
Mus crociduroides	Sumatran shrewlike mouse	DD		x		The species is found in upper montane rainforest though elevation limits are not well defined. The type locality is Korinchi Peak at 3,050 m asl. The species is endemic to Sumatra however it is listed as data deficient as the limits of distribution geographically and attitudinally is not well known.	The mapped distribution of the species is restricted to an area associated with the Kerinci Seblat NP and does not include the DMU. As a result the habitat of the DMU is unlikely to sustain ≥ 95 % of the global population (Criterion 2, Tier 1a) or >1 % but <95 % of the global population (Criterion 2, Tier 2b). The Project Area is not considered to trigger Critical Habitat for this species.
Nesolagus netscheri	Sumatran striped rabbit	VU		x		Habitat preferences for the species are poorly understood however IUCN notes the population is restricted to elevations above 600m and below 1600m (based on data from seven known locations). Based on these preferences the extent of occurrence is estimated to be less than 20,000km^2. Most records of the species are from land being cleared for coffee or tea plantation though the preferred habitat is noted to be montane forest with volcanic soil, and the species has a low tolerance to human disturbance. There are camera trap recordings from Kerinci Seblat NP to the north of the Project Area and Bukit Barisan NP to the south of the Project Area.	There is uncertainty associated with a variety of species information for the Sumatran striped rabbit, in particular habitat requirements. In the context of critical habitat there is potential the DMU provides habitat for the species (in the absence of further detail on habitat preferences) though there are no known records of individuals in the DMU. The DMU overlaps the distribution of the species however mapping largely excludes the primary forest areas of the DMU (likely due to altitude). Most of the DMU is above 1600m and as a result it is considered unlikely that ≥ 95 % of the global population is within the DMU (Criterion 2, Tier 1a) or ≥ 1 % but ≤ 95% of the global population (Criterion 2, Tier 2b). The Project Area is not considered to trigger Critical Habitat for this species.
Panthera tigris sumatrae	Sumatran tiger	CR	x	x		The species is endemic to Sumatra. IUCN reported the species to occur in about 58,321 km^2 of forested habitat in 12 potentially isolated Tiger Conservation Landscapes totaling 88,351 km^2 with about 37,000 km^2 protected in ten national parks. A more recent publication from Wibisono and Pusparini (2010) found that the species was present in 27 habitat patches larger than 250 km^2, this was based on a questionnaire of 35 respondents including tiger conservationists, field biologists and government officials.	There are no population estimates reported for the DMU though given known distribution and population data for other areas it is considered unlikely that the DMU sustains >10 % of the global population of the species (Criterion 1 - Tier 1a). Similarly the Wibisono and Pusparini study (2010) identified more than ten habitat areas so the Project DMU would not be considered one of 10 DMU globally for the species (Criterion 1 - Tier 1b). Forested habitats are noted to be preferred by the species and evidence of the species was detected at Wellpads B and D. In addition tiger prey species were detected in the

Scientific Name	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale
						The Bukit Balai Rejang Protection Forest (Bukit Balai Rejang South Tiger Conservation Landscape) was one of the forest patches evaluated where the species was confirmed to occur though population data is not reported. The tiger is adaptive to a wide range of habitats with sufficient prey and water being key, as well as the presence of threats. They are found in primary forest, secondary forest, coastal forest, peat swamps and logging forest (Ministry of Forestry, 2007). Threats to the species include deforestation and degradation, hunting and trading, conflict and indirect pressures related to poverty (Ministry of Forestry, 2007). Footprints of the species were recorded at Wellpads B, C and D (Greencap, 2015).	Project Area. As a result the DMU would be considered to support a regular occurrence of an individual (Criterion 1, Tier 2c). While there is an overlap of the DMU with the Project Area, the direct disturbance of 163 ha of suitable habitat would not be expected to impact the long-term survivability of the species (Criterion 1, Tier 2d). There is insufficient data to confirm if the DMU habitat contains a nationally/regionally important concentration of the species so a precautionary approach may be suitable (Criterion 1, Tier 2e) Given the known forest patches where the species is reported it is unlikely that the DMU sustains >95 % of the global population however there is potential that the DMU sustains >1 % but <95 % of the global population. (Criterion 2, Tier 1 and 2). **The Project Area is considered to contain Critical Habitat for this species.**
Presbytis melalophos	Sumatran surili	EN	x	x		The species is endemic to Sumatra. The species is considered relatively common in its remaining and appropriate habitat however occurrences are very patchy and fragmented. It is known to occur in five protected areas, including Kerinci Seblat NP to the north of the Project Area and Bukit Barisan NP. Habitat is reported in disturbed and secondary forest areas, primary hill rainforest, shrub forest and plantations. The home range has been observed to be 14-29.5 ha. The Greencap surveys reported (2015) the species in forest areas bordering coffee plantations. The report noted that the density of the species calculated for the survey was only 2 groups/km² in contrast to the Bukit Barisan NP where it is recorded abundant. Greencap	The DMU includes suitable habitat and atleast one known population (recorded by Greencap). Although the species has been recorded within the Project Area, it is expected that the abundance is low. In the absence of more detailed data regarding the remainder of the DMU it cannot be ruled out that Tier 1 of Criterion 1 may apply, most likely Tier 1b. The DMU may be one of 10 or fewer DMU sites for the species globally noting the species is reported to occur in five NPs. Given its low abundance in the forest habitat at the Project and no additional population data there is no evidence to suggest that the DMU sustains >10 % of the global population (Criterion 1, Tier 1a). Specific to Criterion 1 Tier 2 threshold, the DMU has potential to provide habitat for a nationally/regionally important concentrations of the species (in the absence of utilization data) (Tier 2c and Tier 2e).

Scientific Name	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale
						notes that the species is not present in forest with cover between 50 and 75%, and extremely high densities occur between 26 and 50%. The forest cover of the Project Area was reported by Greencap to remain at 75%. The Sumatran surili was recorded 4 times in the 2017 fauna survey, all occurring within primary and secondary forest habitats.	Specific to the Project area there are records of the species close to the footprint, and this must be a consideration when understanding importance of the area given the relatively small home range of the species. While records suggest a population local to the Project Area, the direct disturbance of 163ha would not be expected to impact the long-term survivability of the species (Criterion 1, Tier 2d). Given the known forest patches where the species is reported it is unlikely that the DMU sustains >95 % of the global population and given its likely low abundance in the forest habitat unlikely to sustain >1 % but <95 % of the global population. (Criterion 2, Tier 1 and 2). **The Project Area is considered to contain Critical Habitat for this species.**
Pteromycus pulverulentus	Smoky flying squirrel	EN	x			The species is found in Brunei, Indonesia, Peninsular Malaysia and southern Thailand. Species lives in tree hollows of tall, undisturbed lowland primary forest (below 3000m asl). Two secure populations are noted in Sabah. The species was not recorded during biodiversity field surveys (Greencap, 2015)	The DMU may include suitable habitat though there are no known recorded of the species. The DMU may be one of 10 or fewer DMU sites however there is no evidence to suggest a known, regular occurrence for the species (Criterion 1, Tier 1b). Given there are no recorded in the DMU or nearby tracts is no evidence to suggest that the DMU sustains >10 % of the global population (Criterion 1, Tier 1a) or provides habitat for a nationally/regionally important concentrations of the species (Tier 2c and Tier 2e). In the event the DMU sustains a population of the species, the direct disturbance of 72.63 ha would not be expected to impact the long-term survivability of the species (Criterion 1, Tier 2d). The Project Area is not considered to contain Critical Habitat for this species.

Scientific Name	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale
Rattus korinchi	Sumatran mountain rat	DD		x		This species is reported to be found in primary upper montane or moss forest. The population is not well known and the species is known from relatively few specimens. Records are known from Gunung Kerinci (to the northwest of the Project Area) and Gunung Talakmau in western Sumatra, and these are the two areas mapped as the species distribution. The mapped distribution does not include the DMU.	The mapped distribution of the species is restricted to an area associated with the Kerinci Seblat NP and Talakmau further north and does not include the DMU. As a result the habitat of the DMU is unlikely to sustain ≥ 95 % of the global population (Criterion 2, Tier 1a) or >1 % but <95 % of the global population (Criterion 2, Tier 2b). The Project Area is not considered to trigger Critical Habitat for this species.
Symphalangus syndactylus	Siamang	EN	x			The species is native to Indonesia (Sumatra), Malaysia (Peninsular Malaysia) and Thailand. In Indonesia this species is found in the Barisan Mountains of west-central Sumatra. The species is known from atleast nine protected areas in Indonesia, Thailand and Malaysia and Akrom (2012) notes species density estimates from additional locations. This species lives in primary and secondary semi-deciduous and tropical evergreen forest. Siamangs occur at lower densities in secondary forest, but can persist in secondary areas. They range from the lowlands up to 1500 m in elevation. Greencap (2015) reported records of the species in montane habitat between 1500m and 2000m. Based on the survey 16 groups were documented with a 0.3 group/km^2 density in the surveyed area. Greencap noted that the density is substantially lower than that measured in Kerinci Seblat NP of 2.7 groups/km^2 (Wood et al., 1996 cited in Greencap, 2015). In Burit Barisan NP average group density was reported to be one group for every 2.23km^2 with an average group size of 3.9. The population estimate of Bukit Barisan NP is 22,390 individuals. The siamang was recorded 4 times in the 2017 fauna survey from primary and secondary forest habitats.	The DMU includes suitable habitat and atleast one known population (recorded by Greencap). The species has been recorded within the Project Area however it is expected that the abundance is low in comparison to other known areas where the species occurs. Given its low abundance in the forest habitat at the Project and no additional population data there is no evidence to suggest that the DMU sustains >10 % of the global population (Criterion 1, Tier 1a). Similarly the literature identified more than ten habitat areas so the Project DMU would not be considered one of 10 DMU globally for the species (Criterion 1 - Tier 1b). Specific to Criterion 1 Tier 2 threshold, the DMU has potential to provide habitat for a nationally/regionally important concentrations of the species (in the absence of utilization data) (Tier 2c and Tier 2 e). While records suggest a population local to the Project Area, the direct disturbance of 163 ha would not be expected to impact the long-term survivability of the species (Criterion 1, Tier 2d). **The Project Area is considered to contain Critical Habitat for this species.**

Scientific Name	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale
Tapirus indicus	Malayan tapir	EN	x			This species is native to Indonesia (Sumatra), Malaysia, Myanmar and Thailand. In Sumatra this species occurs in the southern and central areas. Its populations are now highly fragmented within its former range. Linkie *et al*. 2013 (cited in IUCN species profile) recorded the species at 17 of 19 areas sampled using camera traps across Southeast Asia between 1997 and 2011. This species is restricted to tropical moist forest areas and occurs in both primary and secondary forest. It is predominantly found in the lowlands and the lower montane zones in some parts of the range. The species was detected via camera trap near Wellpad B, C, E and I and Puyang Lake during the biodiversity surveys (Greencap, 2015)	The DMU includes suitable habitat for the species and there are known records. The mapped distribution of the species is fragmented and largely isolated to forest fragments (including existing protected areas) and does not include the DMU. Based on this there is no evidence to suggest that the DMU sustains >10 % of the global population (Criterion 1, Tier 1a). While habitat within the DMU is suitable for the species the habitat it is not one of 10 sites globally with many sites noted globally for the species (Criterion 1, Tier 1b). Specific to Criterion 1, Tier 2 thresholds the DMU has potential to provide habitat for a nationally/regionally important concentrations of the species (in the absence of utilization data) (Tier 2c and Tier 2e). While the DMU may contain a population, the direct disturbance of approximately 72.63ha of natural habitat would not be expected to impact the long-term survivability of the species (Criterion 1, Tier 2d). **The Project Area is considered to contain Critical Habitat for this species.**
Hylobates agilis	Agile Gibbon	EN				This species is found from Kalimantan, Sumatra, Peninsular Malaysia and Thailand. It occurs at highest densities in dipterocarp-dominated forests but their habitat ranges from swamp and lowland forests to hill, submontane and montane forests. *Hylobates agilis* is threatened by conversion of forest habitat and opportunistic capture for the pet trade. On Sumatra, the species occurs in a number of protected areas including Bukit Barisan NP, Kerinci Seblat NP, Selantan NP and Way Kambas NP.	*Hylobates agilis* was not found from the project area in 2015 biodiversity surveys. Greencap's CHA report posits that this is due to higher elevation of the project area and its influence on the food resources available to this species. In consideration of survey findings and interpretation, it is assessed that habitats in the DMU do not support a population of *Hylobates agilis* that meets the criteria for CH under Criterion 1.

Scientific Name	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale
Calamaria margaritophora	Stripe-necked reed snake	DD		x		IUCN notes research is needed to establish if the species is present within the Kerinci Seblat NP as only recorded available are from the 1940s. Most known records are from just outside the border of Kerinci Seblat NP. The species is reported to occur between 500 and 1000m asl. The species was believed to be locally common in Bengkulu and rare in the three other Sumatran provinces. It is reported to inhabit lowland dipterocarp forest. The species was not recorded during biodiversity field surveys (Greencap, 2017)	Based on the literature it is considered unlikely this species occurs within the DMU (altitudinal distribution and location of previous records). Given the species was not recorded during field survey and in the absence of other information this species will not be considered a critical habitat candidate in this instance.
Iguanognathus werneri	Spatula-toothed snake	DD		x		Species known from one type specimen only collected in 1898 from an unknown location in Sumatra. There is no information regarding habitat and ecology of the species and research is required to establish the current distribution, habitats and threats. The species was not recorded during biodiversity field surveys (Greencap, 2017)	Given the species was not recorded during field survey and in the absence of other information this species will not be considered a critical habitat candidate in this instance.
Typhlops hypsobothrius	Sumatra worm snake	DD		x		Species known from two type specimens with the collections unavailable. There is no information regarding habitat and ecology of the species and research is required to establish the current distribution, habitats and threats. The species was not recorded during biodiversity field surveys (Greencap, 2017)	Given the species was not recorded during field survey and in the absence of other information this species will not be considered a critical habitat candidate in this instance.

Scientific Name	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale
Chalcorana crassiovis	Korinchi frog	DD		x		The species is known from only a few localities including Barisan, Kerinci, Batang, Tarusan and Solok in west Sumatran. IUCN distribution mapping is restricted to an area over 350,000km to the north east of the DMU. There is an absence of information on extent of occurrence, status and ecological requirements. Greencap (2017) reports the species was found during the survey.	There is uncertainty associated regarding the habitat requirements for the species as well as its extent of occurrence. The IUCN distribution mapping does not include the Project Area or the DMU and as such further work should be undertaken to confirm the record reported by Greencap and as such the critical habitat.
Rhacophorus bifasciatus		NT		x		Species occurs in lowland and submontane forest, likely breeding in streams. Distribution of the species is mapped at six patches across Sumatra, one of which includes the DMU. The extent of occurrence while not calculated is noted to be 'not much greater than 20,000 km^2'. The species was not recorded during the biodiversity survey for the Project (Greencap, 2017)	While the species has not been recorded during field survey, there is suitable habitat and the Project Area is within the mapped distribution for the species. There is no population information specific to the species however given there are six other locations comprising the species distribution it is considered unlikely that the DMU sustains > 95% of the global population (Criterion 3, Tier 1a). That being the case there is potential that the DMU sustains >1% but <95% percent of the global population (Criterion 3, Tier 2b). **The Project Area is considered to contain Critical Habitat for this species.**
Tor tamboides	Mahseer Fish	DD				This species occurs in the Mekong Basin in Yunnan, Lao, Chao Phraya basing in Thailand, Java, Borneo, Sumatra, Brunei, Malay Peninsula and potentially Vietnam. The population appears to be decreasing due to overfishing and anthropogenic modification of river morphology. Logging, deforestation and agricultural impacts along its range also contribute to its decline through the degradation of the aquatic environment. The species lives in large streams and rivers with moderate to swift flow. Adults live in deep pools and juveniles are typically found in or near rapids; these aquatic habitats are found within lowland forest. It is a full migrant, moving upstream	Based on IUCN spatial information of the distribution of *Tor tambroides*, the species appears widespread although there is limited information on the number of watersheds it inhabits. The species was only found from one river in the project area, namely Cawang Tengah River but it is unclear the population status within the DMU. As a precautionary measure, the habitats within the DMU are preliminarily assumed to sustain more than 1 % but less than 95% of the global poplulation of *Tor tambroides*. Given the migratory patterns of the species, any section of river would be critical to its continued survival. Therefore, habitats within the DMU have been assessed as

Scientific Name	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale
						to spawn in smaller streams. During the rainy season, it moves downstream. EcologyAsia states that this species is an indicator of the ecological health of lowland rivers as it avoids silted waters where possible.	CH for *Tor tambroides* under Criterion 3, Tier 2.

CR = Critically Endangered; EN = Endangered; DD = Data Deficient; NT = Near Threatened; NA = Not Assessed

*Species information sourced from IUCN Red List of Threatened Species profiles dated 1 and 2 February 2017 unless otherwise referenced.

Grey indicates species associated with potential Critical Habitat.

3.5.4.4 Threatened and/or Unique Ecosystems (Criterion 4)

Criterion 4 has no tiered system although recent publication (Keith et al, 2013) may introduce this. IFC PS6 describe this Criterion to be one of the following:

i. the ecosystem is at risk of significantly decreasing in area or quality;
ii. has a small spatial extent; and /or
iii. contains unique assemblages of species including assemblages or concentrations of biome-restricted species.

Highly threatened or unique ecosystems are defined by a combination of factors which may include long-term trend, rarity, ecological condition, and threat. Guidance in applying this Criterion suggests the use of an ecosystem map for the region that includes the Project site. Data used to create these maps typically includes vegetation mapping, land use mapping and consideration of other driving environmental factors such as climate, hydrology and landscape position.

Land cover mapping and natural and modified habitat mapping described *Sections 3.2.2* and *3.2.4* have been considered in this instance to identify the ecosystems represented for the purposes of determining if they are highly threatened or unique.

The majority of the AoI is considered to be natural habitat, primarily primary forest and secondary forest. The other modified habitat land covers would not be considered unique, at risk or of small spatial extent. The forested habitat however would be considered part of the Sumatra montane rain forest type which is recognised as one of the Global 200 ecoregions. The Global 200 ecoregions are those ecosystems that represent the most outstanding and representative areas of biodiversity by WWF. This forest type contains far higher levels of mammal and bird endemism than lowland forests, as a result of longer periods of isolations and distinctive forest types. The current status of the ecoregion is described by WWF as 'relatively stable/intact'. It contains several large blocks of intact forest and includes numerous protected areas (covering 40% of the total ecoregion area) (WWF, 2017). Based on this the primary and secondary forest of the AoI is not considered to be an 'ecosystem at risk of significantly decreasing in area or quality' (Criterion 4i). Similarly, the spatial extent of Sumatra montane rain forest type is reported to be around 260,000 km^2 which is not considered to be small (Criterion 4ii) and in turn the area within the AoI is not considered to substantially contribute to the overall extent.

The DMU applied for the assessment of criteria 1 to 3 has been assessed to be Critical Habitat for a number of species and as such there may be a case for the presence of a unique assemblage of species, in particular considering the number of endemic species. When considering the ecosystems more locally, associated with the Project Area region, it would not be considered likely that the habitats in the region provide the niches that would not otherwise be represented within the other protected areas regionally (such as Bukit Barisan Selatan NP).

While the Project Area is within the Sumatra montane rain forest ecoregion its current status is not considered to be highly threatened. In addition to this the habitat of Project Area is of minor value to the wider ecoregion and unlikely to sustain highly threatened or unique ecosystems.

3.5.4.5 Key Evolutionary Processes (Criterion 5)

Criterion 5 has no tiered system though IFC PS6 describes this Criterion to be one of the following:

i. the physical features of a landscape that might be associated with particular evolutionary processes (for example isolated areas, areas of high endemism, spatial heterogeneity, environmental gradients, edaphic interfaces, biological corridors or sites of demonstrated importance to climate change adaptation); and/or
ii. subpopulations of species that are phylogenetically or morphogenetically distinct and may be of special conservation concern given their distinct evolutionary history. The latter includes evolutionarily significant units and evolutionarily distinct and globally endangered species.

There are no physical features within the AoI that are known to be associated with evolutionary processes. The criteria 1 to 3 assessment identified a number of endemic species that are associated with the defined DMU. The DMU may be considered to support a high level of endemism. When considering the habitat within the AoI, the natural habitat areas would not be considered to substantially contribute to the biological values of the DMU that sustain the endemic populations. Similarly, the species assessments did not identify any species subpopulations known to be phylogenetically or morphogenetically distinct to be relying the habitat of the AoI.

As a result it not considered likely that the Project Area and AoI would be considered important in the conservation of Key Evolutionary Processes.

3.5.5 Invasive Alien Species

Invasive species are any species that are non-native to a particular ecosystem and whose introduction and spread causes, or are likely to cause, socio-cultural, economic or environmental harm or harm to human health (FAO, 2013). Invasive species are naturalised species that reproduce often in large numbers and are able to spread over a large area, damaging native species (FAO, 2005). Invasive species have the capacity to exacerbate their role in ecosystem degradation through combination threats by habitat change, climate change, over-exploitation of ecosystem resources and pollution, which further enhances their threat to biodiversity and the human condition (Emerton and Howard, 2008).

The taxa or types of organisms that can become invasive are animals (vertebrates and invertebrates), plants and micro-organisms (including those that are free-living as well as those that cause disease in plants, animals and people) (Emerton and Howard, 2008).

A desktop review of the Global Invasive Species Database (GISD, 2015) identified a list of species that are classified as invasive in Indonesia. The search identified 51 flora species and 39 fauna species that are considered invasive in Indonesia. The database does not specifically identify which part of Indonesia these species are known from and all these species have not been detected during baseline survey. The GISD list was supplemented with findings of the 2017 flora survey along the transmission line and brine pipeline where an additional 32 invasive flora species were recorded.

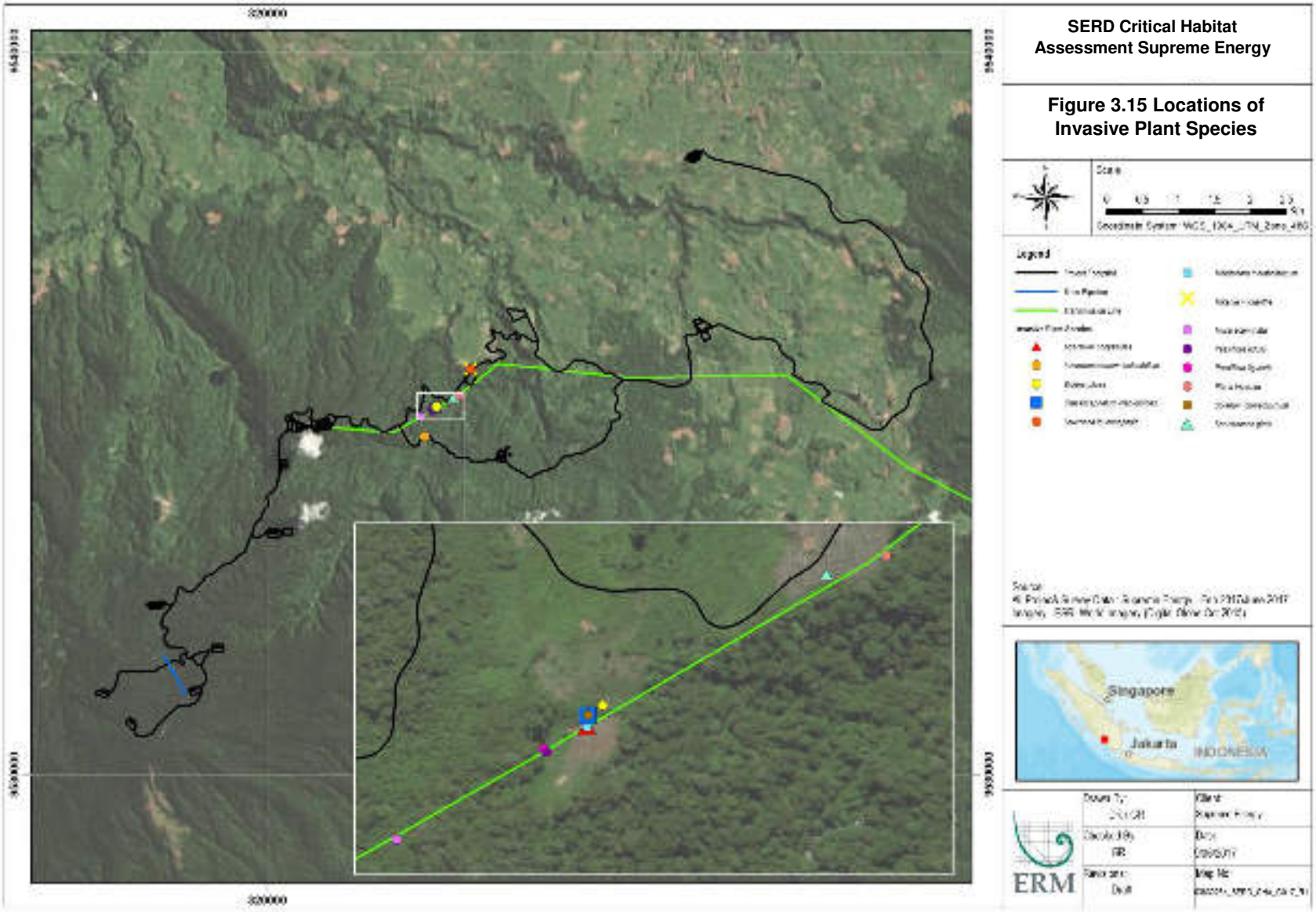
Of the species known in Indonesia four were recorded during baseline surveys or from other datasets (Table *Error! Reference source not found.**17***).

Table 3.17 Invasive species known from the Area of Influence

No	Species/Common Name	Note
	GSID (2015)	
1	*Imperata cylindrica* Cogon grass	Invasive grass. Displaces native plant and animal species and alters fire regimes. Dense swards create an intensely competitive environment for commercially important species.
2	*Leucaena leucocephala* Horse/wild tamarind	Weed of open, often coastal or riverine habitats, semi-natural and other disturbed or rural sites and occasionally agricultural land. Can form dense monospecific thickets which can replace native forest and in some areas threaten endemic species.
3	*Macaca fascicularis* Crab eating macaque	May impact biodiversity by eating eggs and chicks of threatened forest birds. Competes with native birds for resources such as native fruits. May play a role is dispersal of exotic plant species as well as carry potentially fatal human diseases.
4	*Mimosa pigra* Catclaw mimosa	Has the potential to harm a wide number and variety of different types of primary production. If large infestations occur over farmland, may threaten the health of pastoral industries by reducing the area of grazing land and the carrying capacity of the land. If livestock are reliant on natural water sources for drinking, their access to water may be blocked. May reduce water flow and increase silt levels, as it commonly colonises water course edges. Common along roadsides, mimosa may also increase the costs of maintaining power poles and cables used for electricity transmission. It may also decrease driver visibility, increasing the potential for traffic accidents.
	2017 Flora Survey of Transmission Line and Brine Pipeline	
5	*Austroeupatorium inulaefolium*	-
6	*Musa acuminata*	The survey found several clusters of *Musa acuminata* near rivers or wet areas with an open forest canopy. This species was found at the transmission line and brine pipeline areas.
7	*Pteris tripartita*	The survey found several clusters of *Pteris tripartita* at disturbed forests and coffee plantations.
8	*Clidemia hirta*	The survey found several individuals of *Clidemia hirta* at opern areas, particularly at coffee plantations.
9	*Lantana camara*	-
10	*Melastoma malabathricum*	-
11	*Crassocephalum crepidioides*	-
12	*Ludwifia peruviana*	-
13	*Mimosa pudica*	-
14	*Ageratum conyzoides*	-

No	Species/Common Name	Note
15	*Acmella paniculata*	-
16	*Bidens pilosa*	-
17	*Piper aduncum*	-
18	*Passiflora lingularis*	-
19	*Crotalaria pallida*	-
20	*Mimosa diplotricha*	-
21	*Stachytarpheta indica*	-
22	*Ricinus communis*	-
23	*Passiflora edulis*	-
24	*Ageratina riparia*	-
25	*Emilia sonchifolia*	-
26	*Mikania micrantha*	-
27	*Sida rhombifolia*	-
28	*Gliricidia sepium*	-
29	*Spermacoce alata*	-
30	*Ruellia tuberosa*	-
31	*Solanum chrysotrichum*	-
32	*Clibadium surinamense*	-
33	*Senna bicapsularis*	-
34	*Centrosema pubscens*	-
35	*Pennisetum purpureum*	-
36	*Saccharum spontanum*	-

Figure 3.15 Locations of Invasive Plant Species



3.5.6 Priority Ecosystem Services

Priority Ecosystem service identified from the screening assessment at *Section 3.3.1* is shown in ***Table 3.18*** below.

Table 3.18 Priority Ecosystem Services

Service	Discussion
Provisioning Services	
Food: cultivated crops	Local people likely to clear forest for slash and burn agriculture. This area of land available for future clearing has been restricted since 2014.
Freshwater	Local people are likely to use local streams for irrigation and non-potable uses. Extraction of water from the local waterways may reduce water availability for local people.

4 BIODIVERSITY IMPACT ASSESSMENT

4.1 ASSESSMENT METHODOLOGY

4.1.1 Approach

In accordance with IFC PS1 and PS6, the assessment process aims to predict and assess the Project's potential adverse impacts and risks to biodiversity values, in quantitative terms where possible. The objectives of the biodiversity impact assessment are to identify and quantify the potential Project impacts; design measures to avoid, minimise or mitigate potential adverse impacts; and identify likely residual impacts. To achieve this; a six step process was undertaken:

- **Screening** to determine if the Project may pose a risk to biodiversity and in particular which the biodiversity features require study;
- **Scoping** to determine which direct and indirect biological impacts are likely to be significant in order to determine the focus issues of the impact assessment;
- **Baseline Studies** to define the Project's area of influence and describe the relevant biodiversity conditions likely to occur. This includes identifying modified and natural habitat areas and determining the presence of critical habitat in accordance with IFC PS6 definition;
- **Impact Analysis** assesses the extent and complexity of potential adverse impacts considering the two parameters of habitat area (spatially) and threatened species individually;
- **Mitigation Measures** are developed to avoid and minimise potential adverse impacts to biodiversity with a priority given to impacts on features with significant biodiversity values; and
- **Residual Impacts** are determined and in the event significant residual impacts occur biodiversity offsets are considered.

A summary of the baseline conditions is provided in *Section 3*.

4.1.2 Scoping of Likely Impacts to Biodiversity Values

Table 4.1 broadly defines the types of threats to biodiversity values that have potential to occur as a result of a Project. These threats to biodiversity are derived from IFC PS6 and relate to the activities that are likely to occur during construction and post construction phases.

Table 4.1 Types of Threats to Biodiversity Values

Term	Description
Loss of habitat	Permanent loss of habitat or species due to permanent or temporary site activities.
Disturbance or displacement of individuals - Light - Noise - vibration impacts	Disturbance to, or displacement/exclusion of a species from foraging habitat due to construction activities, and operational and maintenance activities. Impacts from light, noise and vibration sources on surrounding habitats causing disturbance and displacement and changes in behaviour
Barrier creation	Creation of barriers to the movements of animals, especially fish, but also mammals, reptiles and amphibians and invertebrates and plants with limited powers of dispersal.
Fragmentation and edge effects	Fragmentation of habitat, or permanent /temporary severance of wildlife corridors between isolated habitats of importance for biodiversity. Impacts that occur when a habitat is exposed to a different adjacent habitat type or structure. These impacts can include increased risk of parasitism or disease, increased risk of predation, adverse microclimate conditions (including drying out and subsequent fire risk), and competition from invasive species
Degradation of habitat - Dust - Water pollution - Invasive species	Disturbance or damage to adjacent habitat and species caused by changes in microclimate, vulnerability to predation and invasion and overall changes in conditions that can lead to a change in the community and its values for flora and fauna. This can include increased exposure to noise, light and dust. Introduction or spreading of alien species during the construction works.
Mortality – vehicle strike, hunting and poaching	Mortality of individual fauna species as a result of vehicle or machinery strike or falling debris during clearing activities. Mortality to individual fauna species as a result of worker influx and hunting/poaching of extant fauna

4.1.3 Screening of Key Project Activities/Aspects Relating to Potential Biodiversity Impacts

The nature of impacts to biodiversity can be described in terms of direct and indirect impacts; and permanent and temporary impacts. ***Table 4.2*** considers the construction and operation of each component of the Project and which threats to biodiversity categories may apply. This table is used in the resulting impact assessment.

Table 4.2 Screening of Key Project Activities/Aspects Relating to Potential Biodiversity Impacts

Activity/Aspect	Loss of habitat	Disturbance or displacement of flora/fauna	Barrier creation	Edge effects and fragmentation	Degradation of habitat	Mortality – vehicle strike hunting and poaching
General Exploration/Construction Activities						
Land clearing activities (Habitat removal)	■	■	■	■	■	■
Well drilling (Noise, vibration)		■				
Water extraction (Changes in aquatic habitats)	▒	■	■			▒
Movement of vehicles (Noise, dust, light and strike)		■		▒	▒	■
Storage of raw materials (Creation of new habitats/dust)					■	
Construction activities including building works, concrete works (Noise, vibration, dust)		■			▒	▒
Labor influx (Hunting and poaching of wildlife)					▒	■
Waste management (Creation of new habitats/foraging resources)		■			▒	
Stormwater runoff (Changes to aquatic habitats)					■	
General Operation Activities						
Movement of vehicles along haul roads and access roads (Vehicles strike/dust generation)				▒	▒	■
Operation of Power Plant (Noise, light and air emissions)		■			▒	
Waste management (Creation of new habitats/foraging resources)		■			▒	
Stormwater runoff (Changes to aquatic habitats)					■	
Maintenance activities (Noise, vibration and light)		■				▒
Land clearing activities (Induced clearing)	■				■	
Labour influx (Hunting and poaching of wildlife)						■

Notes:

■	Screened in to impact assessment
▒	Negligible impact possible, screened out
	No impact possible, screened out

4.2 BIODIVERSITY IMPACT ASSESSMENT

4.2.1 Impact Analysis

The significance of the impacts has been evaluated using a standardised approach based on ERM's Impact Assessment Standard. This Standard has been determined based on the requirements of IFC PS6. It is based on the relationship between the magnitude of impact and nature of receptor (sensitivity). Impacts to biodiversity are often discussed in terms of impacts to habitats and impacts to individual species or species groups. As such significance criteria are defined for both habitats and species. The Project impacts identified have been assessed for their significance according to the criteria provided in ***Table 4.3*** (for habitat areas) and ***Table 4.4*** (for specific species groups).

Table 4.3 Habitat Impact Assessment – Significance Criteria

Habitat Sensitivity/Value		Magnitude of Effect			
		Negligible	**Small**	**Medium**	**Large**
Low	Habitats with no or local designation/ recognition; habitats of significance for species of Least Concern; habitats which are common and widespread within the region.	Negligible	Negligible	Minor	Moderate
Medium	Habitats within nationally designated or recognised areas; habitats of significant importance to globally Vulnerable, Near Threatened or Data Deficient species; habitats of significant importance for nationally restricted range species; habitats supporting nationally significant concentrations of migratory species and/or congregatory species; nationally threatened or unique ecosystems.	Negligible	Minor	Moderate	Major
High	Habitats within internationally designated or recognised areas; habitats of importance to globally Critically Endangered or Endangered species; habitats of importance to endemic and/or globally restricted-range species; habitats supporting globally significant concentrations of migratory species and/ or congregatory species; highly threatened and/or unique ecosystems, areas associated with key evolutionary species.	Negligible	Moderate	Major	Critical

Magnitude of Effect Definition	
Negligible	*Effect is within the normal range of variation*
Small	*Affects a small area of habitat, but without the loss of viability/function of the habitat*
Medium	*Affects a sufficient proportion of the habitat that the viability/function of part of the habitat or the entire habitat is reduced, but does not threaten the long-term viability of the habitat or species dependent on it.*
Large	*Affects the entire habitat or a significant proportion of the habitat to the extent that the viability/function of the entire habitat is reduced and the long-term viability of the habitat and the species dependent on it are threatened.*

Table 4.4 Species Impact Assessment – Significance Criteria

Species Sensitivity/Value		Magnitude of Effect			
		Negligible	**Small**	**Medium**	**Large**
Low	Species which are included on the IUCN Red List of Threatened Species as Least Concern (LC) (IUCN 2011).	Not significant	Not significant	Minor	Moderate
Medium	Species included on the IUCN Red List of Threatened Species as Vulnerable (VU), Near Threatened (NT) or Data Deficient (DD) (IUCN 2011). Species protected under national legislation. Nationally restricted range species. Nationally important number of migratory or congregatory species.	Not significant	Minor	Moderate	Major
High	Species included on the IUCN Red List of Threatened Species as Critically Endangered (CR) or Endangered (EN) (IUCN 2011). Species having a globally Restricted Range (i.e. plants endemic to a site or found globally at fewer than 10 sites, fauna having a distribution range (or globally breeding range for bird species) less than 50,000 km². Internationally important numbers of migratory or congregatory species. Key evolutionary species.	Not significant	Moderate	Major	Critical

Magnitude of Effect Definition	
Negligible	*Effect is within the normal range of variation.*
Small	*Affects a small proportion of a population, but does not substantially affect other species dependent on it, or the populations of the species itself*
Medium	*Affects a sufficient proportion of a species population that it may bring about a substantial change in abundance and /or reduction in distribution over one or more generations, but does not threaten the long term viability of that population or any population dependent on it.*
Large	*Affects an entire population or species at sufficient scale to cause a substantial decline in abundance and/or change in distribution beyond with natural recruitment (reproduction, immigration from unaffected areas) may not return that population or species, or any population or species dependent upon it, to its former level within several generations, or when there is no possibility of recovery.*

4.3 BIODIVERSITY IMPACT TYPOLOGY

The scoping and screening of potential Project impacts identified a number of Project aspects and activities that have potential to biodiversity values (shown in ***Table 4.2***). Whilst the potential impacts relate to a combination of Project aspects/activities and biodiversity threats, they can be summarised into a number of key potential impacts according to the biodiversity threat type. These impacts can relate to habitat areas, specific species or both. These impact types include:

- Loss of habitat;
- Disturbance or displacement of individuals;
- Barrier creation;
- Fragmentation;
- Edge effects;
- Degradation of habitat; and
- Mortality – vehicle strike, hunting and poaching.

These impact assessment types are further explored in relation to the biodiversity values identified within the Project Area and the specific Project activities/aspects in the following sections.

This section elaborates on the nature of impacts to biodiversity values at it relates to the characteristics of the Project Area as determined by assessing the impacts of the Project Description (*Section 2*). The information has been used to inform the evaluation of the significance of the impact in the impact assessment summary tables following each impact assessment type. Impact assessments have been undertaken for both Exploration/Construction Phase and Operation Phase.

4.4 HABITAT IMPACT ASSESSMENT (EXPLORATION/CONSTRUCTION PHASE)

4.4.1 *Loss of Terrestrial Habitat*

As described in *Section 3* there are a number of landcover types that will be cleared to facilitate construction of the required project infrastructure and to undertake the exploration and development phase. The natural habitat areas in particular provide habitat values for a variety of native flora and fauna species, including species listed on the IUCN Red list of threatened species. Albeit modified, the modified habitat areas also provide value to native species, in particular those adapted to disturbed environments and human settlement areas. Natural Habitat within the Project Area consists of 72.63haand Modified Habitat consists of 57.37ha.

The impact assessment summary for loss of habitat relating to the exploration/construction phase is outlined in ***Table 4.5***.

Table 4.5 **Impact Assessment Summary – Permanent and Temporary Loss of Habitat**

Impact	**Permanent and temporary loss of habitat (terrestrial and aquatic) including transition of habitats from one habitat type to another**				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on the terrestrial and aquatic biodiversity is negative				
Impact Type	**Direct**	**Indirect**	Induced		
	Direct terrestrial habitat loss in the Project Footprint in areas within the footprint. Indirect effects occur (and discussed in sections to follow).				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	The loss of habitats within the footprint will be permanent.				
Impact Extent	**Local**	Regional	International		
	The extent of natural habitat to be permanently removed is 72.63ha. This impact is considered to be a localised impact.				
Impact Scale	The Project footprint comprises 72.63haof natural habitat				
Frequency	Once construction is complete there will be no further habitat clearing required.				
Impact Magnitude	Positive	Negligible	**Small**	Medium	Large
	Considering the area of clearing of each habitat discussed above, the overall magnitude of this impact is **Small** during the exploration/construction phase.				
Receptor Sensitivity	Low	Medium	**High**		
	The primary forest habitat within the footprint provides habitat values for IUCN listed species, as such there sensitivity is considered to be **High**.				
Impact Significance	Negligible	Minor	**Moderate**	Major	Critical
	The significance of this impact is **Moderate**.				

4.4.2 Changes to aquatic habitat

The geothermal drilling process will use water-base mud to prevent boreholes from collapsing during drilling and also to protect the environment. Water demand for drilling is matched by surface water and/or collected runoff water, amounting to up to 30 – 100 l/sec. This water will be sourced from the Cawang Tengah/Kiri Rivers.

Water extraction has the potential to change the amount of aquatic habitat available in the waterways where water will be sourced. Intensive aquatic biota sampling has not been undertaken as part of the baseline assessment however impacts to aquatic environmental are identified. If extracted at sufficient volume aquatic habitat can be reduced to an extent that fish and other biota communities are unviable. In addition a reduction in flow volume has potential to reduce quality of downstream habitat and interrupt fish migration triggers and pathways. Based on the Project description the volume of water to be extracted is well within the current reported river discharge however in the absence of more detailed study a precautionary approach is recommended and management measures are recommended to facilitate opportunity for adaptive management.

4.4.3 Disturbance and displacement of resident species

The disturbance and displacement of resident fauna species within the footprint will primarily be caused by light, noise and vibration impacts.

Noise, light and vibration disturbances have the potential to influence breeding, roosting or foraging behaviour of fauna. During the exploration/construction phase temporary impacts from the Project are expected. Noise will be the primary disturbance of this nature due to vegetation clearing, excavation, movement of materials, drilling and general construction activities. These activities will introduce noise sources to areas not currently exposed to these disturbances. In addition there may be vibration associated with drilling activities and the movement of any heavy vehicles/machinery.

The consequences of these influences are dependent on the extent of disturbance but in extreme cases these factors can influence local populations. For example if breeding and communication is inhibited influencing lifecycle, or, if individuals are displaced from noisy areas and home ranges are reduced. Excessive noise can impede fauna communication and deter the use of habitats nearby. Similarly, introducing light sources has the potential to deter foraging and dispersal activities of nocturnal species.

The duration of construction activities (not already undertaken) is expected to short-term. Similarly, it should be noted that the noise, light and vibration disturbances will not be continuous for the construction period, or focused on any one specific location for the total time.

Noise light and vibration disturbances will occur throughout the Project Area during construction for the Project components identified, and the impact will include occurring in natural habitat areas where threatened species are known to occur (Sensitivity High).

Although temporary, the construction schedule is expected to be relatively short and not to span multiple breeding seasons. Noise, light and vibration disturbance are unlikely to occur at all locations simultaneously and will be localized.

The impact assessment summary for disturbance and displacement during the construction phase is outlined in ***Table 4.6***.

Table 4.6 **Impact Assessment Summary – Light, noise and vibration**

Impact	Impact to species from light, noise and vibration from the exploration activities, and construction of access roads, well sites, transmission line, power station, water pipeline and other infrastructure				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on the terrestrial and aquatic biodiversity is negative				
Impact Type	Direct	**Indirect**	Induced		
	The impact for fauna is indirect and has potential to induce individuals to move away from currently utilised habitat. In addition noise and vibration can interfere with communications of fauna, including breeding communication (calls).				
Impact Duration	**Temporary**	Short-term	Long-term	Permanent	
	The impacts will be temporary, limited to during the activities required for infrastructure construction.				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be localised for species that occupy habitats immediately adjacent to infrastructure components and activities.				
Impact Scale	It is anticipated that the scale of impact will be limited to terrestrial habitats near to Project components.				
Frequency	Construction occurs only once.				
Impact Magnitude	Positive	Negligible	**Small**	Medium	Large
	Considering this impact will be localised and temporary, the overall magnitude of this impact is **Small**.				
Receptor Sensitivity	Low	Medium	**High**		
	The primary forest habitat within the footprint provides habitat values for IUCN listed species, as such there sensitivity is considered to be **High**.				
Impact Significance	Negligible	Minor	**Moderate**	Major	Critical
	The significance of this impact is **Moderate**.				

From the impact assessment the following impact types require mitigation:

- Disturbance or displacement of individuals; and
- Degradation of habitat.

Specific mitigations to reduce impacts from these impact types are outlined in ***Tables 5.1*** and ***5.2***.

4.4.4 Barrier to Terrestrial Fauna Movement

Construction activities relating to linear infrastructure have potential to create a barrier to fauna movement (for some fauna groups). This includes construction of the access roads, the transmission line and water pipeline infrastructure. Most other Project components are discrete areas that may be navigated around by fauna that may be moving through the area. The construction of access roads and pipelines will introduce gaps in the forest where some fauna may not readily cross given potential vulnerability to predation and/or mortality. This will be a permanent impact.

The linear infrastructure for the Project will not be permanently fenced, which would substantially restrict movement; however the break in the forest has potential to generate a barrier. Linear infrastructure traversing natural habitat areas represent higher risk areas for impact as a result of barrier to movement. There is approximately 12km of access road that intersects natural habitat.

The impact assessment summary for the creation of barriers to fauna movement during the construction phase is outlined in ***Table 4.7***.

Table 4.7 **Impact Assessment Summary – Barrier to Fauna Movement**

Impact	Impact to fauna movement by the construction of linear infrastructure				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on the terrestrial biodiversity is negative				
Impact Type	Direct	**Indirect**	Induced		
	This is an indirect impact to fauna groups in the local area				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	The infrastructure constructed will be a permanent feature as such the impact will be permanent.				
Impact Extent	**Local**	Regional	International		
	The impact is expected to relate to local fauna movements as opposed to regional or national scale corridor features.				
Impact Scale	It is anticipated that the scale of impact will be limited to areas along linear infrastructure components.				
Frequency	Construction occurs only once.				
Impact Magnitude	Positive	Negligible	**Small**	Medium	Large
	While a barrier will be introduced opportunities for movement across the landscape will remain locally. As a result the overall magnitude of this impact is **Small**.				
Receptor Sensitivity	Low	Medium	**High**		
	The primary forest habitat within the footprint provides habitat values for IUCN listed species, as such there sensitivity is considered to be **High**.				
Impact Significance	Negligible	Minor	**Moderate**	Major	Critical
	The significance of this impact is **Moderate**.				

From the impact assessment the following impact types require mitigation:

- Barrier creation;
- Fragmentation;
- Edge effects;

Specific mitigations to reduce impacts from these impact types are outlined in ***Tables 5.1*** and ***5.2***.

4.4.5 Fragmentation and Edge Effects

Edge effects are an indirect impact of land clearing during construction and throughout operation. Where vegetation clearing occurs, adjacent vegetation and habitats can be exposed to changes in noise, light (natural or artificial), dust, humidity and temperature factors as well as increased competition from predators and invasive species. The impact of edge effects to habitat value and forest composition has been widely recognized as a contributor to forest degradation and impacts to biodiversity. In extreme cases the effects have potential to alter the habitat characteristics of the ecotone and influence suitable habitat for native flora and fauna (including threatened species). Clearing of vegetation for the Project will create 'new' edges in areas that have not previously been disturbed.

Vegetation responses to edge creation are site specific (Harper et al. 2005) and as such there are challenges in defining the magnitude of edge influence for

the Project area. A variety of studies have been undertaken that have assessed a 'distance of edge influence (DEI) using field collected data to measure the distance at which structure or composition is different from undisturbed areas and/or when abiotic factors (e.g. humidity, temperature) are different. Literature review of studies targeted to tropical forest (keywords tropical forest, tropical rainforest, lowland rainforest) types identified a range of DEI values:

- Microclimate effects reported up to 40m from forest edge in tropical rainforest (Turner, 1996);
- Canopy cover effects up to 10m, snag abundance up to 13m, understory density up to 13m in tropical forest (Harper et al. 2005);
- Effects in light, temperature, humidity, gaps, weeds and pioneer species of up to 50-100m for linear clearings (no forest type defined)(Laurance et al. 2009);
- Altered floristic composition and disturbance indicators up to 20-45m in tropical rainforest (Goosen and Jago, no date);
- Edge effects to woody seedling density up to 10m and temperature and vapor pressure effects up to 50m in lowland tropical forest (Sizer and Tanner 1999); and
- Microclimate effects in tropical forest up to 20m (Ewers and Banks-Leite 2013).

The indirect impact area is dominated by the primary and secondary forest land classes. These forest types are largely considered to be natural habitat and are known to support a variety of native and conservation significant species. It is not anticipated that these impacts will cause significant impacts; however dust impacts may occur on areas adjacent to roads, smothering vegetation. It is likely that this impact will be limited to the dry season as rainfall will wash dust from vegetation during the wet season.

Fragmentation of habitats can occur where currently linked habitats are disconnected through the construction of Project components. Fragmentation reduces the continuity of habitat and hence the ability for fauna to move within and between habitat patches. The resulting impact can cause reductions in foraging and breeding habitats. Species with limited home ranges may have a reduction in available area, leading to conflict over resources or negative interactions over territories. Fragmentation of existing habitats is not considered to be a significant impact as the infrastructure design does not lead to isolation of habitat patches.

The impact assessment summary for impacts to habitats by edge effects during the exploration/construction phase is outlined in ***Table 4.8***.

Table 4.8 Impact Assessment Summary – Fragmentation and Edge effects

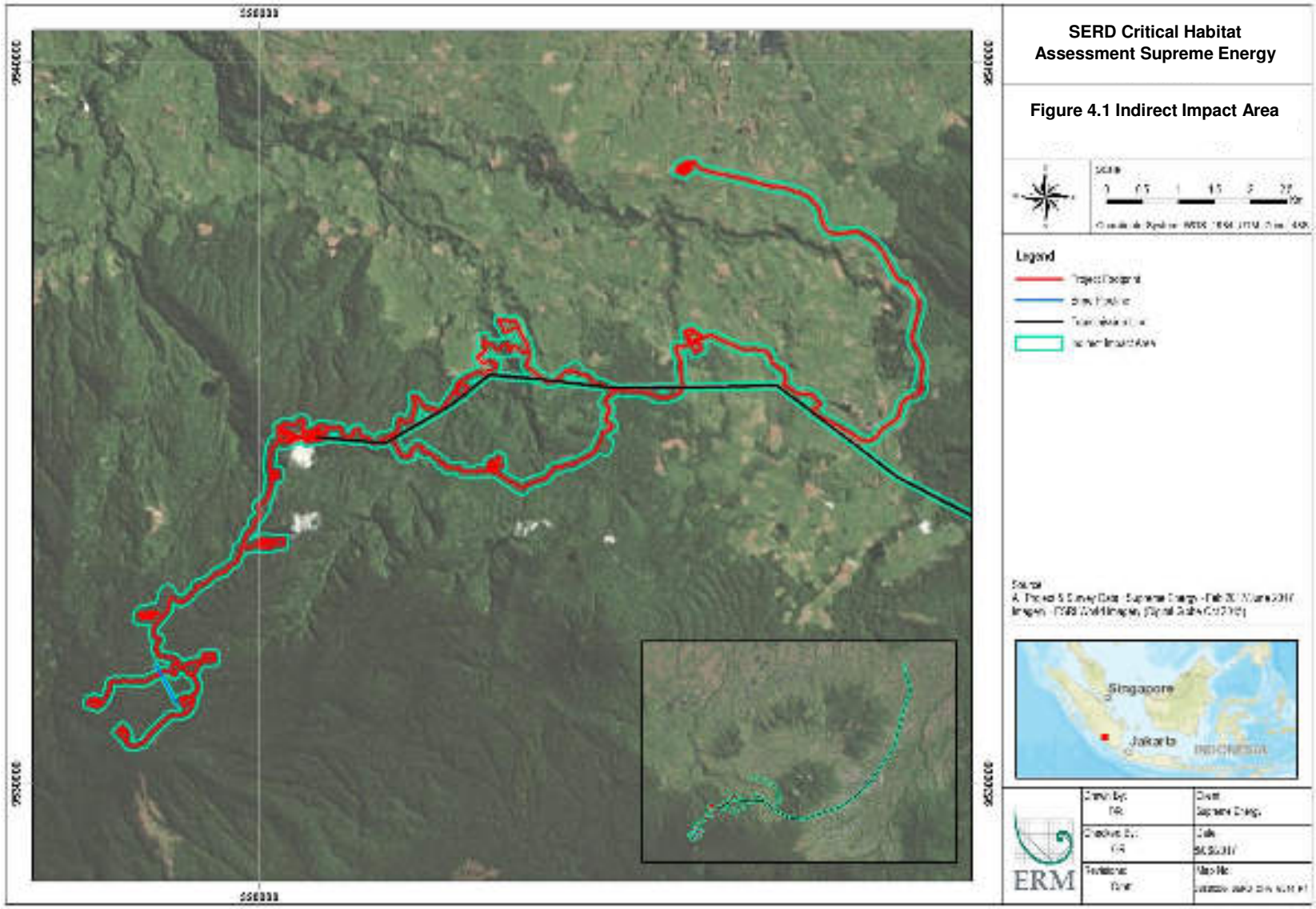
Impact	Impact to fauna movement from the construction of linear infrastructure				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on the terrestrial biodiversity is negative				
Impact Type	Direct	**Indirect**	Induced		
	Indirect impact to flora and fauna species utilising the edge habitat areas.				
Impact Duration	Temporary	Short-term	**Long-term**	Permanent	
	Although construction will be short-term there will be a period of recovery for the edge habitat areas. Edge effects will be permanent however likely restricted to the dry season where dust on vegetation will persist.				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be localised for habitats alongside linear infrastructure components, including roads.				
Impact Scale	It is anticipated that the scale of impact will be limited to areas along linear infrastructure components.				
Frequency	Construction occurs only once.				
Impact Magnitude	Positive	Negligible	**Small**	Medium	Large
	While edge effects will occur, the impact will be localised and in the long-term most severe during dry weather conditions. The overall magnitude of this impact is **Small**.				
Receptor Sensitivity	Low	Medium	**High**		
	The primary forest habitat within the footprint provides habitat values for IUCN listed species, as such there sensitivity is considered to be **High**.				
Impact Significance	Negligible	Minor	**Moderate**	Major	Critical
	The significance of this impact is **Moderate**.				

From the impact assessment the following impact types require mitigation:

- Fragmentation; and
- Edge effects;

Specific mitigations to reduce impacts from these impact types are outlined in ***Tables 5.1*** and ***5.2***.

Figure 4.1 Indirect Impact Area



4.4.6 Degradation of Habitats

A range of Project activities have the potential to lead to degradation of native flora and fauna habitats including excavation, construction, land clearing, spoil disposal, movement of vehicles, drilling, refueling, hazardous materials storage and maintenance. In general the impacts will cause: dust; runoff; release of potential contaminants; and invasive species. Construction activities have been assessed for these impact types, including: construction of the access roads, cement plant, transmission line and water pipeline.

Dust

During construction, land preparation has the potential to generate dust which may settle on vegetation adjacent to the construction area (including access roads). Excessive dust deposition on flora may act to suppress growth through limiting photosynthesis and the dusted foliage may also become unpalatable to foraging fauna. The construction activities will be temporary and dust generation is likely to be localised to active work areas. Rainfall will generally remove dust from foliage and this impact has been assessed for significance as part of the Edge Effects impact in *Section 0*.

Runoff

Land preparation will expose earth areas to be vulnerable to erosion (wind and/or runoff) until infrastructure construction or replanting is completed to stabilise the surface. The Project Area experience varied topography including steep slopes. Erosive processes transport sediment downstream depositing mobilized sediment downstream/downslope of habitats (both aquatic and terrestrial). This indirect impact has potential to degrade downstream habitat areas or change habitat characteristics, and as such influencing suitability for native flora and fauna communities. Runoff may flow into the local river systems which may provide habitat for conservation significant and commercially utilised fish species.

Release of Contaminants

Accidental release or spill of these materials can be toxic to flora and fauna locally and downstream if substances are released into the aquatic environment. Runoff from construction sites has potential to carry contaminants substantial distance downstream. Construction activities such as refueling, storage and other activities that require oil and hazardous substances to be used are undertaken at risk of accidental release.

Invasive Species

Invasive species (flora and fauna) have the potential to be introduced or spread throughout the Project Area through increased movement of people, vehicles, machinery, vegetation and soil. An increase in the prevalence of weeds or other pests has the potential to reduce the quality of habitat for some native flora and fauna, including conservation significant species. Invasive flora species can rapidly germinate in disturbed areas whereby affecting the ability of native vegetation communities to re-establish. Invasive animals also have the potential to be introduced or increased in abundance. These animals

may adversely impact native fauna as a result of increased competition for resources, predation or habitat degradation.

Invasive species were detected within the Area of Influence and Project Area and will be considered as part of the impact analysis. The impact assessment summary for degradation of habitats during the construction phase is outlined in ***Table 4.9***.

Table 4.9 *Impact Assessment Summary – Degradation of Habitats*

Impact	**Impact to habitats from degradation including runoff, release of contaminants and invasive species from the exploration/construction phase**				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on the terrestrial and aquatic biodiversity is negative				
Impact Type	**Direct**	**Indirect**	Induced		
	This impact has potential to be direct (eg. contamination due to accidental spill) or indirect (eg. introduced weeds reducing habitat suitability)				
Impact Duration	Temporary	Short-term	**Long-term**	**Permanent**	
	Although construction phase is short-term, resulting degradation has potential to be long-term or permanent.				
Impact Extent	**Local**	**Regional**	International		
	The impact is expected to be localised for habitats alongside linear infrastructure components and activities. If downstream environments are impacted the extent may be regional.				
Impact Scale	It is anticipated that the scale of impact will be limited to downstream areas and areas along linear infrastructure components.				
Frequency	Construction occurs only once.				
Impact Magnitude	Positive	Negligible	**Small**	Medium	Large
	Given there are currently invasive species known in the habitats of the Project Area magnitude of this impact is **Small**.				
Receptor Sensitivity	Low	Medium	**High**		
	The primary forest habitat within the footprint provides habitat values for IUCN listed species, as such there sensitivity is considered to be **High**.				
Impact Significance	Negligible	Minor	**Moderate**	Major	Critical
	The significance of this impact is **Moderate**.				

From the impact assessment the following impact types require mitigation:

- Degradation of habitat and
- Edge effects;

Specific mitigations to reduce impacts from these impact types are outlined in ***Tables 5.1*** and ***5.2***.

4.4.7 Fauna Mortality

Vehicle/Machinery Strike

Fauna mortality can occur during most construction activities (e.g. vegetation clearing, excavation, vehicle movement) in the event individuals are struck by vehicles and machinery. Animals that are unable to disperse during clearing activities are vulnerable to being injured or destroyed through interaction with machinery or falling debris.

It is likely that most individuals will disperse from construction activity locations into adjacent habitats as a result of noise and other disturbance however some less mobile species may experience a localised reduction in abundance during this period, such as amphibians, reptiles and small mammals.

Hunting and Poaching

With greater human activity in the region and increased access points to the forest there is a risk of increased hunting and poaching activities leading to fauna mortality from workers and also local people who may have access to habitats that were previously restricted or difficult to access. Hunting of wildlife, including conservation significant species is known to occur in Sumatra. Through the installation of new roads, i.e. increased ease of access hunting and poaching may increase. Species located within the Project Area include the Sunda Pangolin (*Manis javanica*) that have been listed as Critically Endangered, primarily due to poaching and wildlife trafficking.

The impact assessment summary for impacts to species from fauna mortality during the construction phase is outlined in ***Table 4.10***.

Table 4.10 Impact Assessment Summary – Fauna Mortality

Impact	Impact to fauna from vehicle strike and hunting/poaching during the exploration/construction phase				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on the terrestrial biodiversity is negative				
Impact Type	**Direct**	Indirect	Induced		
	Direct impact to terrestrial fauna.				
Impact Duration	Temporary	Short-term	**Long-term**	Permanent	
	Although construction vehicle strike impacts will be temporary an increase in hunting and poaching may be a longer term impact for targeted species.				
Impact Extent	**Local**	Regional	International		
	It is anticipated that the scale of impact will largely be limited to the immediate Project vicinity, particularly along roads and near the workers camp.				
Impact Scale	It is anticipated that the scale of impact will largely be limited to the immediate Project vicinity, particularly along roads and near the workers camp.				
Frequency	Construction occurs only once.				
Impact Magnitude	Positive	Negligible	**Small**	Medium	Large
	Considering the magnitude of impacts the overall magnitude of this impact is **Small**.				
Receptor Sensitivity	Low	Medium	**High**		
	Terrestrial species likely impacted are considered to be a **High** sensitivity given the potential presence of Critical Habitat candidate species locally.				
Impact Significance	Negligible	Minor	**Moderate**	Major	Critical
	The significance of this impact is **Moderate**.				

From the impact assessment the following impact types require mitigation:

- Disturbance or displacement of individuals;
- Mortality – vehicle strike, hunting and poaching.

Specific mitigations to reduce impacts from these impact types are outlined in ***Tables 5.1*** and ***5.2***.

4.5 HABITAT IMPACT ASSESSMENT (OPERATION PHASE)

4.5.1 *Loss of Habitat – Induced Clearing*

There will be no additional clearing of habitat as part of operation of the Project however the issue of induced clearing must be considered. Induced clearing has potential to occur locally when Project infrastructure is established and there is increased access to the forest areas and a larger number of people residing in the area for the purposes of employment.

4.5.2 *Disturbance and displacement of resident species*

Disturbance and displacement of species during operation will be primarily caused by light and noise generated during operation and maintenance of the facilities. Light and noise impacts will have the same type of impacts to resident fauna as described in the impact assessment for the exploration/construction phase (as outlined above). Impacts will relate to both natural and modified habitats surrounding the Project infrastructure. Given the Project does not involve high noise generating activities (such as

blasting) this impact is not expected to be substantial. The impact assessment summary for disturbance and displacement during the construction phase is outlined in ***Table 4.11***.

Table 4.11 Impact Assessment Summary – Disturbance and displacement of resident species

Impact	Impact to species from disturbance and displacement of resident species				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on the terrestrial biodiversity is negative				
Impact Type	**Direct**	**Indirect**	Induced		
	Direct impact to terrestrial fauna.				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	The impact will be permanent and ongoing during operation				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be localised for species that occupy habitats immediately adjacent to Project components and activities.				
Impact Scale	It is anticipated that the scale of impact will be limited to terrestrial habitats immediately adjacent to Project components.				
Frequency	The frequency of vehicle movements during operation will be reduced in comparison to construction. Similarly, lighting will be required only at operational facilities (i.e. not along access roads or transmission line).				
Impact Magnitude	Positive	**Negligible**	**Small**	Medium	Large
	The magnitude of this impact is expected to be Negligible to Small				
Receptor Sensitivity	Low	Medium	**High**		
	The primary forest habitat adjacent to the Project component includes habitat suitable for IUCN listed species, as such there sensitivity is considered to be **High**.				
Impact Significance	Negligible	**Minor**	**Moderate**	Major	Critical
	The significance of this impact is **Minor to Moderate**.				

From the impact assessment the following impact types require mitigation:

- Disturbance or displacement of individuals; and
- Degradation of habitat.

Specific mitigations to reduce impacts from these impact types are outlined in ***Tables 5.1*** and ***5.2***.

4.5.3 Fragmentation and Edge Effects

Impacts from fragmentation and edge effects on resident species are likely to be similar to those described in the construction impact assessment (as discussed above). No new edges will be created as part of operational activities. The impact assessment in *Section 4.4.6* addresses this aspect.

4.5.4 Degradation of Habitats

Impacts relating to habitat degradation are likely to be similar to those described in the exploration/construction impact assessment (as discussed above). No new risk activities will be undertaken as part of operational activities. The impact assessment in *Section 4.4.6* addresses this aspect.

4.5.5 *Fauna Mortality*

Impacts relating to fauna mortality are those described in the exploration/construction impact assessment (as discussed above). No new risk activities will be undertaken as part of operational activities. The impact assessment in *Section 4.4.6* addresses this aspect.

4.6 *THREATENED SPECIES IMPACT ASSESSMENT (ALL PHASES)*

Species of conservation significance identified to occur or potentially occur within the Project Area have been assessed below based on the likely impact during construction and operation. The likely impacts to species are outlined in below.

This list includes the identified species listed as CE, EN or VU on the IUCN Red List and species endemic to Sumatra. While Critical Habitat was not confirmed for these species impacts are identified such that measures can be developed to minimize the impact where possible. Impacts on Critical Habitat species is outlined in *Section 4.7*.

4.6.1 *Impacts to Flora*

Flora of conservation significance was identified within the Project area. These species are shown in ***Table 4.12*** below.

Table 4.12 ***Flora of Conservation Significance***

Scientific Name / Common Name	IUCN	Endemic
Dipterocarpus sp.	CR	
Rafflesia bengkuluensis	NA	✓
Taxus sumatrana	EN	
Saurauia cauliflora	VU	✓
Nepenthes rafflesiana	NA	✓
Amorphophallus beccarii	NA	✓

Impacts to threatened flora will occur due to road construction, brine pipeline construction and well installation during the construction phase. This will result in a reduction in species populations that exist within the footprint of the project area.

Indirect impacts on these species may include illegal logging due to increased access to the project area to local people and workers. Target species such as *Dipterocarpus sp.* may suffer a reduction in species populations of mature individuals as they may be targeted for logging.

Impacts due to edge effects on habitats due to the construction of roads and other infrastructure may cause drying out along forest edges, changing the ecology of these areas, impacting on species composition and individual flora along these edges.

The potential introduction of invasive species within the habitat may increase competition with local flora, resulting in a reduction of species diversity within the project area.

The impact assessment summary for impacts to flora during the construction phase is outlined in ***Table 4.13***.

Table 4.13 Impact Assessment Summary – Flora during construction and operation

Impact	Impact to flora during construction and operation				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on flora during construction and operation is negative				
Impact Type	**Direct**	**Indirect**	Induced		
	Direct and indirect impacts to terrestrial flora.				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	The impact will be permanent and ongoing during operation				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be localised for species that occupy habitats immediately adjacent to Project components and activities.				
Impact Scale	It is anticipated that the scale of impact will be limited to terrestrial habitats immediately adjacent to Project components during clearing for construction.				
Frequency	The frequency of impact is likely to be most significant during construction (one time) with potential ongoing impacts during operation.				
Impact Magnitude	Positive	**Negligible**	**Small**	Medium	Large
	The magnitude of this impact is expected to be Negligible to Small within the Project Area as the impact area is relatively small compared to the DMU.				
Receptor Sensitivity	Low	Medium	**High**		
	The primary forest habitat adjacent to the Project component includes habitat suitable for IUCN CR and EN listed species, as such there sensitivity is considered to be **High**.				
Impact Significance	Negligible	**Minor**	**Moderate**	Major	Critical
	The significance of this impact is **Minor to Moderate**.				

From the impact assessment the following impact types require mitigation:

- Loss of habitat;
- Disturbance or displacement of individuals;
- Edge effects; and
- Degradation of habitat.

Specific mitigations to reduce impacts from these impact types are outlined in ***Tables 5.1*** and ***5.2***.

4.6.2 Impacts to Birds

Birds of conservation significance were identified within the Project area. These species are shown in ***Table 4.14*** below.

Table 4.14 Birds of conservation significance identified within the Project Area

Scientific Name / Common Name		IUCN	Endemic
Apalharpactes mackloti	Sumatran trogon	LC	✓
Arborophila rubrirostris	Red-billed partridge	LC	✓
Carpococcyx viridis	Sumatran ground-cuckoo	CR	✓
Cochoa beccarii	Sumatran cochoa	VU	✓
Dicrurus sumatranus	Sumatran drongo	NT	✓
Garrulax bicolor	Sumatran laughingthrush	EN	✓
Hydrornis schneideri	Schneider's pitta	VU	✓
Lophura inornata	Salvadori's pheasant	NT	✓
Myophonus melanurus	Shiny whistling-thrush	LC	✓
Padda oryzivora	Java sparrow	VU	
Pericrocotus miniatus	Sunda minivet	LC	✓
Polyplectron chalcurum	Bronze-tailed peacock-pheasant	LC	✓

Reduction of habitat from clearing during construction and operation will reduce habitats for bird species within the project area. Species such as the Sumatran drongo that rely on hollows for nesting may have a reduction in breading habitat available.

Ground dwelling birds such as the Sumatran Ground Cuckoo and Salvadori's pheasant are likely to be impacted by reduced land cover and ground level barriers such as roads and the brine pipeline, potentially increasing opportunities for predation.

Species such as the Java sparrow, Sumatran cochoa may be subject to increased hunting and poaching pressure from increased access by local people. These species are targeted for the wildlife trade.

Reductions in canopy cover will increase flying distances for forest dwelling birds. Edge effects will also reduce moisture differentials at forest edges, reducing available habitat for forest dwelling birds.

The availability of prey and feeding resources may change across the project area, with potential increases in grass dependent insects potentially enabling an improved food source for insect eating birds.

Carnivorous birds may benefit from greater open spaces enabling prey to be more easily caught. Omnivorous and herbivorous birds may have a reduction or change in plant feed sources due to changes in the distribution and abundance of flora species. Nectar dependent birds may also suffer a reduction in feeding resource, especially in disturbed forest and forest edges.

The impact assessment summary for impacts to birds during the construction phase is outlined in ***Table 4.15***.

Table 4.15 Impact Assessment Summary – Birds during construction and operation

Impact	Impact to birds during construction and operation				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on birds during construction and operation is negative				
Impact Type	**Direct**	**Indirect**	Induced		
	Direct and indirect impacts to birds.				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	The impact will be permanent and ongoing during operation				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be localised for species that occupy habitats immediately adjacent to Project components and activities.				
Impact Scale	It is anticipated that the scale of impact will be limited to terrestrial habitats immediately adjacent to Project components.				
Frequency	The frequency of impact is likely to be most significant during construction (one time) with potential ongoing impacts during operation.				
Impact Magnitude	Positive	**Negligible**	**Small**	Medium	Large
	The magnitude of this impact is expected to be Negligible to Small within the Project Area as the impact area is relatively small compared to the DMU.				
Receptor Sensitivity	Low	Medium	**High**		
	The primary forest habitat adjacent to the Project component includes habitat suitable for IUCN CR and EN listed species, as such there sensitivity is considered to be **High**.				
Impact Significance	Negligible	**Minor**	**Moderate**	Major	Critical
	The significance of this impact is **Minor to Moderate**.				

From the impact assessment the following impact types require mitigation:

- Loss of habitat;
- Disturbance or displacement of individuals;
- Barrier creation;
- Fragmentation;
- Edge effects;
- Degradation of habitat;
- Mortality –hunting and poaching.

Specific mitigations to reduce impacts from these impact types are outlined in ***Tables 5.1*** and ***5.2***.

4.6.3 Impacts to Mammals

Mammals of conservation significance were identified within the Project area. These species are shown in ***Table 4.16*** below.

Table 4.16 Mammals of conservation significance identified within the Project Area

Scientific Name / Common Name		IUCN	Endemic
Arctictis binturong	Binturong	VU	-
Arctonyx hoevenii	Sumatran hog badger	LC	✓
Capricornis sumatraensis	Sumatran serow	VU	-
Cuon aplinus	Dhole	EN	-
Helarctos malayanus	Malayan sun bear	VU	-
Hylopetes winstoni	Sumatran flying squirrel	DD	✓
Muntiacus montanus muntjac	Sumtrana mountain	DD	✓
Pardofelis marmorata	Marbled cat	VU	-
Muntiacus muntjac		LC	-
Maxomys hylomyoides	Sumatran mountain maxomys	DD	✓
Mus crociduroides	Sumatran shrewlike mouse	DD	✓
Nesolagus netscheri	Sumatran striped rabbit	VU	✓
Rattus korinchi	Sumatran mountain rat	DD	✓

Mammal species within the project area will suffer impacts due to a reduction in habitat, feeding/foraging, cover and increased access for humans.

A reduction in habitat from the building of roads, brine pipelines and wellpads will reduce habitat within the project area. The resulting impact will mean that individuals are likely to flee the project area to adjacent forest areas. This has the potential to cause conflicts with existing populations of the same species in those areas, increasing the competition for food and water.

Some species, such as the Sumatran Mountain Muntjac will have potential impacts from hunting and poaching during construction and operation from labour influx and increased access by local people.

Arboreal mammals such as the Sumatran flying squirrel will have a reduction in tree canopy connectivity from the construction of roads and pipelines, increasing the distance to travel between trees or isolating populations where individuals are no longer able to move.

Ground dwelling mammals will be impacted by reductions in ground habitat available for foraging/feeding and shelter. Increase gaps in the understorey, roads and pipelines may impede movement of these species, also making them more susceptible to vehicles strike when they cross roads.

Nesting habitat for species such as the Sumatran shrewlike mouse and Sumatran striped rabbit will be reduced, meaning these species may suffer increased predation as they seek alternative habitats as well as conflict with existing populations in those areas.

Predatory behaviours of some species (such as the Marbled Cat) may benefit due to increased openness of forest cover, enabling prey to be more easily caught. However, this species is likely to flee from the project area during construction, potentially returning during the operation phase.

The impact assessment summary for impacts to mammals during the construction phase is outlined in ***Table 4.17***.

Table 4.17 Impact Assessment Summary – Mammals during construction and operation

Impact	Impact to mammals during construction and operation				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on mammals during construction and operation is negative				
Impact Type	**Direct**	**Indirect**	Induced		
	Direct and indirect impacts to mammals.				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	The impact will be permanent and ongoing during operation				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be localised for species that occupy habitats immediately adjacent to Project components and activities.				
Impact Scale	It is anticipated that the scale of impact will be limited to terrestrial habitats immediately adjacent to Project components.				
Frequency	The frequency of impact is likely to be most significant during construction (one time) with potential ongoing impacts during operation.				
Impact Magnitude	Positive	**Negligible**	**Small**	Medium	Large
	The magnitude of this impact is expected to be Negligible to Small within the Project Area as the impact area is relatively small compared to the DMU.				
Receptor Sensitivity	Low	Medium	**High**		
	The primary forest habitat adjacent to the Project component includes habitat suitable for IUCN CR and EN listed species, as such there sensitivity is considered to be **High**.				
Impact Significance	Negligible	**Minor**	**Moderate**	Major	Critical
	The significance of this impact is **Minor to Moderate**.				

From the impact assessment the following impact types require mitigation:

- Loss of habitat;
- Disturbance or displacement of individuals;
- Barrier creation;
- Fragmentation;
- Edge effects;
- Degradation of habitat;
- Mortality –hunting and poaching.

Specific mitigations to reduce impacts from these impact types are outlined in *Tables 5.1* and *5.2*.

4.6.4 Impacts to Herpetofauna

Herpetofauna of conservation significance were identified within the Project area. These species are shown in ***Table 4.18*** below.

Table 4.18 Herpetofauna of conservation significance identified within the Project Area

Scientific Name / Common Name	IUCN	Endemic
Rhacophorus bifasciatus	NT	✓

Amphibians within the project area are likely to see an overall reduction in habitat availability as the removal of forest cover is likely to dry out forest edges and habitat. The reduction in available habitat will likely mean that individuals will suffer direct mortality due to the low mobility of the species.

An increase in pools along artificial drainage systems may provide additional breading habitat for the species. Increases in predation may occur due to increased access to open forest areas. A reduction in the species population is likely to occur during construction and persist during operation in the project area.

The impact assessment summary for impacts to herpetofauna during the construction phase is outlined in ***Table 4.19.***

Table 4.19 Impact Assessment Summary – Herpetofauna during construction and operation

Impact	Impact to herpetofauna during construction and operation				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on herpetofauna during construction and operation is negative				
Impact Type	**Direct**	**Indirect**	Induced		
	Direct and indirect impacts to herpetofauna.				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	The impact will be permanent and ongoing during operation				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be localised for species that occupy habitats immediately adjacent to Project components and activities.				
Impact Scale	It is anticipated that the scale of impact will be limited to terrestrial habitats immediately adjacent to Project components.				
Frequency	The frequency of impact is likely to be most significant during construction (one time) with potential ongoing impacts during operation.				
Impact Magnitude	Positive	**Negligible**	**Small**	Medium	Large
	The magnitude of this impact is expected to be Negligible to Small within the Project Area as the impact area is relatively small compared to the DMU.				
Receptor Sensitivity	Low	Medium	**High**		
	The primary forest habitat adjacent to the Project component includes habitat suitable for IUCN CR and EN listed species, as such there sensitivity is considered to be **High**.				
Impact Significance	Negligible	**Minor**	**Moderate**	Major	Critical
	The significance of this impact is **Minor to Moderate**.				

From the impact assessment the following impact types require mitigation:

- Loss of habitat;
- Disturbance or displacement of individuals;
- Barrier creation;
- Fragmentation;
- Edge effects;
- Degradation of habitat;
- Mortality –hunting and poaching.

Specific mitigations to reduce impacts from these impact types are outlined in ***Tables 5.1*** and ***5.2***.

4.7 IMPACTS TO FISH

Fish of conservation significance were identified within the Project area. These species are shown in ***Table 4.20*** below.

Table 4.20 Fish of Conservation Significance within the Project Area

Scientific Name / Common Name		IUCN	Endemic
Tor tambroides	Mahseer Fish	DD	-

Fishes within the project area may suffer impacts to changes in water quality and quantity in surrounding waterways. Increases in overland flows from hard packed surfaces may change stream dynamics, increasing the amount of flow within rivers and streams.

Runoff from disturbed soil surfaces may include sediment and turbidity, smothering stream habitat and reducing the ability of fish species to forage.

The impact assessment summary for impacts to fish during the construction phase is outlined in ***Table 4.21***.

Table 4.21 Impact Assessment Summary – Fish during construction and operation

Impact	Impact to fish during construction and operation				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on fish during construction and operation is negative				
Impact Type	**Direct**	**Indirect**	Induced		
	Direct and indirect impacts to fish.				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	The impact will be permanent and ongoing during operation				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be localised for species that occupy habitats immediately adjacent to Project components and activities.				
Impact Scale	It is anticipated that the scale of impact will be limited to terrestrial habitats immediately adjacent to Project components.				
Frequency	The frequency of impact is likely to be most significant during construction (one time) with potential ongoing impacts during operation.				
Impact Magnitude	Positive	**Negligible**	**Small**	Medium	Large
	The magnitude of this impact is expected to be Negligible to Small within the Project Area as the impact area is relatively small compared to the DMU.				
Receptor Sensitivity	Low	Medium	**High**		
	The primary forest habitat adjacent to the Project component includes habitat suitable for IUCN CR and EN listed species, as such there sensitivity is considered to be **High**.				
Impact Significance	Negligible	**Minor**	**Moderate**	Major	Critical
	The significance of this impact is **Minor to Moderate**.				

From the impact assessment the following impact types require mitigation:

- Loss of habitat;
- Barrier creation;
- Fragmentation;
- Edge effects; and
- Degradation of habitat.

Specific mitigations to reduce impacts from these impact types are outlined in ***Tables 5.1*** and ***5.2***.

4.8 IMPACT ASSESSMENT FOR CRITICAL HABITAT SPECIES (ALL PHASES)

The following Critical Habitat species were determined to occur within the Project Area. The following impacts and mitigations have been identified for each species. Specific mitigations for Critical Habitat species are outlined in ***Section 5.3, Table 5.3***.

4.8.1 Impact Assessment for Rafflesia bengkuluensis

Rafflesia bengkuluensis is a parasitic plant endemic to Sumatra. The species was determined to be a Critical Habitat species due to its endemicity meeting the thresholds contained in IFC PS6 for Criterion 2, Tier 1a. The Project Area is considered to contain Critical Habitat for this species.

R. bengkuluensis is likely to be impacted due to direct habitat losses and destruction of individuals within the Project Area from the construction of roads, well pads and brine pipelines. The impacts are expected to be localised to the Project area and not impact the species within the broader DMU.

The impact assessment summary for impacts to *R. bengkuluensis* during the construction and operation phase is outlined in ***Table 4.22***.

Table 4.22 Impact Assessment Summary – R. bengkuluensis during construction and operation

Impact	Impact to *R. bengkuluensis* during construction and operation				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on fish during construction and operation is negative				
Impact Type	**Direct**	**Indirect**	Induced		
	Direct and indirect impacts to *R. bengkuluensis*				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	The impact will be permanent and ongoing during operation				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be localised for individuals of *R. bengkuluensis* that occupy habitats immediately adjacent to Project components and activities.				
Impact Scale	It is anticipated that the scale of impact will be limited to terrestrial habitats immediately adjacent to Project components. Loss of habitat may impact species populations, as may poaching of individuals within the Project area. The impact however is likely to be localised within the immediate area surrounding the Project.				
Frequency	The frequency of impact is likely to be most significant during construction (one time) with potential ongoing impacts during operation.				
Impact Magnitude	Positive	Negligible	**Small**	**Medium**	Large
	The magnitude of this impact is expected to be Small to Medium within the Project Area.				
Receptor Sensitivity	Low	Medium	**High**		
	The species is a Critical Habitat species and hence the receptor sensitivity is considered to be High.				

Impact	Impact to *R. bengkuluensis* during construction and operation				
Impact Significance	Negligible	**Minor**	**Moderate**	Major	Critical
	The significance of this impact is **Minor to Moderate**.				

4.8.2 *Impact Assessment for Vanda foetida*

Vanda foetida is an orchid species that is found on trees and rocks within the forests of the Project Area. The species was determined to be a Critical Habitat species due to its endemicity meeting the thresholds contained in IFC PS6 for Criterion 2. The Project Area is considered to contain Critical Habitat for this species.

V. foetida is likely to be impacted due to habitat destruction within the Project Area through the direct removal of host trees and destruction of ground habitat (such as fallen logs and rocks). This will reduce the distribution and abundance of the species across the Project Area. The species may also be targeted by orchid collectors and hence may suffer population loss due to illegal poaching enabled by increased access to the Project area and DMU.

The impact assessment summary for impacts to *V. foetida* during the construction and operation phase is outlined in ***Table 4.23***.

Table 4.23 Impact Assessment Summary – Vanda foetida during construction and operation

Impact	Impact to *Vanda foetida* during construction and operation				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on fish during construction and operation is negative				
Impact Type	**Direct**	**Indirect**	Induced		
	Direct and indirect impacts to *Vanda foetida*.				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	The impact will be permanent and ongoing during operation				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be localised for individuals of *Vanda foetida* that occupy habitats immediately adjacent to Project components and activities.				
Impact Scale	It is anticipated that the scale of impact will be limited to terrestrial habitats immediately adjacent to Project components. Loss of habitat may impact species populations, as may poaching of individuals within the Project area. The impact however is likely to be localised within the immediate area surrounding the Project.				
Frequency	The frequency of impact is likely to be most significant during construction (one time) with potential ongoing impacts during operation.				
Impact Magnitude	Positive	**Negligible**	**Small**	Medium	Large
	The magnitude of this impact is expected to be Negligible to Small within the Project Area as the impact area is relatively small compared to the DMU.				
Receptor Sensitivity	Low	Medium	**High**		
	The species is a Critical Habitat species and hence the receptor sensitivity is considered to be High.				
Impact Significance	Negligible	**Minor**	**Moderate**	Major	Critical
	The significance of this impact is **Minor to Moderate**.				

4.8.3 *Impact Assessment for Malayan Pangolin (Manis javanica)*

The Sunda Pangolin (*Manis javanica*) was identified as a Critical Habitat species within the Project area and DMU. Individuals were identified in the forested areas of the Project area. There is insufficient data to confirm if the DMU habitat contains a nationally/regionally important concentration of the species so a precautionary approach has been taken and the species has been triggered under Criterion 1, Tier 2e.

The primary threat to *M. javanica* is hunting and poaching for international trade, both targeted and untargeted, and which is largely driven by export trade to China, involving live animals, their meat and scales. Increases in access to the project area may facilitate hunting and poaching for the species.

Reductions in habitat used for foraging and nesting (hollows and dens) may also occur due to direct habitat loss. The species feeds on ants and termites meaning that a reduction in forest cover will also lead to a reduction in feed sources for the species. Given the mobility of the species and the relatively small impact area, this is seen as a relatively minor potential impact for the species.

The impact assessment summary for impacts to *M. javanica* during the construction and operation phase is outlined in ***Table 4.24***.

Table 4.24 Impact Assessment Summary – Manis javanica during construction and operation

Impact	**Impact to *Manis javanica* during construction and operation**				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on fish during construction and operation is negative				
Impact Type	**Direct**	**Indirect**	Induced		
	Direct and indirect impacts to *Manis javanica*				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	The impact will be permanent and ongoing during operation				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be localised for individuals of *Manis javanica* that occupy habitats immediately adjacent to Project components and activities.				
Impact Scale	It is anticipated that the scale of impact will be limited to terrestrial habitats immediately adjacent to Project components. Increased human access to the Project area may facilitate reductions in populations due to hunting and poaching. The impact however is likely to be localised within the immediate area surrounding the Project.				
Frequency	The frequency of impact is likely to be most significant during construction (one time) with potential ongoing impacts during operation.				
Impact Magnitude	Positive	**Negligible**	**Small**	Medium	Large
	The magnitude of this impact is expected to be Negligible to Small within the Project Area as the impact area is relatively small compared to the DMU.				
Receptor Sensitivity	Low	Medium	**High**		
	The species is a Critical Habitat species and hence the receptor sensitivity is considered to be High.				
Impact Significance	Negligible	**Minor**	**Moderate**	Major	Critical
	The significance of this impact is **Minor to Moderate**.				

4.8.4 Impact Assessment for Broad-nosed Sumatran maxomys (Maxomys inflatus)

The Broad-nosed Sumatran maxomys (*Maxomys inflatus*) was identified as a Critical Habitat species within the Project area and DMU. Individuals were identified in the forested areas of the Project area. The species has been identified has being a Critical Habitat species under Criterion 2, Tier 1b.

Threats identified for this species include illegal logging and habitat destruction. Impacts from the Project will cause increased habitat construction from the construction of roads, wellpads and the brine pipeline. This will result in a direct loss of habitat for the species. Increased access due to new roads in the area may increase illegal logging within the Project area and surrounds if not appropriately controlled. Impacts from speculative land clearing are also possible. Direct impacts from fauna mortality from vehicle strike may also occur during construction.

The impact assessment summary for impacts to ***M. inflatus*** during the construction and operation phase is outlined in ***Table 4.25***

Table 4.25 Impact Assessment Summary – M. inflatus during construction and operation

Impact	**Impact to *M. inflatus* during construction and operation**				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on fish during construction and operation is negative				
Impact Type	**Direct**	**Indirect**	Induced		
	Direct and indirect impacts to *M. inflatus*				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	The impact will be permanent and ongoing during operation				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be localised for individuals of *M. inflatus* that occupy habitats immediately adjacent to Project components and activities.				
Impact Scale	It is anticipated that the scale of impact will be limited to terrestrial habitats immediately adjacent to Project components. Increased human access to the Project area may facilitate reductions in populations due to illegal logging and clearing. The impact however is likely to be localised within the immediate area surrounding the Project.				
Frequency	The frequency of impact is likely to be most significant during construction (one time) with potential ongoing impacts during operation.				
Impact Magnitude	Positive	**Negligible**	**Small**	Medium	Large
	The magnitude of this impact is expected to be Negligible to Small within the Project Area as the impact area is relatively small compared to the DMU.				
Receptor Sensitivity	Low	Medium	**High**		
	The species is a Critical Habitat species and hence the receptor sensitivity is considered to be High.				
Impact Significance	Negligible	**Minor**	**Moderate**	Major	Critical
	The significance of this impact is **Minor to Moderate**.				

4.8.5 Impact assessment for Sumatran Tiger (Panthera tigris sumatrae)

The Sumatran Tiger (*Panthera tigris sumatrae*) was identified as a Critical Habitat species within the Project area and DMU. Individuals' tracks were identified in the forested areas of the Project area. The species has been identified has being a Critical Habitat species under Criterion 2, Tier 1 and 2.

Threats to the Sumatran Tiger have been identified to include habitat loss, illegal trade in individuals and animal parts and prey-base depletion. The Project will result in habitat loss within the Project Area and a minor reduction of habitat across the DMU. Increased access by local people may increase opportunities for poaching of individuals. Reduction in prey species within the project area may also reduce foraging resources.

The impact assessment summary for impacts to *P. tigris sumatrae* during the construction and operation phase is outlined in ***Table 4.26.***

Table 4.26 Impact Assessment Summary – P. tigris sumatrae during construction and operation

Impact	**Impact to *P. tigris sumatrae* during construction and operation**				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on fish during construction and operation is negative				
Impact Type	**Direct**	**Indirect**	Induced		
	Direct and indirect impacts to *P. tigris sumatrae*				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	The impact will be permanent and ongoing during operation				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be localised for individuals of *P. tigris sumatrae* that occupy habitats immediately adjacent to Project components and activities.				
Impact Scale	It is anticipated that the scale of impact will be limited to terrestrial habitats immediately adjacent to Project components. Increased human access to the Project area may facilitate reductions in populations due to poaching and a reduction in prey availability. The impact however is likely to be localised within the immediate area surrounding the Project.				
Frequency	The frequency of impact is likely to be most significant during construction (one time) with potential ongoing impacts during operation.				
Impact Magnitude	Positive	**Negligible**	**Small**	Medium	Large
	The magnitude of this impact is expected to be Negligible to Small within the Project Area as the impact area is relatively small compared to the DMU.				
Receptor Sensitivity	Low	Medium	**High**		
	The species is a Critical Habitat species and hence the receptor sensitivity is considered to be High.				
Impact Significance	Negligible	**Minor**	**Moderate**	Major	Critical
	The significance of this impact is **Minor to Moderate**.				

4.8.6 *Impact Assessment for Sumatran ground-cuckoo (Carpococcyx viridis)*

Although there are no records of the species known from the DMU it is considered that the DMU contains habitat that may be nationally and/or regionally important concentration (Criterion 1, Tier 2e) of the species.

The Species is only known from eight specimens and a recent series of sightings. It was unrecorded since 1916 until an individual trapped in 1997 in Bukit Barisan Selatan NP (at 500m). Subsequent records include from NP and Wildlife Sanctuary to the north of the Project Area, a bird caught and additional sightings in Bukit Barisan Seletan NP.

Threats to the species relate to deforestation and possibly susceptibility to bycatch through hunting.

Impacts from the project will likely cause a reduction in available habitat within the Project area, affecting local populations. Increase access may give rise to hunting and poaching for individuals within the Project area by local people and workers (if not controlled). Fragmentation of the forest canopy will occur within the Project area due to the construction of roads and the brine pipeline, impacting habitat to the species.

The impact assessment summary for impacts to *Carpococcyx viridis* during the construction and operation phase is outlined in ***Table 4.27***.

Table 4.27 Impact Assessment Summary – Carpococcyx viridis during construction and operation

Impact	**Impact to *Carpococcyx viridis* during construction and operation**				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on fish during construction and operation is negative				
Impact Type	**Direct**	**Indirect**	Induced		
	Direct and indirect impacts to *Carpococcyx viridis*				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	The impact will be permanent and ongoing during operation				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be localised for individuals of *Carpococcyx viridis* that occupy habitats immediately adjacent to Project components and activities.				
Impact Scale	It is anticipated that the scale of impact will be limited to terrestrial habitats immediately adjacent to Project components. Increased human access to the Project area may facilitate reductions in populations due to poaching. Fragmentation will also likely impact the population within the project area, restricting access to foraging habitat. The impact however is likely to be localised within the immediate area surrounding the Project.				
Frequency	The frequency of impact is likely to be most significant during construction (one time) with potential ongoing impacts during operation.				
Impact Magnitude	Positive	**Negligible**	**Small**	Medium	Large
	The magnitude of this impact is expected to be Negligible to Small within the Project Area as the impact area is relatively small compared to the DMU.				
Receptor Sensitivity	Low	Medium	**High**		
	The species is a Critical Habitat species and hence the receptor sensitivity is considered to be High.				
Impact Significance	Negligible	**Minor**	**Moderate**	Major	Critical

4.8.7 *Impact Assessment for Sumatran surili (Presbytis melalophos)*

The Sumatran surili (*Presbytis melalophos*) was identified as a Critical Habitat species within the Project area and DMU. Individuals were identified in the forested areas of the Project area. The Project area and DMU has been identified as Critical Habitat under IFC PS6 Criterion 2, Tier 1 and 2.

There has been extensive loss of habitat across the species range however; the species has some tolerance to forest conversion. Trapping of the species for the illegal pet trade is a threat across their range, with some incidental hunting for food. Forest fragmentation is a long-term consideration for population persistence.

Impacts from the project will likely cause a reduction in available habitat within the Project area, affecting local populations. Increase access may give rise to hunting and poaching for individuals within the Project area by local people and workers (if not controlled). Fragmentation of the forest canopy will occur within the Project area due to the construction of roads and the brine pipeline, impacting habitat to the species.

The impact assessment summary for impacts to *Presbytis melalophos* during the construction and operation phase is outlined in ***Table 4.28***.

Table 4.28 Impact Assessment Summary – Presbytis melalophos during construction and operation

Impact	**Impact to *Presbytis melalophos* during construction and operation**				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on fish during construction and operation is negative				
Impact Type	**Direct**	**Indirect**	Induced		
	Direct and indirect impacts to *Presbytis melalophos*				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	The impact will be permanent and ongoing during operation				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be localised for individuals of *Presbytis melalophos* that occupy habitats immediately adjacent to Project components and activities.				
Impact Scale	It is anticipated that the scale of impact will be limited to terrestrial habitats immediately adjacent to Project components. Increased human access to the Project area may facilitate reductions in populations due to poaching. Fragmentation will also likely impact the population within the project area, restricting access to foraging habitat. The impact however is likely to be localised within the immediate area surrounding the Project.				
Frequency	The frequency of impact is likely to be most significant during construction (one time) with potential ongoing impacts during operation.				
Impact Magnitude	Positive	**Negligible**	**Small**	Medium	Large
	The magnitude of this impact is expected to be Negligible to Small within the Project Area as the impact area is relatively small compared to the DMU.				
Receptor Sensitivity	Low	Medium	**High**		
	The species is a Critical Habitat species and hence the receptor sensitivity is considered to be High.				
Impact Significance	Negligible	**Minor**	**Moderate**	Major	Critical
	The significance of this impact is **Minor to Moderate**.				

4.8.8 *Impact Assessment for Siamang (Symphalangus syndactylus)*

The Siamang (*Symphalangus syndactylus*) was identified as a Critical Habitat species within the Project area and DMU. Individuals were identified in the forested areas of the Project area. The Project area and DMU has been identified as Critical Habitat under IFC PS6 Criterion 2, Tier 1 and 2.

S. syndactylus is threatened by forest conversion and opportunistic collection for the international pet trade in Sumatra. Forest conversion to agriculture or plantations and illegal logging also are a major threat.

Clearing for project components, induced clearing and illegal logging within the Project area would be the largest threats to the species during construction and operation from the project. Increases in access through the construction of roads may give rise to increases in hunting and poaching pressure for the species in the Project Area and immediate surrounds.

The impact assessment summary for impacts to *S. syndactylus* during the construction and operation phase is outlined in ***Table 4.29***

Table 4.29 Impact Assessment Summary – S. syndactylus during construction and operation

Impact	**Impact to *S. syndactylus* during construction and operation**				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on fish during construction and operation is negative				
Impact Type	**Direct**	**Indirect**	Induced		
	Direct and indirect impacts to *S. syndactylus*				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	The impact will be permanent and ongoing during operation				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be localised for individuals of *S. syndactylus* that occupy habitats immediately adjacent to Project components and activities.				
Impact Scale	It is anticipated that the scale of impact will be limited to terrestrial habitats immediately adjacent to Project components. Increased human access to the Project area may facilitate reductions in populations due to poaching. Fragmentation and clearing of habitat will also likely impact the population within the project area, restricting access to foraging habitat. The impact however is likely to be localised within the immediate area surrounding the Project.				
Frequency	The frequency of impact is likely to be most significant during construction (one time) with potential ongoing impacts during operation.				
Impact Magnitude	Positive	**Negligible**	**Small**	Medium	Large
	The magnitude of this impact is expected to be Negligible to Small within the Project Area as the impact area is relatively small compared to the DMU.				
Receptor Sensitivity	Low	Medium	**High**		
	The species is a Critical Habitat species and hence the receptor sensitivity is considered to be High.				
Impact Significance	Negligible	**Minor**	**Moderate**	Major	Critical
	The significance of this impact is **Minor to Moderate**.				

4.8.9 Impact Assessment for Malayan tapir (Tapirus indicus)

The Malayan tapir (*Tapirus indicus*) (IUCN EN) was identified as a Critical Habitat species within the Project area and DMU. Individuals were identified in the forested areas of the Project area. The Project area and DMU has been identified as Critical Habitat under IFC PS6 Criterion 1, Tier 2d.

Destruction of habitat is the main threat to the species as is hunting and poaching for meat. Project related impacts will reduce habitat within the Project area and facilitate local people to enter the project area who may undertake hunting for the species within the project area and adjacent Protection Forest.

The impact assessment summary for impacts to *Tapirus indicus* during the construction and operation phase is outlined in ***Table 4.30***.

Table 4.30 Impact Assessment Summary – Tapirus indicus during construction and operation

Impact	**Impact to *Tapirus indicus* during construction and operation**				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on fish during construction and operation is negative				
Impact Type	**Direct**	**Indirect**	Induced		
	Direct and indirect impacts to *Tapirus indicus*				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	The impact will be permanent and ongoing during operation				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be localised for individuals of *Tapirus indicus* that occupy habitats immediately adjacent to Project components and activities.				
Impact Scale	It is anticipated that the scale of impact will be limited to terrestrial habitats immediately adjacent to Project components. Increased human access to the Project area may facilitate reductions in populations due to poaching. Fragmentation and clearing of habitat will also likely impact the population within the project area. The impact however is likely to be localised within the immediate area surrounding the Project.				
Frequency	The frequency of impact is likely to be most significant during construction (one time) with potential ongoing impacts during operation.				
Impact Magnitude	Positive	**Negligible**	**Small**	Medium	Large
	The magnitude of this impact is expected to be Negligible to Small within the Project Area as the impact area is relatively small compared to the DMU.				
Receptor Sensitivity	Low	Medium	**High**		
	The species is a Critical Habitat species and hence the receptor sensitivity is considered to be High.				
Impact Significance	Negligible	**Minor**	**Moderate**	Major	Critical
	The significance of this impact is **Minor to Moderate**.				

4.8.10 Impact Assessment for Rhacophorus bifasciatus

The frog species *Rhacophorus bifasciatus* (IUCN NT) was identified as a Critical Habitat species within the Project area and DMU. Individuals were identified in the forested areas of the Project area. The Project area and DMU has been identified as Critical Habitat under IFC PS6 Criterion 3, Tier 2b.

The main threat is localized forest loss due to agricultural development across the species range. The species has a restricted range of less than 20,000 km^2.

Impacts to the species from the project will entail a reduction in habitat for the species, including drying out of forested habitat and edges. The species will also be restricted in accessing areas due to barriers constructed, such as roads and brine pipelines. However, this impact is considered to be small. Habitat loss from induced clearing and habitat clearing due to the construction of project components will be the major impact to the species during construction and operation. Changes in water quality and quantity may also impact on aquatic habitats for the species.

The impact assessment summary for impacts to *Rhacophorus bifasciatus* during the construction and operation phase is outlined in ***Table 4.31***.

Table 4.31 Impact Assessment Summary – Rhacophorus bifasciatus during construction and operation

Impact	**Impact to *Rhacophorus bifasciatus* during construction and operation**				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on fish during construction and operation is negative				
Impact Type	**Direct**	**Indirect**	Induced		
	Direct and indirect impacts to *Rhacophorus bifasciatus*				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	The impact will be permanent and ongoing during operation				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be localised for individuals of *Rhacophorus bifasciatus* that occupy habitats immediately adjacent to Project components and activities.				
Impact Scale	It is anticipated that the scale of impact will be limited to terrestrial habitats immediately adjacent to Project components. Increased human access to the project areas may cause induced clearing. Clearing for the construction of project components may also reduce habitat extent. The impact however is likely to be localised within the immediate area surrounding the Project.				
Frequency	The frequency of impact is likely to be most significant during construction (one time) with potential ongoing impacts during operation.				
Impact Magnitude	Positive	**Negligible**	**Small**	Medium	Large
	The magnitude of this impact is expected to be Negligible to Small within the Project Area as the impact area is relatively small compared to the DMU.				
Receptor Sensitivity	Low	Medium	**High**		
	The species is a Critical Habitat species and hence the receptor sensitivity is considered to be High.				
Impact Significance	Negligible	**Minor**	**Moderate**	Major	Critical
	The significance of this impact is **Minor to Moderate**.				

4.9 DECOMMISSIONING PHASE IMPACT ASSESSMENT

Supreme Energy has advised that decommissioning of the Rantau Dedap Project area is dependent on the potential extensions of concession periods for the project for up to 50 years. The Environmental and Social Impact Assessment (Greencap 2016) highlights that the decommissioning phase will be directed by the development of decommissioning plans. These plans will be developed as part of recommendations for mitigations contained within the ESIA.

4.10 ECOSYSTEM SERVICES IMPACT ASSESSMENT

Impacts were assessed based on the vulnerability of beneficiaries and the magnitude of potential or realised impacts, as described below.

4.10.1 Methods

4.10.1.1 Assessing Level of Vulnerability

Determination of the vulnerability of beneficiaries included consideration of the following questions:

- Are beneficiaries heavily dependent on a particular resource, with few alternatives available?
- Are resource shortages frequent and serious?
- Are key species or areas depended upon for goods or services legally protected and use is illegal?
- Are key resources controlled by an influential receptor and access is not guaranteed?
- Is there a low availability of alternatives for a number of important of Ecosystem Services?

Beneficiaries were considered vulnerable in the context of their immediate surroundings and were considered against existing pre-project baseline levels. Because of this there are always some vulnerable receptors within the receiving environment.

4.10.1.2 Rating Magnitude of Impact

Magnitude of social and health impacts is understood as a reflection of the 'size' of change caused by social impacts. Magnitude is a function of the extent, duration, scale, and frequency. Impacts on human receptors as a result of changes in Ecosystem Services were assessed according to the four magnitude criteria listed above and ranked from *negligible* to *large*.

4.10.1.3 Evaluating Significance

The significance of the impact was determined by combining the magnitude of predicted impact with the value of the receptor, to produce a significance rating from Negligible to Significant. The definitions of the criteria for vulnerability and magnitude, as well as the matrix for evaluating significance are provided in ***Table 4.32*** and ***Table 4.33*** below.

Table 4.32 Impact Assessment Matrix for Positive Impacts to Ecosystem Services

Positive impacts			Vulnerability of Receptors		
Magnitude of Impact	Negligible	Change remains within the range commonly experienced within the household or community	**Negligible**	**Negligible**	**Negligible**
	Low	Perceptible difference from baseline conditions. The impact results in an improvement in the availability or functionality of the Ecosystem Service across a small area and has implications for a small number of receptors. The change in the service is for a short duration or occurs with low frequency.	**Negligible**	**Minor**	**Moderate**
	Medium	Clearly evident difference from baseline conditions. The impact results in an improvement in the availability or functionality of the Ecosystem Service across a substantial area or number of people and is of medium duration or occasional frequency. Does not improve the long-term viability of the service.	**Minor**	**Moderate**	**Significant**
	Large	Change dominates over baseline conditions. The impact results in the improvement of all or a significant proportion of the availability or functionality of an Ecosystem Service and/or has implications for a large proportion or absolute number of receptors. The long-term viability of the service may potentially be improved.	**Moderate**	**Significant**	**Significant**
Vulnerability of Receptor Definitions		**Low** Low ability to take up on potential opportunities and realise positive sustained benefits			
		Medium Ability to partially capture potential opportunities and realise positive sustained benefits			
		High Able to capture potential benefits and utilise them for positive sustained benefits			

Table 4.33 Impact Assessment Matrix for Negative Impacts to Ecosystem Services

Negative impacts					
			Vulnerability of Receptors		
Magnitude of Impact	Negligible	Change remains within the range commonly experienced within the household or community.	**Negligible**	**Negligible**	**Negligible**
	Low	Perceptible difference from baseline conditions. The impact results in a reduction in the availability or functionality of the Ecosystem Service across a small area and has implications for a small number of receptors. The change in the service is for a short duration or occurs with low frequency.	**Negligible**	**Minor**	**Moderate**
	Medium	Clearly evident difference from baseline conditions. The impact results in a reduction in the availability or functionality of the Ecosystem Service across a substantial area or number of people and is of medium duration or occasional frequency. Does not threaten the long-term viability of the service.	**Minor**	**Moderate**	**Significant**
	Large	Change dominates over baseline conditions. The impact results in the loss of all or a significant proportion of the availability or functionality of an Ecosystem Service and/or has implications for a large proportion or absolute number of receptors. The long-term viability of the service is threatened.	**Moderate**	**Significant**	**Significant**
Vulnerability of Receptor Definitions		**Low:** Minimal areas of vulnerabilities; consequently with a high ability to adapt to changes brought by the project.			
		Medium: Few areas of vulnerability; but still retaining an ability to at least in part adapt to change brought by the project			
		High: Profound or multiple levels of vulnerability that undermine the ability to adapt to changes brought by the project.			

1.1.1 Results

The following results apply the assessment criteria for the priority ecosystem service values identified from the screening assessment.

4.10.1.4 Food: cultivated crops

Local people clear forested areas for the creation of fields to cultivate crops. This practice is undertaken on a rotational seasonal basis. Induced clearing has occurred within 500m of the Project Area due to increased access allowed by the construction of roads. The Project has restricted clearing activities within the AoI since 2013 to reduce impacts on biodiversity values. This will subsequently reduce land available for clearing by local people. Whilst this reduction in access will have biodiversity benefits, local people will have a reduction in area available to clear and use for cultivated crops.

The impact assessment summary for food: cultivated crops during the construction and operation phase are outlined in ***Table 4.34.***

Table 4.34 Impact Assessment Summary – Availability of land for clearing to produce cultivated crops

Impact	Impact to the availability of land for clearing to produce cultivated crops				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on the ecosystem service is negative				
Impact Type	**Direct**	**Indirect**	Induced		
	Direct impact to local people from reduction of land available for clearing and cultivation				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	The impact will be permanent and ongoing during operation				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be localised for local people that occupy land immediately adjacent to Project components and activities.				
Impact Scale	It is anticipated that the scale of impact will be limited to local people immediately adjacent to Project components.				
Frequency	Not applicable				
Impact Magnitude	Positive	**Negligible**	**Small**	Medium	Large
	The magnitude of this impact is expected to be Negligible to Small				
Receptor Sensitivity	Low	**Medium**	High		
	Local people will have access to existing cleared land; however they may identify land in other areas to conduct clearing to cultivate crops. Suitable alternative cropping areas are available within the vicinity of the Project.				
Impact Significance	Negligible	**Minor**	Moderate	Major	Critical
	The significance of this impact is **Minor**.				

4.10.2 Freshwater

Local people are reported to use freshwater from local waterways for irrigation, potable and non-potable uses. Water extraction is proposed to occur that will reduce the amount of water available all year. The resource loss will be predominately in the dry season each year. The amount of water extraction is estimated to be small.

The impact assessment summary for food: cultivated crops during the construction and operation phase are outlined in ***Table 4.35***.

Table 4.35 ***Impact Assessment Summary – Impact to freshwater availability from water extracted from local waterways***

Impact	Impact to freshwater availability from water extracted from local waterways				
Impact Nature	**Negative**	Positive	Neutral		
	The impact on the ecosystem service is negative				
Impact Type	**Direct**	**Indirect**	Induced		
	Direct impact to local people from reduction of water available for irrigation and domestic use.				
Impact Duration	Temporary	Short-term	Long-term	**Permanent**	
	The impact will be permanent and ongoing during operation				
Impact Extent	**Local**	Regional	International		
	The impact is expected to be localised for local people that use water from local streams impacted by the water extraction.				
Impact Scale	It is anticipated that the scale of impact will be limited to local people immediately adjacent to Project components.				
Frequency	Not applicable				
Impact Magnitude	Positive	**Negligible**	**Small**	Medium	Large
	The magnitude of this impact is expected to be Negligible to Small				
Receptor Sensitivity	Low	**Medium**	High		
	Local people will have access to water from the streams. It is estimated that the impact will be minor as the water extraction is small.				
Impact Significance	Negligible	**Minor**	Moderate	Major	Critical
	The significance of this impact is **Minor**.				

The mitigation hierarchy aims to minimize impacts on biodiversity and should be applied sequentially to: avoid, minimize and where residual impacts remain compensate/offset.

IFC Performance Standard 1 (IFC, 2012a) highlights that options to 'minimize' are variable and include abate, rectify, repair and/or restore.

A key aspect of managing impacts to biodiversity is the implementation of an adaptive management approach. This approach is designed to provide opportunity for measures to be reviewed and changed (if and where necessary) such that environmental outcomes can be improved and ineffective measures can be identified and rectified in an appropriate timeframe. All parties involved in the construction and operation phases, (e.g. PT SERD, Contractors and Specialists) have a role to play in suggesting modifications to the Project EMP and Biodiversity Action Plan (BAP). The overall responsibility for managing change to the management of biodiversity values (and the BAP) will rest with PT SERD's SSM. The steps for managing change to the BAP include:

1. Identify and describe unanticipated impacts, ineffective mitigation or changes in the Project construction or operation that require updates to the BAP.
2. Suggest mitigation to manage the identified issues with the Corporate SHE Manager. Concerns/issues could, for example, be highlighted on an ongoing basis through stakeholder engagements with PT SERD or during routine fauna & flora monitoring surveys.
3. Review and update the BAP.

Specific measures to be incorporated into the BAP and Project EMP are provided in this section.

5.1 EXPLORATION/CONSTRUCTION PHASE

Disturbance to habitat in modified and natural habitat areas during exploration/construction has the potential to impact the local biodiversity and habitats including habitats for conservation significant species. Mitigation measures can be implemented to manage the disturbance during construction such that biodiversity values are not significantly impacted or impacts are reduced by the application of the mitigation hierarchy (avoid, minimize, mitigate and compensate through offsets).

Management measures specific to managing the natural environment will be incorporated into Project specific management plans and a Biodiversity Action Plan (BAP). These general environmental management measures will assist in reducing the potential for degradation of habitat, behavior disturbance, fauna mortality and edge for native species.

In addition to the general measures for the management of potential impacts to the natural environment, measures specific to managing potential impacts to the identified priority biodiversity values are also considered. The recommended mitigation and management measures during the construction phase are shown in ***Table 4.1*** in relation to habitat and threatened species impacts.

Table 5.1 Habitat Mitigation and Management Measures, Exploration/Construction Phase (Habitats and threatened species)

Nature of Impact	Pre-Mitigation Impact Significance	Overview of Mitigation Measures	Residual Impact Assessment	Post-Mitigation Impact Significance
Loss of habitat	Moderate	• The design and layout plan will be prepared to minimise tree cutting and Protected Area disturbance where possible. SERD shall be directly responsible for dissemination to its staff and workers of all rules, regulations and information concerning these restrictions, as well as the punishment that can expected if any staff or worker or other person associated with the Project violate rules and regulations; • Strict rules against logging outside the approved construction areas and against wildlife hunting and poaching will be imposed on all Project staff, workers, and all contractors and personnel engaged in or associated with the Project, with penalties levied for anyone caught carrying and using fire arms, or using animal snares and traps, including fines and dismissal, and prosecution under the relevant laws; • The planned clearance area for the construction works shall be clearly identified and marked using spray paint or marking tape to avoid accidental clearing. Site team are to be briefed prior to works in each area to highlight the areas to be avoided; • Following clearing of any vegetation an inspection will be undertaken to confirm no additional clearing was undertaken. Clearing outside the marked area is to be reported to the SSM and Construction Manager such that adaptive measures can be developed and implemented; • Native seed will be collected prior to vegetation clearing. Seedlings will be cultivated and propagated and maintained for a defined period for use in forest restoration activities; • A site nursery will be established to cultivate native species for use in forest restoration activities. Native seed stock and saplings will be obtained from within the Project Area and/or similar habitats and/or from other nurseries; • An offset plan will be developed to compensate for the habitat lost as a result of the Project clearing activities; • All clearing activities are to be undertaken using a Habitat	• 72.63ha of Montane, Sub Montane and Riparian Forest (classed as Natural Habitat) will be permanently lost due to the construction of the Project. This area of habitat loss will require to be offset to achieve no-net-loss. • Site rehabilitation during construction and operation using native species will reduce habitat loss within the project footprint; however habitat will remain reduced within the Project area and DMU. • Mitigation measures to control induced clearing will occur to ensure that continued habitat loss will be prevented during construction. • Residual impacts will likely remain during construction; however these are expected to reduce during operation and are considered to be minor.	Minor

Nature of Impact	Pre-Mitigation Impact Significance	Overview of Mitigation Measures	Residual Impact Assessment	Post-Mitigation Impact Significance
		Clearance Protocol supervised by an appropriately trained ecologist; • In natural habitat areas to be cleared, microhabitat features such as hollow logs will be relocated to adjacent natural habitat areas rather than being destroyed where possible; • Conduct ground-truth surveys at new well pad locations to confirm presence of any threatened or endemic flora species (in particular orchids) and signs of threatened fauna habitat. Outcomes to be communicated to site team so avoidance measures can be implemented where appropriate or other measures (for example translocation, seed harvest) can be implemented. Expert input may be required; • All construction personnel will undertake biodiversity awareness training prior to commencement of construction.		
Changes to aquatic habitat	Moderate	• Prior to water extraction feasibility assessment should be undertaken that considers suitability of the specific extraction site as well as volume to be extracted. Extraction rates may need to be altered depending on seasonal conditions and flow rates in order to maintain sufficient base flow and reliant ecosystems; • Monitoring of aquatic habitats will be undertaken throughout water extraction period to identify if extraction rates are too great to maintain ecosystem functioning. This may require input from a specialist; • A management plan will be developed and implemented specific to the aquatic environment and the extraction; • The extraction pipe will be suitably designed to avoid drawing fish into the pipe leading to mortality.	• Temporary impacts during project construction will occur and there is potential for minor water pollution as a result. • Sediment and erosion control measures will substantially reduce the risk of water pollution and impacts on aquatic habtiats • Monitoring of water extraction rates will ensure that water flow within rivers is maintained at required rates. • Residual impacts will likely remain during construction; however these are expected to reduce during operation and are considered to be minor.	Minor
Disturbance and displacement	Moderate	• Construction vehicles and machinery will be maintained in accordance with industry standard to minimise unnecessary noise generation; • Arrangement of transportation schedules will aim to avoid peak hours of road usage to minimise heavy traffic through habitat areas; • Traffic signs will be installed on all roads throughout construction areas depicting speed limits;	• Temporary impacts due to project construction will occur for arboreal fauna and ground dwelling fauna. Individuals will be restricted in movement and possibly be isolated during this time. • Fauna are likely to flee from the project area during construction phase. • Installation of fauna crossings, lighting control measures, and sediment and erosion control measures will reduce impacts on the terrestrial and aquatic environment during construction,	Minor

Nature of Impact	Pre-Mitigation Impact Significance	Overview of Mitigation Measures	Residual Impact Assessment	Post-Mitigation Impact Significance
		• For construction areas requiring night-time lighting, lights will be used only where necessary and will be directed toward the subject area and away from habitat areas where possible;	however a reduction in available habitat will occur. • Residual impacts will likely remain during construction but will abate during operation and are considered to be minor.	
Barrier to movement	Moderate	• The Project shall implement landscaping and re-vegetation after completion of construction in suitable areas to limit edge effects and vulnerability to weed invasion. This approach will reduce access road gaps where possible to minimise barrier influence; • Identify wildlife crossing locations to identify higher risk crossing points along access roads for which targeted mitigation should be designed and implemented; • Wildlife crossing areas are not to be directly lit (if safe to do so); • Prior to construction of access roads in natural habitat areas assess the need to install artificial crossing structures for endangered arboreal mammal species with input from species experts regarding most appropriate design and with regard for safety requirements; • Appropriate monitoring and maintenance specific to the constructed crossing points will be undertaken with inspections at no less than 6 month intervals; • Sediment and erosion control measures should be designed and maintained for all disturbed soil surfaces, including the road and spoil piles; • Where possible during access road construction maintain canopy trees to encourage canopy connectivity above the road; • Any in-stream works will be carried out in low-flow conditions where possible; • Throughout construction any road kill or fauna crossing sightings will be reported to the Project owner representative in the event a corridor pathways hotspot is identified. Data analysis throughout the construction period should inform implementation of additional measures (such as go slow areas or fauna crossing structures) if required; • The transmission line and access roads will not be fenced;	• Barriers to fauna movement will be mitigated during construction and operation; however it is likely that residual impacts will remain during the construction phase. • Wildlife crossings will be installed during the operation phase so as not to impede equipment movement. It is likely that fauna will flee the project area during construction and return during operation, meaning that the residual impacts will be temporary. • Mitigation measures such as sediment and erosion control measures, in-stream works and adaptive management for road kill will reduce impacts during construction and operation. • Residual impacts will likely remain during construction; however these are expected to reduce during operation and are considered to be minor.	Minor

Nature of Impact	Pre-Mitigation Impact Significance	Overview of Mitigation Measures	Residual Impact Assessment	Post-Mitigation Impact Significance
Fragmentation and Edge effects	Moderate	• Dust suppression techniques will be utilised during construction, to control the dispersion of dust created by clearing lands at the construction sites; • The Project shall implement landscaping and re-vegetation after completion of construction using native species where possible; • To avoid/minimize releasing sediment load into the surrounding waterways, erosion control measures will be implemented and maintained e.g. using silt fence and temporary re-vegetation to minimize sediment transport;	• Residual impacts due to fragmentation and edge effects are likely to be permanent along the transmission line, roads and the brine pipeline where canopy cover does not meet. This impact is likely to be minor given that significant habitat values remain within the DMU. • Mitigations will reduce impacts; however habitat offsets are likely to compensate for the loss of habitat due to edge impacts to forest values.	Minor
Degradation of habitat	Moderate	• Flora and fauna will be monitored throughout the Project by experts with information collected used as a basis for habitat and population management; • All work places will be kept clean with waste disposed of appropriately; • Workers and visitors will be educated regarding appropriate waste disposal and prohibition of feeding wildlife; • Construction and domestic waste will be appropriately stored and disposed of to avoid attracting native and alien species to the construction and camp areas; • For areas in direct runoff path to a watercourse, sediment and erosion control devices will be installed and maintained until vegetation replanting can occur to stabilise disturbed soil surfaces; • Oil, chemical and solid waste will be stored, and handled and disposed of by appropriately licenced waste management contractors; • Speed limits to maximum of 40 km/hr for construction vehicles will be enforced to limit noise and dust generation; • Construction materials and chemicals will be appropriately secured to avoid accidental release to the natural environment (wind and water erosion).	• Residual impacts due to degradation of habitat will likely to be higher during the construction phase as construction activities increase air, noise and dust pollution. • During operation, the application of mitigation measures and the rehabilitation of disturbed areas will reduce the overall residual impact to minor.	Minor

Nature of Impact	Pre-Mitigation Impact Significance	Overview of Mitigation Measures	Residual Impact Assessment	Post-Mitigation Impact Significance
Light, Noise and Vibration	Minor	• Design of lighting will be directed away from vegetated areas and habitats; • Upward lighting will be avoided; • Lights will not be left on after construction hours; • No drilling will be undertaken at night time; • Workers will be trained in noise-reduction behaviours; • All machinery used should be compliant with relevant noise regulations	• Impacts from light, noise and vibration will be mitigated through design and measures to reduce impacts during construction and operation. Residual impacts are likely to persist during construction and reduce during operation to a minor/negligible level.	Minor/ Negligible
Fauna mortality, Hunting and Poaching	Moderate	• Local community engagement will be undertaken to raise awareness of the conservation values of the habitats and to promote no hunting of threatened species; • Use of the access road should be restricted to construction vehicles only. Checkpoints should be used to manage access and inspect vehicles for wildlife. • Controls will be placed on domesticated animals permitted within the Project Area. • Speed limits to maximum of 40 km/hr for construction vehicles will be enforced to minimise potential for fauna strike. All drivers will receive driving training and will be required to pass a driving test; • Commitment will be made to raise awareness of values of natural habitat areas to construction work force and arrangements will be made for restriction of poaching and forest product collection; • Wildlife shepherding procedures to be implemented immediately prior to any vegetation clearing to allow fauna individuals to move to adjacent refuge habitat. Temporary fencing may be required around construction areas to limit fauna access; • A Wildlife Rescue Protocol will be established for implementation during all clearance activities. This will include actions to be undertaken for injured wildlife, communication processes to forestry officers of injured wildlife, recording procedures, and identification of management of change measures necessary to reduce risk of future events;	• Residual impacts due to fauna mortality may persist from construction through to operation if not appropriately controlled. Persistent interventions are required to implement mitigations to reduce encroachment, hunting and poaching. If the mitigations are appropriately implemented, residual impacts are expected to be moderate/minor.	Moderate/ Minor

Nature of Impact	Pre-Mitigation Impact Significance	Overview of Mitigation Measures	Residual Impact Assessment	Post-Mitigation Impact Significance
		• Establish an incident reporting mechanism, including database (map, record), to record injured or killed wildlife; • Access restriction should be applied to Project facilities for non-construction vehicles; • Access roads will be monitored daily for poaching activity; • Hunting wild animals will be strictly prohibited to apply for all staff; • Monitoring of construction areas will be undertaken monthly for signs of potential wildlife conflict, illegal logging or poaching.		

5.2 HABITAT MITIGATION AND MANAGEMENT (OPERATION PHASE)

Impacts relating to the operation phase are associated with vehicle movements, displacement/disturbance, potential for induced clearing, hunting and poaching exposure, and barrier to movement. Mitigation measures can be implemented to manage the disturbance during operation such that biodiversity values are not significantly impacted or impacts are reduced by the application of the mitigation hierarchy (avoid, minimise, mitigate and compensate through offsets).

Management measures specific to managing the natural environment will be incorporated into Project specific Operation management plans. The proposed mitigation and management measures proposed for the operation phase are outlined in ***Table 5.2***.

Table 5.2 Habitat Mitigation and Management Measures, Operation Phase

Nature of Impact	Pre-Mitigation Impact Significance	Overview of Mitigation Measures	Residual Impact Assessment	Post-Mitigation Impact Significance
Habitat Loss – induced clearing	Minor/ Moderate	• 24 hour Access controls are to be placed at all access roads to the Project Area to reduce access by local people • A habitat mapping database will be established to store all biodiversity monitoring data including species sightings • Regular patrols (at least every month) of the Project boundary will be undertaken to identify any incursion by local people into the Project Area and surrounding forested area • Regular drone flights will be undertaken, at least every year, to monitor vegetation clearance within the Project Area	• Evidence suggests that induced clearing has been minimal within the project area since the exploration phase with 5.5ha identified that would constitute induced clearing (refer to induced clearing assessment at *Section 3.2.4*). Access controls have been implemented to date to reduce access by local people into the Project area • Monitoring of induced clearing is an important measure that will require additional follow up and introduce adaptive measures, as required. • Residual impacts from induced clearing are considered to be minor/ negligible, however ongoing monitoring and enforcement is required.	Minor/ Negligible
Disturbance and displacement	Minor/ Moderate	• Operational vehicles will be maintained in accordance with industry standard to minimise unnecessary noise generation; • Traffic signs will be maintained on all roads depicting speed limits; • Access to facilities, including the access road should be restricted to operational vehicles only; • For operational areas requiring night-time lighting, lights will be used only where necessary and will be directed toward the subject area and away from habitat areas where possible; • Commitment will be made to raise awareness of the operator work force regarding flora and fauna values and make arrangements for restriction of poaching; • Surveys to identify locations of invasive species infestations will be undertaken and where necessary work with specialists will be undertaken to manage extent.	• Permanent impacts due to project operation will occur for arboreal fauna and ground dwelling fauna. Individuals will be restricted in movement during operation. • Installation of fauna crossings, lighting control measures, sediment and erosion control measures will reduce impacts on the terrestrial and aquatic environment during operation. • Residual impacts are expected to reduce during operation as the project area reaches a new equilibrium. Residual impacts are likely to be minor to negligible.	Minor/ Negligible

Nature of Impact	Pre-Mitigation Impact Significance	Overview of Mitigation Measures	Residual Impact Assessment	Post-Mitigation Impact Significance
Degradation of habitat	Minor/ Moderate	• Flora and fauna will be monitored throughout the Project by experts with information collected used as a basis for habitat and population management; • All work places will be kept clean with waste disposed of appropriately; • Workers and visitors will be educated regarding appropriate waste disposal and prohibition of feeding wildlife; • Oil, chemical and solid waste will be stored, and handled and disposed of by appropriately licenced waste management contractors.	• During operation, the application of mitigation measures to reduce impacts from waste, pollution and the rehabilitation of disturbed areas will reduce the overall residual impact to minor.	Minor
Light, Noise and Vibration	Minor/ Moderate	• Design of lighting will be directed away from vegetated areas and habitats; • Upward lighting will be avoided; • Lights will not be left on after hours when not required; • All machinery used should be compliant with relevant noise regulations	• Impacts from light, noise and vibration will be mitigated through design and measures to reduce impacts operation. Residual impacts are likely to reduce during operation to a minor level.	Minor
Fauna mortality, hunting and poaching	Minor/ Moderate	• Speed limits to maximum of 40 km/hr for construction vehicles will be enforced to minimise potential for fauna strike. All drivers will receive driving training and will be required to pass a driving test; • Commitment will be made to raise awareness of values of natural habitat areas to operator work force and arrangements will be made for restriction of poaching and forest product collection; • Access to Project Areas, including the access road should be restricted to operational vehicles only. Warning signs will be installed and patrols will be undertaken. Security gates will be installed and manned 24 hours per day; • Hunting wild animals will be strictly prohibited to apply for all staff.	• Residual impacts due to fauna mortality may persist during operation if not appropriately controlled. Persistent interventions are required to implement mitigations to reduce encroachment, hunting and poaching. If the mitigations are appropriately implemented, residual impacts are expected to be moderate/ minor.	Moderate/ Minor

5.3 CRITICAL HABITAT MITIGATION AND MANAGEMENT MEASURES (ALL PHASES)

Priority Biodiversity Values are described in *3.5.4.3 Critical Habitat Candidate Species*. In addition to protected areas the values are those species described as critical habitat candidates in IFC PS6. As required by IFC PS6, a Biodiversity Action Plan (BAP) is required for all Critical Habitat candidate species. ***Table 5.3*** outlines the proposed Critical Habitat mitigation and management measures.

Table 5.3 Mitigation Measures for Critical Habitat Species

Scientific Name / Common Name	IUCN	Impact types and current threats	Pre-Mitigation Impact Significance	Overview of Mitigation Measures	Residual Impact Assessment	Post-Mitigation Impact Significance
Rafflesia bengkuluensis	NA	• Habitat loss • Edge effects • Fragmentation • Degradation of habitat • Loss of individuals	Moderate/ Minor	• Surveys are to occur along the transmission line, roads, brine pipelines and within well pads to identify individuals prior to clearing activities. If possible, individuals should be avoided and translocated. • Cultivation of individuals are to be trailed in the company nursery • Replanting of individuals are to occur within the forested Project area • Monitoring of individuals identified within the project area and retained is to occur on an annual basis.	• A permanent loss of individuals that existed within the footprint of the Project Area has occurred. It is not possible to determine the number of individuals that have been lost as no survey was undertaken prior to construction. • Cultivation and replanting activities will replace individuals lost • Monitoring of the existing population will determine if there are changes in the population within the Project Area. Additional measures/replanting is to occur if a reduction in population is detected. • This is likely to lead to a no-net-loss/net gain outcome for the species.	Minor
Vanda foetida	NA	• Habitat loss • Edge effects • Fragmentation • Hunting and poaching • Degradation of habitat • Loss of individuals	Moderate/ Minor	• Surveys are to occur along the transmission line, roads, brine pipelines and within well pads to identify individuals prior to clearing activities. If possible, individuals should be avoided and translocated. • Cultivation of individuals are to be trailed in the company nursery • Replanting of individuals are to occur within the forested Project area • Monitoring of individuals identified within the project area and retained is to occur on an annual basis. • Access control and anti-poaching measures are to be applied to the Project area	• A permanent loss of individuals that existed within the footprint of the Project Area has occurred. It is not possible to determine the number of individuals that have been lost as no survey was undertaken prior to construction. • Cultivation and replanting activities will replace individuals lost. • Monitoring of the existing population will determine if there are changes in the population within the Project Area. Additional measures/replanting is to occur if a reduction in population is detected. • This is likely to lead to a no-net-loss/net gain outcome for the species.	Minor

Scientific Name / Common Name	IUCN	Impact types and current threats	Pre-Mitigation Impact Significance	Overview of Mitigation Measures	Residual Impact Assessment	Post-Mitigation Impact Significance
Manis javanica Malayan pangolin	CR	• Habitat loss • Hunting and poaching	Moderate/ Minor	• Anti-hunting and poaching measures are to be employed within the Project Area, including 24 hour access restrictions, regular patrols and inspections. • Hunting and poaching by SERD Employees is to be strictly prohibited. • Education programs are to be undertaken with the local community to discourage hunting and poaching for Sunda Pangolin. • Regular monitoring of the species population is to occur within the Project Area.	• Measures will reduce the primary threat to the species (poaching) within the Project Area and immediate surrounds. Given the species large range, hunting and poaching pressure will remain in the DMU. Specific measures are recommended within the Biodiversity Offset Plan. • Monitoring of the existing population will determine if there are changes in the population within the Project Area. Additional measures/replanting is to occur if a reduction in population is detected. • Permanent habitat loss for the species.	Minor
Maxomys inflatus Broad-nosed Sumatran maxomys	VU	• Habitat loss • Hunting and poaching • Fragmentation	Moderate/ Minor	• Anti-hunting and poaching measures are to be employed within the Project Area, including 24 hour access restrictions, regular patrols and inspections. • Hunting and poaching by SERD Employees is to be strictly prohibited. • Education programs are to be undertaken with the local community to discourage hunting and poaching for Borad-nosed Sumatran Maxomys. • Regular monitoring of the species population is to occur within the Project Area.	• Measures will reduce the primary threat to the species (poaching) within the Project Area and immediate surrounds. Given the species large range, hunting and poaching pressure will remain in the DMU. Specific measures are recommended within the Biodiversity Offset Plan. • Monitoring of the existing population will determine if there are changes in the population within the Project Area. Additional measures/replanting is to occur if a reduction in population is detected. • Permanent habitat loss for the species.	Minor
Panthera tigris sumatrae Sumatran tiger	CR	• Habitat loss • Hunting and poaching • Degradation of habitat	Minor/ Moderate	• Anti-hunting and poaching measures are to be employed within the Project Area, including 24 hour access restrictions, regular patrols and inspections. • Hunting and poaching by SERD Employees is to be strictly prohibited. • Regular monitoring of the species population is to occur within the Project Area.	• Anti-hunting and poaching measures will occur within the project area. Given the species large range, hunting and poaching pressure will remain in the DMU. Specific measures are recommended within the Biodiversity Offset Plan. • Permanent habitat loss for the species.	Minor

Scientific Name / Common Name	IUCN	Impact types and current threats	Pre-Mitigation Impact Significance	Overview of Mitigation Measures	Residual Impact Assessment	Post-Mitigation Impact Significance
Presbytis melalophos Sumatran surili	EN	• Habitat loss • Hunting and poaching • Fragmentation	Moderate/ Minor	• Measures for canopy connectivity are to be provided throughout the Project Area. • Anti-hunting and poaching measures are to be employed within the Project Area, including 24 hour access restrictions, regular patrols and inspections. • Hunting and poaching by SERD Employees is to be strictly prohibited. • Regular monitoring of the species population is to occur within the Project Area.	• Canopy connectivity measures will enable the species to inhabit the Project Area during operation. Temporary loss of habitat and disturbance will displace the species during construction. Individuals may return during operation. • Anti-hunting and poaching measures will occur within the project area. Given the species large range, hunting and poaching pressure will remain in the DMU. Specific measures are recommended within the Biodiversity Offset Plan. • Permanent habitat loss for the species.	Minor
Carpococcyx viridis Sumatran ground-cuckoo	CR	• Habitat loss • Hunting and poaching • Fragmentation	Moderate/ Minor	• Measures for canopy connectivity are to be provided throughout the Project Area. • Anti-hunting and poaching measures are to be employed within the Project Area, including 24 hour access restrictions, regular patrols and inspections. • Hunting and poaching by SERD Employees is to be strictly prohibited. • Regular monitoring of the species population is to occur within the Project Area.	• Canopy connectivity measures will enable the species to inhabit the Project Area during operation. Temporary loss of habitat and disturbance will displace the species during construction. Individuals may return during operation. • Anti-hunting and poaching measures will occur within the project area. Given the species large range, hunting and poaching pressure will remain in the DMU. Specific measures are recommended within the Biodiversity Offset Plan. • Permanent habitat loss for the species.	Minor
Symphalangus syndactylus Siamang	EN	• Habitat loss • Hunting and poaching • Fragmentation	Moderate/ Minor	• Measures for canopy connectivity are to be provided throughout the Project Area. • Anti-hunting and poaching measures are to be employed within the Project Area, including 24 hour access restrictions, regular patrols and inspections. • Hunting and poaching by SERD Employees is to be strictly prohibited. • Regular monitoring of the species population is to occur within the Project Area.	• Canopy connectivity measures will enable the species to inhabit the Project Area during operation. Temporary loss of habitat and disturbance will displace the species during construction. Individuals may return during operation. • Anti-hunting and poaching measures will occur within the project area. Given the species large range, hunting and poaching pressure will remain in the DMU. Specific measures are recommended within the Biodiversity Offset Plan. • Permanent habitat loss for the species.	Minor

Scientific Name / Common Name	IUCN	Impact types and current threats	Pre-Mitigation Impact Significance	Overview of Mitigation Measures	Residual Impact Assessment	Post-Mitigation Impact Significance
Tapirus indicus Malayan tapir	EN	• Habitat loss • Vehicle Strike • Hunting and poaching • Degradation of habitat	Moderate/ Minor	• Speed limits to maximum of 40 km/hr for construction vehicles will be enforced to minimise potential for fauna strike. • Anti-hunting and poaching measures are to be employed within the Project Area, including 24 hour access restrictions, regular patrols and inspections. • Hunting and poaching by SERD Employees is to be strictly prohibited. • Regular monitoring of the species population is to occur within the Project Area.	• Threats from vehicle strike will be reduced through measures to reduce potential impacts. Some minor potential loss of individuals possible although unlikely. • Anti-hunting and poaching measures will occur within the project area. Given the species large range, hunting and poaching pressure will remain in the DMU. Specific measures are recommended within the Biodiversity Offset Plan. • Permanent habitat loss for the species.	Minor
Rhacophorus bifasciatus	NT	• Habitat loss • Edge effects • Fragmentation • Degradation of habitat (water pollution)	Moderate/ Minor	• For areas in direct runoff path to a watercourse, sediment and erosion control devices will be installed and maintained until vegetation replanting can occur to stabilise disturbed soil surfaces • Regular monitoring of the species population is to occur within the Project Area.	• Measures to reduce pollution during construction and operation will limit degradation of habitats for the species. • Permanent habitat loss for the species, including edge habitats.	Minor

CR = Critically Endangered; EN = Endangered; DD = Data Deficient; NT = Near Threatened; NA = Not Assessed

Mitigation and management approaches have been considered to avoid, minimize and mitigate potential impacts to biodiversity as a result of Project activities. In general, many of the indirect impacts to biodiversity values can be minimized, such as behavioral disturbances, degradation of habitats, edge effects and barriers to terrestrial fauna movement. The next step of the mitigation hierarchy necessitates consideration of biodiversity offsets for residual impacts.

ERM has undertaken a biodiversity offsets assessment based on the guidance contained in the Business and Biodiversity Offset Program (BBOP) resource documents:

- *Biodiversity Offset Design Handbook* (BBOP 2012a); and
- *Resource Paper: No Net Loss and Loss-Gain Calculations in Biodiversity Offsets* (BBOP 2012b).

The purpose of these offsets is to manage biodiversity values to offset the residual impacts on biodiversity values. For natural habitats, as required by IFC PS6, a no-net-loss goal has been applied.

6.1 RESIDUAL IMPACTS ON BIODIVERSITY VALUES

6.1.1 Habitats

The residual impacts to biodiversity identified largely relate to unavoidable habitat loss within the footprint of the Project and edge effects. Direct disturbance to habitats will be minimized where possible however this impact assessment has identified an unavoidable loss of approximately 72.63ha of Natural Habitat will occur due to Project related activities (including 5.5ha identified as being from induced clearing). To achieve no-net-loss of biodiversity values, a biodiversity offset will be required to compensate for this loss of habitat.

6.1.2 Conservation Significant Species

The fauna species assessed will have a loss of habitat due to Project related activities, however it is not expected that this loss is significant. Mitigation measures have been designed to reduce impacts to species in relation to Project related activities (See ***Table 5.2***). Monitoring of species within the Project Area will be required to determine if populations of species are maintained. Additional measures may be required if monitoring indicates that species populations have been decreasing within the Project Area.

6.1.3 Critical Habitat Species

Nine (9) Critical Habitat species have been identified to occur within the Project Area and associated DMU. The impact assessment conducted on these species as required by the steps in the mitigation hierarchy identified minor to

negligible impacts to these species within the Project Area (See ***Table 5.3***). The assessment identified that habitat offsets will be sufficient to compensate for residual impacts for these species. Specific monitoring of species populations is recommended to determine whether populations are stable and increasing within the Project Area and DMU.

Table 6.1 outlines the biodiversity offset and monitoring KPIs required for Critical Habitat species identified within the Project Area.

Table 6.1 No-net-loss/Net Gain assessment for Critical Habitat Species

Scientific Name / Common Name	IUCN	Pre-mitigation impact and threats	Residual impact after mitigation	Required Offset	Biodiversity Offset KPI
Rafflesia bengkuluensis	NA	• Habitat loss • Edge effects • Fragmentation • Degradation of habitat • Loss of individuals	• Habitat loss	• Habitat offset compensates for losses. No specific species offset required • Translocation and/or replanting will compensate for losses within the Project Area	• Net increase in species population within the Project Area
Vanda foetida	NA	• Habitat loss • Edge effects • Fragmentation • Hunting and poaching • Degradation of habitat • Loss if individuals	• Habitat loss	• Habitat offset compensates for losses. No specific species offset required • Translocation and/or replanting will compensate for losses within the Project Area	• Net increase in species population within the Project Area
Manis javanica Malayan pangolin	CR	• Habitat loss • Hunting and poaching	• Habitat loss	• Habitat offset compensates for losses. No species specific offset required	• Management of threats • Net increase in species population within the Project Area/DMU
Maxomys inflatus Broad-nosed Sumatran maxomys	VU	• Habitat loss • Hunting and poaching • Fragmentation	• Habitat loss	• Habitat offset compensates for losses. No species specific offset required	• Management of threats • Net increase in species population within the Project Area/DMU
Panthera tigris sumatrae Sumatran tiger	CR	• Habitat loss • Hunting and poaching • Degradation of habitat	• Habitat loss	• Habitat offset compensates for losses. No species specific offset required	• Management of threats • Net increase in species population within the Project Area/DMU
Presbytis melalophos Sumatran surili	EN	• Habitat loss • Hunting and poaching • Fragmentation	• Habitat loss	• Habitat offset compensates for losses. No species specific offset required	• Management of threats • Net increase in species population within the Project Area/DMU
Symphalangus syndactylus Siamang	EN	• Habitat loss • Hunting and poaching • Fragmentation	• Habitat loss	• Habitat offset compensates for losses. No species specific offset required	• Management of threats • Net increase in species population within the Project Area/DMU
Tapirus indicus Malayan tapir	EN	• Habitat loss • Vehicle Strike • Hunting and poaching • Degradation of habitat	• Habitat loss	• Habitat offset compensates for losses. No species specific offset required	• Management of threats • Net increase in species population within the Project Area/DMU

Scientific Name / Common Name	IUCN	Pre-mitigation impact and threats	Residual impact after mitigation	Required Offset	Biodiversity Offset KPI
Rhacophorus bifasciatus	NT	• Habitat loss • Edge effects • Fragmentation • Degradation of habitat (water pollution)	• Habitat loss	• Habitat offset compensates for losses. No species specific offset required	• Management of threats • Net increase in species population within the Project Area

CR = Critically Endangered; EN = Endangered; DD = Data Deficient; NT = Near Threatened; NA = Not Assessed

6.2 HABITAT BIODIVERSITY OFFSET ASSESSMENT

A biodiversity offset metric has been developed to determine the offsets required to offset residual impacts on biodiversity for the SERD Project. ERM have used the Habitat Hectare model (BBOP 2012a) to calculate the offset "quantum" required to compensate for the residual values lost.

This model captures the *type* (habitat and species), *amount* and *condition* of the habitat biodiversity values present on the impacted site and candidate offset sites. The basis of the analysis is calculating the change in condition (*loss*) at the impact site compared to the *gain* in condition at candidate offsets sites over time from management.

Offset metrics have been designed for the terrestrial biodiversity values using data on:

- Classification of habitat classes in the impact area (*Type*);
- Area of habitat classes from spatial analysis (*Amount*); and
- Land class condition assessment from field data (*Condition*).

Given that a candidate offset site has not been identified to offset the impacts of the Project, the range of Habitat Hectare values that would be required for an offset site has been determined. Two scenarios have been used to calculate the range of habitat hectares required based on area and condition values scores:

1. First scenario calculates the area required if the offset site is in benchmark condition; and
2. Second scenario considers the offset site to be in degraded condition for the habitat types assessed.

This analysis will provide the range of habitat hectare values and hence the maximum and minimum area required to achieve the offset for each habitat type

6.3 BIODIVERSITY OFFSET CALCULATIONS AND RESULTS

6.3.1 *Impact Site Habitat Hectare Calculations*

Ecological "Gain" Period

To determine likely biodiversity gains available from managing tropical forests in Indonesia, ERM has undertaken a literature review. Research indicates that ecological restoration activities for Indonesian rainforests can take a significant time period to achieve improvements in forest ecological values, dependent on the initial state of the land or forest.

Research undertaken by Kettle (Kettle, 2009) indicates that ecological restoration in lowland dipterocarp forests is possible, even in severely degraded sites through careful establishment and maintenance planting.

As reported by the *Global Forest Expert Panel on Biodiversity, Forest Management and REDD+* (Parrotta J et al, 2012) there is a strong correlation between forest

restoration, species diversity and improvements in the availability of ecosystem services. However, forest restoration is likely to result in differing forest outcomes based on the existing disturbance. Disturbed secondary forests are likely to return to similar species diversity and mix over time.

Budiharta et al (Budiharta 2014) asserts that restoration activities can provide habitat outcomes (as well as carbon storage through above-ground biomass accumulation) from degraded forest landscapes through active planting and management over a 30 to 50 year time period in relation to REDD+ projects in tropical forests in Indonesia.

However, Elliot et al (Elliot et al 2013) discusses that ecological forest restoration from a degraded to a mature state is likely to take a much greater time period to achieve in tropical forests in Indonesia (that is, over 100 years or more).

The literature also indicates that there is significant uncertainty over the success of restoring ecological function of degraded tropical landscapes (Parrotta J et al, 2012).

In summary, the literature does not provide a definitive time period to achieve improvements in habitat values from degraded forests. Indicative timeframes are available however and the "Habitat Condition" and "Offset Gain" scores outlined below have been derived using these estimated ecological restoration time periods based on this research.

It is acknowledged that due to the uncertainty regarding success (or otherwise) of forest restoration activities to enable ecological improvements (or gains) robust monitoring and evaluation of offset restoration projects will be necessary to determine the rate of success (or failure). The use of adaptive management processes is necessary to reduce risks of failure.

It should also be noted that available gains have not taken into account any background change of ecological values due to uncertainty over what these impacts are currently and would be in the future. It is assumed that the management interventions at an offset site would reduce direct human derived ecological change. Background change caused by natural factors and human induced climate change have not been considered in the estimated gain periods given the uncertainty of what impacts/benefits that these factors could have on ecological restoration activities.

Habitat Condition Scores

The Habitat Hectare baseline calculations are used to quantify the residual value of the impacted habitats. Areas of habitat types within the Project Area have been determined based on Habitat condition scores. These scores are used to set a baseline condition of the impact site against a habitat condition benchmark (set at a value of 1 or a greater than 100 year restoration period). The Habitat Hectare model relies on scores to define 'vegetation quality' being the degree to which the current vegetation differs from a 'benchmark' representing characteristics of a mature and apparently long-undisturbed

stand of the same vegetation community. Essentially, this method attempts to assess how 'natural' a site is by comparing it to the same vegetation type in the absence of major ecosystem changes that have occurred (Parkes *et al.*, 2003).

Table 6.2 outlines the habitat class condition scores applied. These scores have been derived based on the definitions contained in IFC PS6 for "natural" and "modified" habitats and the definition of "degradation" of habitats (IFC, 2012). Impacted habitats are defined as those where little, if any natural biodiversity remaining.

The scores applied have been derived to reflect the relative difference (and hence ability to restore) the habitat over time.

Table 6.2 Habitat condition scores (A)

Condition	Definition	Value
Benchmark	Being habitats in a mature condition with only native origin vegetation, a diversity of species of a mature or senescent state; and no sign of human disturbance (such as the presence of waste, vegetation removal).	1
Natural	High condition is defined as habitat largely of native origin, and/or where human activity has not essentially modified the primary ecological functions and species composition. Some disturbance is likely present such as selective logging, vegetation removal, waste and minor introduction of invasive species.	0.8
Modified	Moderate condition habitats are areas that may contain a large proportion of plant and/or animal species of non-native origin, and/or where human activity has substantially modified an area's primary ecological functions and species composition	0.6
Degraded	Degraded condition is defined as significant conversion or degradation of the habitat such as the diminution of the integrity of a habitat caused by a major and/or long-term change in land use; or (ii) a modification that substantially minimizes the habitat's ability to maintain viable populations of its native species.	0.2
Impacted	Impacted condition is defined as major conversion whereby little if any natural vegetation remains on the site caused by significant land use change.	0

Habitat Hectare Calculation Formula (Impact Site)

The following formula has been used to calculate the Habitat Hectares of the residual values of the impacted habitats:

Habitat Type Condition (A) x Area of Habitat Type (B) = Habitat Hectares

Results of Habitat Hectare Calculations for the Impact Site

The results of the calculations are outlined in ***Table 6.3***

Table 6.3 Calculation of impact area habitat hectares

Landcover Class/Habitat Type	Habitat Type	Habitat Type Condition	Condition Score(A)	Habitat Type Area (B)*	Habitat Hectares (Impact Area)
Primary/secondary forest	Natural Habitat	Natural	0.8	72.63	58.1

6.3.2 Candidate Offset Site Habitat Hectare Calculations

The management of candidate offset sites enables biodiversity value "gains" and hence enables impacts to be offset (that is, compensate for losses). This is calculated based on the expected outcomes from positive interventions from management actions at the offset site to improve biodiversity values.

The gains in condition value are relative to the existing condition of the offset site. Sites with an existing "high" condition are likely to have an incrementally smaller improvement in biodiversity condition values through management over time. Sites with a lower baseline condition have a greater capacity to improve from conservation management over time.

Offset Gain Period

The time period chosen for management of the offset areas has been 30 years. This period has been chosen as this equates to the concession agreement period for the operation of the Project by the Government of the Republic of Indonesia.

Offset Gain Scores

Offset gain scores have been derived based on the relative gain in condition available from the Habitat Condition Scores over the offset gain period (refer to discussion on *Ecological Gain Period* above). The offset gain scores outlined have been derived based on the relative time frames to achieve ecological restoration and the available Offset Gain Period. For example, an offset site condition in "Natural" state (0.8) assumes that there is a 20% available improvement in condition to achieve a "Benchmark" condition (1.0). It is also assumed that offset management over time will have diminishing results, hence the multiplier reduces over time. In the case of Natural state vegetation, an 8.44% increase in value is estimated to be achieved in 10 years; 11.25% increase by 20 years; and a 15% increase is achievable in 30 years. After 30 years of management, the condition of Natural vegetation would be 95% of the condition of benchmark vegetation.

Averted loss also applies to habitat within benchmark condition whereby offset management actions avert or reduce background losses to biodiversity values. The averted loss value is set at 11.25% of benchmark value over 30 years.

The estimates of gain may vary in practice and require monitoring to determine if the estimation are accurate. Where significant variations occur in

estimated value increases, additional management or increases in offset areas managed will need to be applied.

Table 6.4 outlines the values chosen to derive the Offset Gain scores.

Table 6.4 ***Offset gain score (C1)***

Existing Site Condition	Base Condition Value	Gain (10 Years)	Gain (20 years)	Gain (30 years)
Benchmark	1	0.0633	0.0844	0.1125
Natural	0.8	0.0844	0.1125	0.15
Modified	0.6	0.1125	0.15	0.2
Degraded	0.2	0.15	0.2	0.275
Impacted	0	0.2	0.275	0.35

Habitat Hectare Calculation Formula (Offset site)

The formulae used to calculate the offset gains available from candidate offset areas are outlined below:

1. Calculation of Baseline Habitat Hectares:

Candidate Offset Habitat Condition Score (A1) x Area of Habitat Type (B1) = Candidate Offset Habitat Hectares (W)

2. Calculation of Habitat Hectare Gains:

[Candidate Offset Habitat Condition Score (A1) + Candidate Offset Habitat Condition Score (Gain) (C1)] x Area of Habitat Type (B1) = Candidate Offset Habitat Hectares Gain (X)

3. Calculation of Habitat Hectares:

Candidate Offset Habitat Hectares Gain (X) - Candidate Offset Baseline Habitat Hectares (W) = Candidate Offset Habitat Hectares (Y)

4. Calculation of Habitat Type Area (B1) required to achieve no-net-loss:

Habitat Hectare Candidate Offset Value (Y) / Candidate Offset Habitat Condition Score (Gain) (C1) = Habitat Type Area (B1)

The offset goal is to achieve the same number of Habitat Hectares impacted at the offset site. ***Table 6.5*** shows the areas of Habitat Hectares required to be offset.

Table 6.5 ***Candidate Offset site Habitat Hectares***

Forest Type	Habitat Condition	Condition Score (A1)	Offset Gain Score (C1)	Habitat Type Area (B1)*	Habitat Hectare Offset Area (W)	Habitat Hectare Gain Value (X)	Habitat Hectare Candidate Offset Value (Y)
Primary/ secondary forest	Benchmark	1	0.1125	516.0	516	574	58.10
	Natural	0.8	0.1500	387.0	310	368	58.10
	Modified	0.6	0.2000	290.0	174	232	58.10
	Degraded	0.2	0.2750	211.0	42	100	58.10

From this analysis, the required range of areas of Primary/secondary Forest for difference condition classes to achieve a no-net-loss of biodiversity values for the habitat types impacted is shown in ***Table 6.6***.

Table 6.6 ***Areas of Required Offsets to Achieve No-Net-Loss***

Forest Type	Habitat Condition	Habitat Type Area (Hectares)
Primary/secondary Forest	Benchmark	516.0
	Natural	387.0
	Modified	290.0
	Degraded	211.0

6.3.3 Calculation of Offset Site Habitat Hectares

An assessment will be required to be undertaken of the proposed candidate offset site to determine the condition and hence available area to achieve a no-net-loss of biodiversity values. The chosen offset site is likely to contain a range of condition types and this will affect the final size of the offset site chosen. The chosen site will also need to consider compliance with the offset rules.

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Annex A

Endangered Species Report (Greencap 2015)

Annex B

Transmission Line and Brine Pipeline Botanical and Incidental Fauna Reports (ERM 2017)

Annex C

Forest Borrow Use Permit issued to SERD

INDONESIA INVESTMENT COORDINATING BOARD

DECREE OF HEAD OF INDONESIA INVESTMENT COORDINATING BOARD NUMBER: 27/1 / IPPKH-PB / PMA / 2017 FORESTRY BORROW USE PERMIT FOR GEOTHERMAL EXPLOITATION ACTIVITIES AND ITS SUPPORTING FACILITIES FOR PT SUPREME ENERGY RANTAU DEDAP

IN PROTECTED FOREST IN LAHAT REGENCY, MUARA ENIM REGENCY AND PAGAR ALAM CITY, SOUTH SUMATERA PROVINCE, COVERING ± 115

(ONE HUNDRED AND FIFTEEN) HECTAR

HEAD OF INDONESIA INVESTMENT COORDINATING BOARD

HAD DECIDED

To Issue:

DECISION OF THE HEAD OF INDONESIA INVESTMENT COORDINATING BOARD CONCERNING FORESTRY BORROW USE PERMIT FOR GEOTHERMAL EXPLOITATION ACTIVITIES AND ITS SUPPORTING FACILITIES FOR PT SUPREME ENERGY RANTAU DEDAP IN PROTECTED FOREST IN LAHAT REGENCY, MUARA ENIM REGENCY AND PAGAR ALAM CITY, SOUTH SUMATERA PROVINCE, COVERING ± 115 (ONE HUNDRED AND FIFTEEN) HECTAR

FIRST: Giving permission of forestry borrow use permit for geothermal exploitation activities and its supporting facilities for PT Supreme Energy Rantau Dedap in Protected Forest area in Muara Enim Regency, Lahat Regency and Pagar Alam City, South Sumatera Province covering ± 115 (one hundred and fifteen) hectare, as illustrated in the Attachment Map which is an integral part of this Decision.

SECOND: The granting of forestry borrow use permit as mentioned in the FIRST article shall be for the execution of geothermal exploitation activities and its supporting facilities, so that the obligations under its responsibility shall be settled immediately after the expiry of the permit, and the area shall remain a forest area.

THIRD: PT Supreme Energy Rantau Dedap within a period of 1 (one) year after the issuance of the forestry borrow use permit as mentioned in the FIRST article shall be obliged to :

a. Complete the boundary marking of forestry borrow use permit area with the supervision of Conservation Center of Forestry Area II Palembang (Balai Pemantapan Kawasan Hutan II) and submitted to the Director General of Planology Forestry and Environmental Planning to get determination of the working area of forestry borrow use permit, and cannot be extended;
b. Submitting the planting location plan for rehabilitation of the watershed;
c. Submitting the baseline of forest area utilization in accordance with the outcome of the area boundary for forestry borrow use permit.
d. Make a statement in the form of notarial deeds willing to replace forest management investment cost to forest area managers

FOURTH: If In the period of 1 (one) year following the issuance of this decree, PT Supreme Energy Rantau Dedap does not settle the obligations as referred to the THIRD article, the forestry borrow use permit shall be declared null and void.

FIFTH: PT Supreme Energy Rantau Dedap, is entitled to:

a. Existing, occupying, managing and carrying out activities that includes in the geothermal exploitation and its supporting facilities and also carrying out other activities in connection with it in the borrowed used forest area;
b. Utilizing the results of activities undertaken in connection with the exploitation of geothermal and its supporting facilities on the borrowed used forest area;

c. Felling trees in the framework of land clearing by paying the Provision of Forest Resources (Provisi Sumber Daya Hutan/ PSDH) and / or Reforestation Fund (Dana Reboisasi) in accordance with legislation

SIXTH: PT Supreme Energy Rantau Dedap after obtaining the boundary of working area of Forestry Borrow Use Permit as referred in the THIRD article, shall:

a. Making plans and implementing reclamation and revegetation on unused forest areas without waiting for the completion of forestry borrow use permit period, in accordance with the provisions of the laws and regulations
b. Planting for rehabilitation of watersheds and implemented no later than 1 (one) year before the expiration of forestry borrow use permit, with a ratio of 1: 1, in accordance with the provisions of the laws and regulations;
c. Pay Non-Tax State Revenue of Forestry Borrow Use Permit, in accordance with the provisions of the laws and regulations;
d. Carry out a plant inventory in accordance with the annual forest utilization plan;
e. Paying PSDH and DR and also other financial obligations in accordance with the provisions of laws and regulations;
f. Indemnified the investment cost of forest management to forest area managers
g. Conducting maintenance of boundaries of forestry borrow use area
h. Implement forest protection in accordance with the provisions of laws and regulations
i. Preparing Human Resources for controlling forest fires within the Forest and Land Fire Control Brigades (Brigdalkarhutla);
j. Placing at least 1 (one) Forest Fire Core Control Team;
k. Recruiting employees to the company as members of the Forest Fire Control Support Team;

l. Preparing *sarpas* to support Brigdalkarhutla activities, which are *sarpas* forest fire prevention and *sarpas* forest fire bases;
m. Conducting community empowerment around the area of forestry borrow use permit;
n. Coordinate with the Provincial Forestry Agency of South Sumatra;
o. Provide convenience for the Ministry of Environment and Forestry officials both Central and Regional at the time of monitoring and evaluation in the field; and

p. Report periodically every 6 (six) months to the Minister of Environment and Forestry on the utilization of forestry borrowed used areas, with copies to:
    1. Director General of Planology Forestry and Environmental Planning
    2. Director General of Watershed Control and Protection Forest
    3. Director General of Sustainable Production Forest Management
    4. Head of Forestry Agency of South Sumatera Province
    5. Head of Center of Forest Conservation Area II Palembang
    6. Head of Watershed Management and Protection Forest Musi Palembang

    Reports contains about:
    1. Plan and realization of forestry area utilization
    2. Plan and realization of reclamation and revegetation
    3. Fulfillment of Non-Tax State Revenue of Forest Area Utilization

SEVEN: The provisions for planting rehabilitation of watersheds as mentioned in the SIXTH article point b shall refer to the Regulation of the Minister of Environment and Forestry Number P.89 / MenLHK / Setjen / Kum.1 / 11/2016

EIGHTH: PT Supreme Energy Rantau Dedap is prohibited:

a. Transfer forestry borrow use permit to another party or change the name of the company without the approval of the Minister of Environment and Forestry;
b. Ensure or mortgaged the area of forestry borrow use permit to another party;
c. Felling trees in forest areas with radius or distance up to:
    a. 200 (two hundred) meters from the edge of the springs and left-right of the river in the swamp area
    b. 100 (one hundred) meters from the left-right of the riverside
    c. 50 (fifty) meters from the left-right the edge of the creek
d. Use mercury in geothermal exploitation activities.

NINTH: Where there are rights of third parties within the area of forestry borrow use permit, to be resolved immediately by asking for guidance and facilitation to the local government

TENTH: This forestry borrow use permit is revoked and the permit holder is subject to sanctions in accordance with the provisions of law and regulation, if the holder of the license violates the provisions as mentioned in the permit, with conditions:

a. The Director General of Planology Forestry and Environmental Management issue a warning at maximum 3 (three) times with a grace period of at least 30 (thirty) working days after receipt of the warning letter; and

b. In the event of warning issuance as referred to letter a is not executed and the permit holder does not make any improvement effort within 30 (thirty) working days since the receipt of the third warning letter.

ELEVENTH: Forestry borrow use permit applies and is inherent as a timber utilization permit, as well as import and equipment utilization permit.

TWELFTH: Determination of disturbed areas, reclamation and revegetation and procedures for the imposition, collection and payment of PNBP The use of Forest Areas shall be refered to Minister of Forestry Regulation Number P.56 / Menhut-II / 2008 jo. Regulation of the Minister of Forestry Number P.84 / Menhut-II / 2014 and Regulation of the Minister of Finance No. 91 / KMK.02 / 2009

THIRTEENTH:
a. The application for extension shall be made by the Permit Holder no later than 2 (two) months before the expiration of the permit period;
b. For the extension of permit referred to in letter a, the Ministry of Environment and Forestry Agency shall evaluate:

1. Forestry area of borrow use permit is still used for geothermal exploitation activities and it's supporting facilities by the permit holder or its affiliates or by other parties which are allowed under the provisions of laws and regulations
2. No violations committed by the permit holder to the terms of the permit
3. Has fulfilled all obligations under this Decree

FOURTEENTH: This Decree shall come into force on the date of stipulation by the maximum period up to December 28, 2045, and expire on its own if not renewed.

Stipulated in Jakarta on September 22, 2017
On behalf of Minister of Environment and Forestry of the Republic of Indonesia,
Head of Indonesia Investment Coordinating Board

Thomas Trikasih Lembong

Annex D

Species Profiles

Annex D Critical Habitat Species Profiles

Scientific Name	Source	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale	Location in the AOI	Likely Distribution	Existing Threats	Potential Impacts Associated with Project	Specific Mitigation Measures
Rafflesia bengkuluensis	Not recorded in project or study area. Detected in the DMU based on literature review. Ie. Not recorded but identified with potential as part of baseline report (CHA Report 2017)		NA		x		This species is a parasitic plant endemic to Sumatra. It was discovered in Bengkulu province (2006). Kaur Forest, Penangkulan River and Sakaian Mayan forest area are locations where habitat is known and the species is known (AnataraNews.com, 2016).	There is little reported regarding the extent of occurrence for this species. As a result the precautionary approach may apply and there is potential that the forest of the DMU sustains at least >1% but < 95% of the global population (Criterion 2, Tier 2b). It may also sustain >95% of the global population however there is a lack of species data to confirm this (Criterion 2, Tier 1a). The Project Area is considered to contain Critical Habitat for this species.	Not recorded in project or study area. Detected in the DMU based on literature review. Ie. Not recorded but identified with potential as part of baseline report (CHA Report 2017)	Occurs in the highland forests of Sumatra, and is endemic to the Bengkulu region of Indonesia.		Reduction of habitat from clearing during construction and operation. Removal of individuals during clearing.	Habitat Clearance Protocol to include searches for individuals and consider localized avoidance, or if unable to avoid, consideration to of translocation or seed collection. Degradation of habitat measures
Vanda foetida	Flora Survey in Project Area of PT Supreme Energy Rantau Dedap South Sumatera Province, 2017	-	NA		x		Endemic to Sumatra, 1 individual was found from the project area in the 2017 flora survey growing on a dead tree in a shrub-dominated area. The population of V. foetida appears to be small and can only be found in Pagar Alam, South Sumatra Province. Populations are fragmented and isolated by tea and coffee plantations, and are generally decreasing due to deforestation and exploitation.	This species is considered endemic based on IFC PS6 as more than 95% of its global range lies within Sumatra. The individual found falls within the known distribution range of the species. The Project DMU covers a large portion of secondary and primary forest habitats in the Muara Enim and Lahat regencies, and habitats surrounding Pagar Alam. It is likely that the DMU supports more than 1% of the global population of V. foetida. V. foetida therefore triggers CH under Criterion 2. The Project Area is considered to contain Critical Habitat for this species.	Found within primary forest growing on trees as epiphytes. Found only at the transmission line, segments T17-18. Location 4° 12′ 2.79″ LS 103° 26′ 7.55″ BT			Reduction of habitat from clearing during construction and operation. Removal of individuals during clearing. Poaching of individuals.	Habitat Clearance Protocol to include searches for individuals and consider localized avoidance, or if unable to avoid, consideration to of translocation or seed collection. Degradation of habitat measures Anti-poaching measures
Manis javanica		Malayan pangolin	CR	x			Endemic to Sumatra, 1 individual was found from the project area in the 2017 flora survey growing on a dead tree in a shrub-dominated area. The population of V. foetida appears to be small and can only be found in Pagar Alam, South Sumatra Province. Populations are fragmented and	This species is considered endemic based on IFC PS6 as more than 95% of its global range lies within Sumatra. The individual found falls within the known distribution range of the species. The Project DMU covers a large portion of secondary and	Found within primary forest growing on trees as epiphytes. Found only at the transmission line, segments T17-18. Location 4° 12′			Reduction of habitat from clearing during construction and operation. Removal of individuals during clearing. Poaching of	Habitat Clearance Protocol to include searches for individuals and consider localized avoidance, or if unable to avoid, consideration to of

Scientific Name	Source	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale	Location in the AOI	Likely Distribution	Existing Threats	Potential Impacts Associated with Project	Specific Mitigation Measures
							isolated by tea and coffee plantations, and are generally decreasing due to deforestation and exploitation.	primary forest habitats in the Muara Enim and Lahat regencies, and habitats surrounding Pagar Alam. It is likely that the DMU supports more than 1% of the global population of V. foetida. V. foetida therefore triggers CH under Criterion 2. The Project Area is considered to contain Critical Habitat for this species.	2.79″ LS 103° 26′ 7.55″ BT			individuals.	translocation or seed collection. Degradation of habitat measures Anti-poaching measures
Maxomys inflatus	WWF Ecoregion Species	Broad-nosed Sumatran maxomys	VU		x		This species is believed to be confined to lower and mid-montane elevations, inhabiting tropical evergreen forest. The species distribution is mapped across the mountains of the length of western Sumatra incorporating the national parks to the north and the DMU. The species is known to be present in the Kerinci Seblat NP and has been recorded between 900 and 1500m asl.	The species distribution is mapped across the mountains of the length of western Sumatra including to the southern extent DMU. Based on this distribution it is unlikely that the DMU sustains >95 % of the global population (Criterion 2, Tier 1a) however there is potential that the DMU sustains >1 % but <95 % of the global population in the absence of any detailed population information (Criterion 2, Tier 1b). The Project Area is considered to contain Critical Habitat for this species.	WWF Ecoregion species that could utilise habitats within the project.	Known only from the mountains of western Sumatra, recorded at elevations between 900 - 1,500 m asl. Potentially locally abundant. Inhabits evergreen forest. Within the project area, likely to occur at lower elevation forests.	There are unlikely to be any threats at the highest elevations at which it occurs, but forest loss due to logging is certainly a major threat at lower elevations (IUCN Red List, 2017).	Reduction and degradation of habitat. Vulnerability to fauna mortality.	• Degradation of habitat measures • Fauna mortality measures
Panthera tigris sumatrae	2016 Baseline Survey (2017 CHA Report) WWF Ecoregion Species	Sumatran tiger	CE	x	x		The species is endemic to Sumatra. IUCN reported the species to occur in about 58,321 km2 of forested habitat in 12 potentially isolated Tiger Conservation Landscapes totaling 88,351 km2 with about 37,000 km2 protected in ten national parks. A more recent publication from Wibisono and Pusparini (2010) found that the species was present in 27 habitat patches larger than 250 km2, this was based on a questionnaire of 35 respondents including tiger conservationists, field biologists and government officials. The Bukit Balai Rejang Protection	There are no population estimates reported for the DMU though given known distribution and population data for other areas it is considered unlikely that the DMU sustains >10 % of the global population of the species (Criterion 1 - Tier 1a). Similarly the Wibisono and Pusparini study (2010) identified more than ten habitat areas so the Project DMU would not be considered one of 10 DMU globally for the species (Criterion 1 - Tier 1b). Forested habitats are noted to be	Footprints of the species were recorded at Wellpads B, C and D (Greencap, 2015).	Likely to be found in good quality forests within the project area but in low densities. Distribution is fragmented and patchy throughout its range on Sumatra.	Habitat loss due to expansion of oil palm plantations and conversion to plantations. Also traded illegally and suffers from prey-base depletion.	Reduction of habitat from clearing during construction and operation. Potential impacts from hunting and poaching during construction and operation from labour influx during construction and operation.	• Loss of habitat measures • Disturbance and displacement measures • Degradation of habitat measures • Fauna mortality measures

Scientific Name	Source	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale	Location in the AOI	Likely Distribution	Existing Threats	Potential Impacts Associated with Project	Specific Mitigation Measures
							Forest (Bukit Balai Rejang South Tiger Conservation Landscape) was one of the forest patches evaluated where the species was confirmed to occur though population data is not reported. The tiger is adaptive to a wide range of habitats with sufficient prey and water being key as well as the presence of threats. They are found in primary forest, secondary forest, coastal forest, peat swamps and logging forest (Ministry of Forestry, 2007). Threats to the species include deforestation and degradation, hunting and trading, conflict and indirect pressures related to poverty (Ministry of Forestry, 2007). Footprints of the species were recorded at Wellpads B, C and D (Greencap, 2015).	preferred by the species and evidence of the species was detected at Wellpads B and D. In addition tiger prey species were detected in the Project Area. As a result the DMU would be considered to support a regular occurrence of an individual (Criterion 1, Tier 2c). While there is an overlap of the DMU with the Project Area, the direct disturbance of 163 ha of suitable habitat would not be expected to impact the long-term survivability of the species (Criterion 1, Tier 2d). There is insufficient data to confirm if the DMU habitat contains a nationally/regionally important concentration of the species so a precautionary approach may be suitable (Criterion 1, Tier 2e) Given the known forest patches where the species is reported it is unlikely that the DMU sustains >95 % of the global population however there is potential that the DMU sustains >1 % but <95 % of the global population. (Criterion 2, Tier 1 and 2). The Project Area is considered to contain Critical Habitat for this species.					
Presbytis melalophos	2014 Baseline Survey (2017 CHA Report) 2017 Incidental Fauna Survey at PT Supreme Energy Rantau Dedap South Sumatera Province	Sumatran surili	EN	x	x		The species is endemic to Sumatra. The species is considered relatively common in its remaining and appropriate habitat however occurrences are very patchy and fragmented. It is known to occur in five protected areas, including Kerinci Seblat NP to the north of the Project Area and Bukit Barisan NP. Habitat is reported in disturbed and	The DMU includes suitable habitat and atleast one known population (recorded by Greencap). Although the species has been recorded within the Project Area, it is expected that the abundance is low. In the absence of more detailed data regarding the remainder of the DMU it cannot be ruled out that	Recorded near wellpad B and Lake Puyang through direct and vocal observations between October 2014 and January 2015. In the 2017	The surili appears to be relatively common in its remaining and appropriate habitat. Tolerant of habitat conversion to a degree, it can be found in disturbed and secondary	While the speices has some tolerance to forest conversion, habtiat loss remains a key threat. Trapping of this species for the illegal pet trade and incidental hunting for food are also threats. Forest fragmentation is a long-term consideration	Reduction of habitat from clearing during construction and operation. May avoid movement across linear barriers. Potential impacts from hunting and poaching during	• Loss of habitat measures • Disturbance and displacement measures • Degradation of habitat measures • Fauna mortality measures

Scientific Name	Source	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale	Location in the AOI	Likely Distribution	Existing Threats	Potential Impacts Associated with Project	Specific Mitigation Measures
	WWF Ecoregion Species						secondary forest areas, primary hill rainforest, shrub forest and plantations. The home range has been observed to be 14-29.5 ha. The Greencap surveys reported (2015) the species in forest areas bordering coffee plantations. The report noted that the density of the species calculated for the survey was only 2 groups/km2 in contrast to the Bukit Barisan NP where it is recorded abundant. Greencap notes that the species is not present in forest with cover between 50 and 75%, and extremely high densities occur between 26 and 50%. The forest cover of the Project Area was reported by Greencap to remain at 75%. The Sumatran surili was recorded 4 times in the 2017 fauna survey, all occurring within primary and secondary forest habitats.	Tier 1 of Criterion 1 may apply, most likely Tier 1b. The DMU may be one of 10 or fewer DMU sites for the species globally noting the species is reported to occur in five NPs. Given its low abundance in the forest habitat at the Project and no additional population data there is no evidence to suggest that the DMU sustains >10 % of the global population (Criterion 1, Tier 1a). Specific to Criterion 1 Tier 2 threshold, the DMU has potential to provide habitat for a nationally/regionally important concentrations of the species (in the absence of utilization data) (Tier 2c and Tier 2e). Specific to the Project area there are records of the species close to the footprint, and this must be a consideration when understanding importance of the area given the relatively small home range of the species. While records suggest a population local to the Project Area, the direct disturbance of 163ha would not be expected to impact the long-term survivability of the species (Criterion 1, Tier 2d). Given the known forest patches where the species is reported it is unlikely that the DMU sustains >95 % of the global population and given its likely low abundance in the forest habitat unlikely to sustain >1 % but <95 % of the global population. (Criterion 2, Tier 1 and 2). The Project Area is considered to contain Critical Habitat for this species.	Incidental Fauna Survey, at least 4 groups of Sumatran Surili found consisting of 2-5 individuals. Observed at the transmission line (T10-11, T15-16, T29-30). All were recorded from primary and secondary forest.	forest areas. Within the project area, the surili is likely to be found in lower montane primary and secondary forest; coffee plantations do not appear to support their needs.	for population persistence (IUCN Red List, 2017).	construction and operation from labour influx during construction and operation.	

Scientific Name	Source	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale	Location in the AOI	Likely Distribution	Existing Threats	Potential Impacts Associated with Project	Specific Mitigation Measures
Symphalangus syndactylus	2016 Baseline Survey (2017 CHA Report) 2017 Incidental Fauna Survey at PT Supreme Energy Rantau Dedap South Sumatera Province WWF Ecoregion Species	Siamang	EN	x			The species is native to Indonesia (Sumatra), Malaysia (Peninsular Malaysia) and Thailand. In Indonesia this species is found in the Barisan Mountains of west-central Sumatra. The species is known from atleast nine protected areas in Indonesia, Thailand and Malaysia and Akrom (2012) notes species density estimates from additional locations. This species lives in primary and secondary semi-deciduous and tropical evergreen forest. Siamangs occur at lower densities in secondary forest, but can persist in secondary areas. They range from the lowlands up to 1500 m in elevation. Greencap (2015) reported records of the species in montane habitat between 1500m and 2000m. Based on the survey 16 groups were documented with a 0.3 group/km2 density in the surveyed area. Greencap noted that the density is substantially lower than that measured in Kerinci Seblat NP of 2.7 groups/km2 (Wood et al., 1996 cited in Greencap, 2015). In Burit Barisan NP average group density was reported to be one group for every 2.23km2 with an average group size of 3.9. The population estimate of Bukit Barisan NP is 22,390 individuals. The siamang was recorded 4 times in the 2017 fauna survey from primary and secondary forest habitats.	The DMU includes suitable habitat and atleast one known population (recorded by Greencap). The species has been recorded within the Project Area however it is expected that the abundance is low in comparison to other known areas where the species occurs. Given its low abundance in the forest habitat at the Project and no additional population data there is no evidence to suggest that the DMU sustains >10 % of the global population (Criterion 1, Tier 1a). Similarly the literature identified more than ten habitat areas so the Project DMU would not be considered one of 10 DMU globally for the species (Criterion 1 - Tier 1b). Specific to Criterion 1 Tier 2 threshold, the DMU has potential to provide habitat for a nationally/regionally important concentrations of the species (in the absence of utilization data) (Tier 2c and Tier 2 e). While records suggest a population local to the Project Area, the direct disturbance of 163 ha would not be expected to impact the long-term survivability of the species (Criterion 1, Tier 2d). The Project Area is considered to contain Critical Habitat for this species.	Found along the transmission T06-07, T1819, T28-39, T35-56; and brine line within primary and secondary forest. The coffee plantation habitats within the AOI are not suitable for this species.	Inhabits the forest remnants of Sumatra and the Malay Peninsula, and is widely distributed from lowland forest to mountain forest up to altitudes of 3,800 m.	Threatened by forest conversion and opportunistic collection for the pet trade. Coffee plantations present an increasing threat (IUCN Red List, 2017).	Reduction of habitat from clearing during construction and operation. May avoid movement across linear barriers. Potential impacts from hunting and poaching during construction and operation from labour influx during construction and operation.	• Species specific measures required • Loss of habitat measures • Disturbance and displacement measures • Barrier to movement measures • Fragmentation and edge effects measures • Degradation of habitat measures • Fauna mortality measures
Tapirus indicus	2016 Baseline Survey (2017 CHA Report) WWF	Malayan tapir	EN	x			This species is native to Indonesia (Sumatra), Malaysia, Myanmar and Thailand. In Sumatra this species occurs in the southern and central	The DMU includes suitable habitat for the species and there are known records. The mapped distribution of the species is	Camera trap surveys in 2016 have captured the species north of	The tapir can be found in Sumatra from the southern part of Lake Toba	The primary threats to the species are large scale deforestation and increasingly, hunting	Reduction of habitat from clearing during construction and operation. Potential	• Species specific measures required • Loss of habitat measures

Scientific Name	Source	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale	Location in the AOI	Likely Distribution	Existing Threats	Potential Impacts Associated with Project	Specific Mitigation Measures
	Ecoregion Species						areas. Its populations are now highly fragmented within its former range. Linkie et al. 2013 (cited in IUCN species profile) recorded the species at 17 of 19 areas sampled using camera traps across Southeast Asia between 1997 and 2011. This species is restricted to tropical moist forest areas and occurs in both primary and secondary forest. It is predominantly found in the lowlands and the lower montane zones in some parts of the range. The species was detected via camera trap near Wellpad B, C, E and I and Puyang Lake during the biodiversity surveys (Greencap, 2015)	fragmented and largely isolated to forest fragments (including existing protected areas) and does not include the DMU. Based on this there is no evidence to suggest that the DMU sustains >10 % of the global population (Criterion 1, Tier 1a). While habitat within the DMU is suitable for the species the habitat it is not one of 10 sites globally with many sites noted globally for the species (Criterion 1, Tier 1b). Specific to Criterion 1, Tier 2 thresholds the DMU has potential to provide habitat for a nationally/regionally important concentrations of the species (in the absence of utilization data) (Tier 2c and Tier 2e). While the DMU may contain a population, the direct disturbance of approximately 163ha would not be expected to impact the long-term survivability of the species (Criterion 1, Tier 2d). The Project Area is considered to contain Critical Habitat for this species.	Wellpad I. Footprints were recorded at Wellpad B, I, E, C and Puyang Lake.	down to Lampung. The species occupies lowland forest but can be detected up to 2,000 m asl.	(IUCN Red List, 2017).	impacts from hunting and poaching during construction and operation from labour influx during construction and operation.	• Disturbance and displacement measures • Degradation of habitat measures • Fauna mortality measures
Rhacophorus bifasciatus	Not recorded in project or study area. Detected in the DMU based on literature review. Ie. Not recorded but identified with potential as part of baseline report (CHA Report 2017)		NT		x		Species occurs in lowland and submontane forest, likely breeding in streams. Distribution of the species is mapped at six patches across Sumatra, one of which includes the DMU. The extent of occurrence while not calculated is noted to be 'not much greater than 20,000 km2'. The species was not recorded during the biodiversity survey for the Project (Greencap, 2017)	While the species has not been recorded during field survey, there is suitable habitat and the Project Area is within the mapped distribution for the species. There is no population information specific to the species however given there are six other locations comprising the species distribution it is considered unlikely that the DMU sustains > 95% of the global population (Criterion 3, Tier 1a). That being	Not recorded in project or study area. Detected in the DMU based on literature review. Ie. Not recorded but identified with potential as part of baseline report (CHA Report 2017)		The main threat is localized forest loss due to agricultural development (including for non-timber plantations) (IUCN Red List 2017).	Reduction and degradation of habitat. Vulnerability to fauna mortality.	• Loss of habitat measures • Disturbance and displacement measures • Degradation of habitat measures

Scientific Name	Source	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Species information*	CH rationale	Location in the AOI	Likely Distribution	Existing Threats	Potential Impacts Associated with Project	Specific Mitigation Measures
								the case there is potential that the DMU sustains >1% but <95% percent of the global population (Criterion 3, Tier 2b). The Project Area is considered to contain Critical Habitat for this species.					
Tor tambroides	2016 Baseline Survey (2017 CHA Report)	Mahseer Fish	DD				This species occurs in the Mekong Basin in Yunnan, Lao, Chao Phraya basing in Thailand, Java, Borneo, Sumatra, Brunei, Malay Peninsula and potentially Vietnam. The population appears to be decreasing due to overfishing and anthropogenic modification of river morphology. Logging, deforestation and agricultural impacts along its range also contribute to its decline through the degradation of the aquatic environment. The species lives in large streams and rivers with moderate to swift flow. Adults live in deep pools and juveniles are typically found in or near rapids; these aquatic habitats are found within lowland forest. It is a full migrant, moving upstream to spawn in smaller streams. During the rainy season, it moves downstream. EcologyAsia states that this species is an indicator of the ecological health of lowland rivers as it avoids silted waters where possible.	Based on IUCN spatial information of the distribution of Tor tambroides, the species appears widespread although there is limited information on the number of watersheds it inhabits. The species was only found from one river in the project area, namely Cawang Tengah River but it is unclear the population status within the DMU. As a precautionary measure, the habitats within the DMU are preliminarily assumed to sustain more than 1 % but less than 95% of the global poplulation of Tor tambroides. Given the migratory patterns of the species, any section of river would be critical to its continued survival. Therefore, habitats within the DMU have been assessed as CH for Tor tambroides under Criterion 3, Tier 2.	Present within Cawang Tengah River.	Within rivers in the project area that have clear water conditions and high oxygen content, moderate to swift flow.	The species is at threat from overfishing, where dynamite, poison and hooks are used. Anthropogenic modification of river morphology impacts this species by reducing or interrupting water flow. Logging, deforestation and agriculture occurs throughout the species range, with associated impacts on the aquatic environment expected (IUCN Red List, 2017)	Alteration of aquatic habitat leading to degradation. Vulnerability to fauna mortality (water extraction pipe).	• Species specific measures required • Degradation of habitat measures • Fauna mortality measures

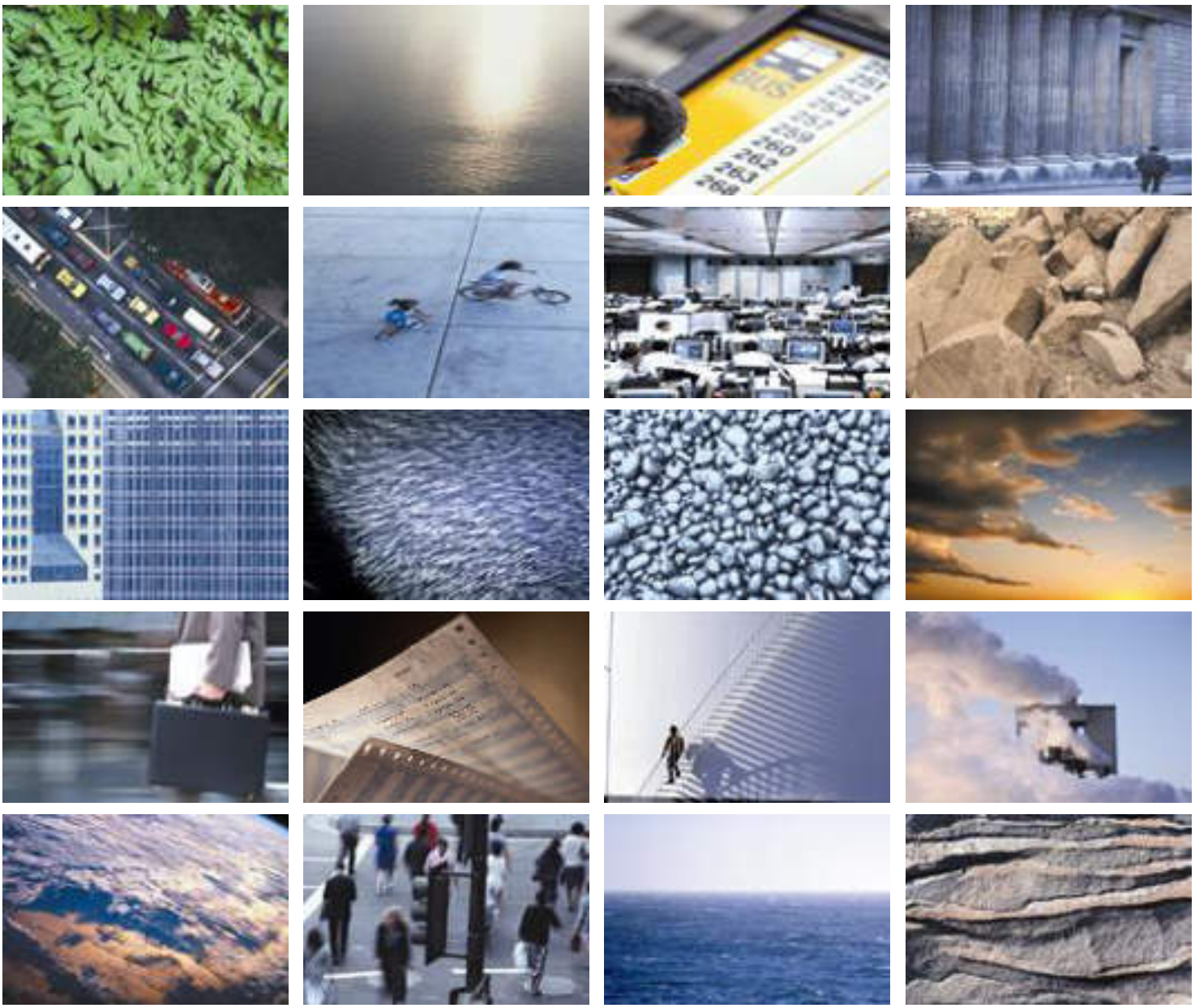
CR = Critically Endangered; EN = Endangered; DD = Data Deficient; NT = Near Threatened; NA = Not Assessed

**Species information sourced from IUCN Red List of Threatened Species profiles dated 1 and 2 February 2017 unless otherwise referenced.*

Grey indicates species associated with potential Critical Habitat.

Annex E

Ecosystem Services Assessment (ERM Nov 2017)



Supreme Energy Rantau Dedap Ecosystem Services Assessment

PT Supreme Energy Rantau Dedap (SERD)

November 2017

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FINAL REPORT

Supreme Energy Rantau Dedap (SERD)

Ecosystem Services Assessment

November 2017

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For and on behalf of ERM-Siam Co Ltd

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Position: Partner

Date: 22 November 2017

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EXECUTIVE SUMMARY

PT Supreme Energy Rantau Dedap (SERD) plans to develop a Geothermal Power plant project at the geothermal field in Rantau Dedap, South Sumatra ('the Project'). The concession is located approximately 91km south of Muara Enim, 225km to the southwest of Palembang, the capital city of South Sumatra Province and 100km southeast of Bengkulu, the capital of Bengkulu Province.

The concession for the Rantau Dedap geothermal project was awarded to Supreme Energy in early December 2010 and the Mining Area License was granted to the project company PT Supreme Energy Rantau Dedap (SERD) at the same time. SERD has received the assignment from the Minister of Energy and Mineral Resources through assignment letter No. 5834/26/MEM.L/2011 September 30, 2011.

The Asian Development Bank (ADB) identified that an ecosystem services assessment was necessary to assist with compliance with the ADB's Safeguard's Policy Statement (SPS) in relation to the identification and management of Critical Habitats. Previous assessments undertaken for the SEML project had not specifically undertaken assessments for ecosystem services. As a result, an ecosystem service assessment was identified as a gap and an action as part of the SERD Biodiversity Action Plan (BAP) (ERM 2017) (v.10 S/N 39).

Environmental Resources Management (ERM) was contracted to conduct an ecosystem services assessment of the SERD concession. This assessment was undertaken as required by the SERD Biodiversity Action Plan to satisfy the requirements of the Asian Development Bank (ADB) Safeguards Policy Statement (SPS).

In accordance with the World Resources Institute Guidelines (WRI 2013), ERM conducted ecosystem screening assessment in order to determine the likely ecosystem service values that could be potentially important to affected communities within 5km of the SERD concession area. This assessment was done using existing sources of data, including information obtained during the scoping visit. This visit was held in October 2017 and consisted of initial interviews with SERD representatives as well as with local community representatives in the following villages: Tunggul Bute, Rantau Dedap, and Talang Pisang.

There are three categories of ecosystem services that were found when ERM conducted the ecosystem services assessment: (1) provisioning services; (2) regulating services; and (3) cultural services.

For provisioning aspect, the ecosystem services assessment included: (a) *Food: wild-caught fish and shellfish and aquaculture; (b) Food: wild meat; (c) Food: cultivated crops; (d) Food: herbs and plants; (e) Livestock farming; (f) Biomass fuel; (g) Timber and wood products; (h) Non-timber forest products.* For regulating

aspect, the ecosystem services assessment included *freshwater utilization, soil control and forest protection*. For the cultural aspect, the ecosystem services assessment included *spiritual, religious or cultural value*.

After conducting screening on ecosystem services prioritization, ERM identified two priority ecosystem services: freshwater and erosion regulation. ERM considered that SEML project may likely impact to such both priority ecosystem services. To reduce the impacts on the priority ecosystem services, ERM proposed mitigations. At the mitigation stage, ERM identifies options through the mitigation hierarchy to enhance or at least maintain: (1) the well-being affected beneficiaries derive from ecosystem services and (2) the performance the project derives from ecosystem services at acceptable levels.

ERM has determined that the application of these mitigations is sufficient to reduce the impact to these ecosystem services to negligible or minor. As a result, no residual impacts have been identified on ecosystem services that require additional mitigation and offsetting.

1. PROJECT BACKGROUND

PT Supreme Energy Rantau Dedap (SERD) plans to develop a Geothermal Power plant project at the geothermal field in Rantau Dedap, South Sumatra ('the Project'). The concession is located approximately 91km south of Muara Enim, 225km to the southwest of Palembang, the capital city of South Sumatra Province and 100km southeast of Bengkulu, the capital of Bengkulu Province.

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PT ERM Indonesia was appointed by PT Supreme Energy to conduct an ecosystem services assessment for its geothermal energy site in South Sumatra. The field assessment to define ecosystem services at the site was conducted for the period of 5 to 8 October 2017.

1.1 DEFINING ECOSYSTEM SERVICES

Ecosystem services are defined as the benefits that people, including businesses, derive from ecosystems (IFC 2012). These services are substantial and varied, underpinning basic human health and survival needs as well as supporting economics activities, the fulfillment of people's potential, and enjoyment of life.

In order to provide a uniform basis to assess the status of all major global habitat across all of the word's bioregions, the United Nation's Millennium Ecosystem Assessment (UN 2005) combine diverse Ecosystem Services typologies into a consistent classification scheme.

There are four categories of ecosystem services defined in Millennium Ecosystem Assessment as outlined in IFC Performance Standard 6:

- **Provisioning Services**; these services that can be extracted from ecosystem to support human needs. This term is more or less synonymous with the term " **Ecosystem Goods**" that was used in some prior classification schemes, including such tangible assets as fresh water, food, fiber, timber and medicinal plants;
- **Regulating Services**; the benefit obtained from an ecosystem's control of the natural environment, including of the regulation of surface water purification, carbon storage, and sequestration, climate regulation, protection from natural hazard, air quality, erosion and pests;
- **Cultural Services**; non-material benefits including diverse aspect of aesthetic, spiritual, recreational, and others cultural value;
- **Supporting services**; the natural process essential to the maintenance of the integrity, resilience, and functioning of ecosystem, thereby supporting the delivery of all other benefits. They include soil formation, nutrient cycling, and primary production.

1.2 APPLICABLE STANDARDS AND GUIDELINES

The ADB SPS requires that ecosystem services are assessed when determining whether a project triggers the requirements for Critical Habitat. The definition of Critical Habitat under the SPS (Clause 151 of the ADB Source Book) specifically references ecosystem services as a component of Critical Habitat. Clause 183 of the ADB Source Book also identifies ecosystem services as a component necessary for assessment in relation to sustainable natural resource management (ADB 2012).

The International Finance Corporation's (IFC) performance standards require projects to assess and preserve the benefits from ecosystem services. The IFC also requires that the environmental and social risks and impacts identification process considers a project's dependence on ecosystem services. A fundamental component is to apply the mitigation hierarchy to determine measures to limit impacts on ecosystem services.

ERM has utilized the World Resources Institute (WRI) Guidelines: *Weaving Ecosystem Service into Impact Assessment* to guide the approach used to assess ecosystem services in relation to the project.

The Ecosystem Services Review was undertaken following a five-stage approach (WRI 2014):

- ***Screening assessment*** to Identify Ecosystem Services that may occur within the study area;
- ***Data Collection and prioritization*** for 'screened in' Ecosystem Services;
- ***Scoping***; to refine the list of ecosystem services based on those identify in the study area and potentially impacted by the project;
- ***Prioritization*** to identify Ecosystem services importance to beneficiaries; and;
- ***Impact Assessment*** to identify the impacts to ecosystem services and their human beneficiaries as a result of the project.

2. *ECOSYSTEM SERVICES SCREENING AND SCOPING*

2.1 APPROACH

An ecosystem services screening assessment was undertaken to determine the likely ecosystem service values that could be potentially important to affected communities.

The scoping exercise was undertaken in order to refine the list of Ecosystem Services that:

- **Potential Beneficiaries**: Known and potential beneficiaries for a service were identified and where possible identifying people at the local, national, and / or global level;
- **Sources of Impact**: Potential sources of impact were considered based on the critical habitat assessment report conducted by ERM for SERD;
- **Project Dependence:** IFC PS-6 requires that the Ecosystem Services assessment take into consideration any services that the Project may rely upon during construction, operation and/or decommissioning. Therefore all services for which there is a potential project dependency were scoped into the prioritisation stage.

The goal of the scoping exercise was to identify a list of Ecosystem Services to be assessed during through the surveys.

2.2 RESULTS

This assessment was done using existing sources of data, including information gleaned during the scoping visit. This visit was held in October 2017 and consisted of initial interviews with SERD representatives as well as with local community representatives

The results of the scoping assessment are contained in ***Table 2-1***.

Table 2-1 Ecosystem Services Screening Assessment

Ecosystem Service Type	Description, Examples	Current Known Ecosystem Services	Screened in?
Provisioning Services			
Food: wild-caught fish and shellfish & aquaculture	Fish caught for subsistence or commercial sale; Fish, shellfish, and/or plants that are bred and reared in ponds, enclosures, and other forms of fresh- or salt-water confinement for harvesting	Villagers do not catch fishes in local rivers/creeks/small lake on regular basis. Instead, villagers do fishing as an entertaining activities (not main source of livelihood/fulfill protein needs). For that reason, few villagers catch fishes in Deduruk small lake and Endikat river where local fishes such as mujair, nila, and gold fish. According to the information provided by local villager, to fulfill protein needs from fishes, villagers bought fishes in the market sold by sellers who live outside and price of fish bought from local market is ranging from Rp. 30,000 to Rp. 35,000 per kilogram. In addition to that, some villagers have fishponds in their house yards (small quantity of production) for their own consumption or sell to other neighbors when needed. Types of fish that are in the fish pond (local name): mujair, nila and catfish. Fish seeds are supplied from outside Kota Agung District. There are rules for local villagers who are fishing in Deduruk small lake that they are not allowed to use fish net or electric shock for catching fishes. And fishing undertaken is limited to areas outside of the Project area. Therefore, the project is unlikely to have a significant impact on this service.	No
Food: wild meat	Animals hunted for primarily for food (recreational hunting covered under cultural services)	Villagers still do catch wild animals (such as wild boar and deer) in the protected forest (Bukit Jambul Gunung Patah) occasionally as they do it for fun/entertainment. They hunt deer for own consumption and to be sold if their neighbors need for protein needs which bought with sincere price (sukarela). The weight of deer is approximately 40-65 kilograms. While hunting wild boar is carried out every Saturday or Sunday. If the wild boars are dead, local villagers bury them or their dogs eat them as local villagers do not eat wild boars due to religious beliefs which all local villagers are Moslem. Wild boars are pest and they like eating potatoes, and cabbage which local villagers' planted. Evidence suggests that there is currently hunting by local people for wild meat within the Project Area and AoI.	Yes
Food: cultivated crops	Annual and permanent crops grown for subsistence use and commercial sale	95% of local villagers' livelihood is relied on coffee plantation. Type of coffee is robusta. In addition to that, local villagers also plant vegetables such spring union, chili and potatoes. Type of agriculture is permanent plot as each villager has various size of land ranging from 0.25 hectare to four hectares. For coffee, there are few middle men who live in village and some others come from outside village and help local villagers to sell outside village or districts. There is no forest conversion for new coffee plantation. Coffee can be harvested for minimum of 15 years. After that, local villagers replant new coffee plant or utilize other prospective crops such as cocoa, or timber/wood plant such as rubber, meranti and albasia where such woods are utilized for building houses. Evidence suggests that cultivated crops occur within the Project Area and AoI. There is potential for impacts to cultivated crops from air emissions.	Yes

Ecosystem Service Type	Description, Examples	Current Known Ecosystem Services	Screened in?
Food: herbs and plants	Herbs and plants collected for food by local people	Herbs and plant are planted in the local villagers' house yard and in between other crops such as ginger, turmeric, galangal, lemongrass, etc. Herbs are used for cooking ingredient. Local villagers have less interest in making traditional herbs drink (example ginger drink) in their daily consumption, however, if they need to keep body health stamina, local villagers made herbs drink from ginger and lemongrass. Evidence suggests that herbs and plants are planted in villagers' farm or house yard.	No
Livestock farming	Sedentary and nomadic livestock farming	There are no livestock farming because livestock farming is not primary livelihood of local villagers. However, there is one villager (Bapak Masrul Rohim) in Rantau Dedap who owns livestock of 64 "garut" goats. Cows and chicken are kept by local villagers in very small amount such as one or two cows and five to 15 chicken. In addition, cows, and chicken are sold during religious festive such as Eid Fitr or Eid Mubarak to those local villagers who need them. "Garut" goats are sold to neighbors or outside village during religious festive such as Eid Mubarak. Evidence suggests that local people do not undertake livestock farming within the Project Area and AoI.	No
Biomass fuel	Wood, dung and plant matter collected for charcoal, fuel	Local villagers do not utilize biomass fuel for their daily cooking fuel from their livestock. Cows and chicken are in very small quantity. Cow and chicken dung are utilized for crops fertilizer. Evidence suggests that there is no collection of wood, dung and plant matter for the production of charcoal and fuel.	No
Timber and wood products	Wood collected for local use or for sale as timber, wood pulp and paper	Local villagers collect timber and wood from their own crops field/ plantation where they plant albasia, cemara (casuarina equisetifolia) and meranti (shorea sp.) trees for building houses. If they do not have it, they bought it from neighbors whose timber plantation. Local government official (forestry) forbids access to forest for anyone for cutting wood through local government regulation (by regency head). There is a heavy penalty imposed to those who violate the law/regulation. Wood/timber needs are reduced due to local villagers prefer to build houses using concrete wall as local villagers have better access (transportation) to go to house building store in nearby city. Evidence suggests that wood is harvested from villagers' own plantation or farm.	No
Non- Timber Forest Products (NTFP)	Non-timber products collected from the forest. For example, cane, palm, straw, cotton, hemp, twine and rope, natural rubber	Local villagers do not collect or gather non-timber forest product such as wild honey. Wild honey is gathered or collected from bees that made their nests in trees like coffee, cemara in plantation/crops field. The honey is sold to local villagers who need it. The price of honey is valued Rp. 150,000 per bottle (1 liter). In addition to that, a few local villagers make "small rice basket" made from Enau plant (arenga pinnata) in small quantity. Small rice basket is sold around Rp. 8,000 per piece. Evidence suggests that NTFP is harvested from villagers' own trees planted in their farm/plantation.	No

Ecosystem Service Type	Description, Examples	Current Known Ecosystem Services	Screened in?
Regulating services			
Freshwater Biochemical, natural medicines, pharmaceuticals	Freshwater for bathing, drinking, irrigation, laundry, household and industrial use	Freshwater is utilized by local villagers for various purposes such as development of micro-hydro power and hygiene activities. Through development of micro-hydro power, local villagers use it for their electricity as the PLN network is not available. There is no water quality and quantity issue since local villagers utilize water from trusted source such as spring water distributed through PAMSIMAS. River water which is distributed to villagers' houses using water piping or water hose. The river water is only utilized for hygiene activities not for cooking or drinking. Addition to that, local villagers have their own shallow well which can be easily obtained with a depth of 7 meters. Evidence suggests that freshwater is used by local people from within the Project Area and AoI. The project may restrict or impact this activity.	Yes
	Natural medicines, biocides, food additives, pharmaceuticals and other biological material for commercial or domestic use. For example, pelts, carved or decorative animal products, live animal trade	Local villagers do not collect or gather any natural medicines from the forest. Local villagers go to doctor or drugstore or village health center if they are sick. Medicinal plants grow wildly in crops field/plantation. Evidence suggests that there is no use of natural medicines biocides, food additives, pharmaceuticals and other biological material for commercial or domestic use.	No
	Genes and genetic information used for animal breeding, plant improvement, and biotechnology	There is no genes and genetic information used for animal breeding, plant improvement, and biotechnology. Evidence suggests that there is no current use of genes and genetic information used for animal breeding, plant improvement, and biotechnology.	No
Ecosystem functions	The influence ecosystems have on air quality by extracting chemicals from the atmosphere (i.e., serving as a "sink") or emitting chemicals to the atmosphere (i.e., serving as a "source")	Evidence suggests that the Project area of AoI has no major influence on air quality in the vicinity due to the project has not been initiated yet.	No
	Carbon sequestration (impacts on global climate change) regulation of temperature, shade air quality by vegetated areas	Evidence suggests that the Project area of AoI has no major influence on Carbon sequestration in the vicinity due to the project has not been initiated yet.	No
	Influence ecosystems have on the timing and magnitude of water runoff, flooding, and aquifer recharge	Evidence suggests that the Project area of AoI has no major influence on water runoff, flooding, and aquifer recharge in the vicinity due to the project has not been initiated yet.	No
	Role played by vegetation and bacteria in the filtration and decomposition of organic wastes and pollutants and the assimilation and detoxification of compounds.	Evidence suggests that the Project area of AoI has no major influence on filtration and decomposition of organic wastes and pollutants in the vicinity due to the project has not been initiated yet.	No

Ecosystem Service Type	Description, Examples	Current Known Ecosystem Services	Screened in?
	Role of natural habitats (e.g. wetlands, beaches, reefs) in protecting crops, buildings, recreation areas from waves, wind and flooding from coastal storms.	Evidence suggests that the Project area of AoI has no major influence on protecting crops, buildings, recreation areas from waves, wind and flooding from coastal storms in the vicinity due to the project has not been initiated yet.	No
	Regulation of fire frequency and intensity (e.g. dense forest can provide firebreaks)	Evidence suggests that the Project area of AoI has no major influence on regulation of fire frequency and intensity in the vicinity due to the project has not been initiated yet.	No
	Predators from forests, grassland areas, etc. may control pests attacking crops or livestock	Evidence suggests that the Project area of AoI has no major influence on Predators from forests, grassland areas, etc. may control pests attacking crops or livestock in the vicinity due to the project has not been initiated yet.	No
	Influence ecosystems have on the incidence and abundance of human pathogens	Evidence suggests that the Project area of AoI has no major influence on incidence and abundance of human pathogens in the vicinity due to the project has not been initiated yet.	No
	Role of vegetation in regulating erosion on slopes and riparian areas	Evidence suggests that the Project area of AoI for the geothermal site has regulating erosion on slopes and riparian areas in the vicinity, due to the project has not been initiated yet.	No
	Birds, insects and some small mammals pollinate certain flora species, including some agricultural crops	Evidence suggests that the Project area of AoI has no major influence on birds, insects and some small mammals pollinate certain flora species, including some agricultural crops in the vicinity due to the project has not been initiated yet.	No
Cultural Services			
Spiritual, religious or cultural value	Natural spaces or species with spiritual, cultural or religious importance	There are no natural spaces or species with spiritual, cultural or religious importance. Local villagers are embracing the religion of Islam. Therefore, they do not utilize any natural spaces or species with spiritual and religious values. However, there are two sacred sites (Puyang Lake and Belerang Hill) where both are considered haunted places. Puyang Lake is located nearby well pad B, C, E and I and according to Supreme Energy representative, location is far from basecamp about 10 km. For Belerang Hill, it is located faraway about 30 km and it is located in other district. Evidence suggests that the Project area of AoI is not considered as important natural spaces or species with spiritual, cultural or religious importance.	No
	Cultural value placed on traditional practices such as hunting, fishing, crafts and use of natural resources.	Evidence suggests that the Project area of AoI is not considered important areas for cultural value on traditional practices.	No
	Use of natural spaces and resources for tourism and recreation (e.g. swimming, boating, hunting, bird-watching, fishing)	There is a waterfall in the forest namely "Sebidang Rindu" which is located 2 km from project area with 60 metres high. Evidence suggests that the Project area of AoI is considered important natural spaces and resources for tourism and recreation.	Yes

Ecosystem Service Type	Description, Examples	Current Known Ecosystem Services	Screened in?
	Cultural value placed on the aesthetic value provided by landscapes, natural landmarks	Evidence suggests that the Project area of AoI is not considered as important aesthetic value provided by landscapes, natural landmarks.	No
	Information derived from ecosystems used for intellectual development, culture, art, design, and innovation.	Evidence suggests that the Project area of AoI is not considered important for information derived from ecosystems used for intellectual development, culture, art, design, and innovation.	No
	Ornamental resources	A few local villagers use ornamental resources from coconut trees (leaves) which can be found in their crops field/plantation. The coconut leaves are used for decoration such as for wedding event. Evidence suggests that the Project area of AoI is not considered important ornamental resources.	No
Supporting Services			
Non-use value of biodiversity (e.g. existence, bequest value)	Species and areas valued globally as of high conservation value	There is no non-use value of biodiversity in the villages. However, Evidence suggests that the Project areas of AoIs may contain species that are considered as being a high conservation value.	Yes
	Formation of biological material by plants through photosynthesis and nutrient assimilation.	Evidence suggests that the Project area of AoI is not considered important regarding biological material by plants through photosynthesis and nutrient assimilation.	No
	Flow of nutrients (e.g., nitrogen, sulfur, phosphorus, carbon) through ecosystems.	Evidence suggests that the Project area of AoI is not considered important for the flow of nutrients.	No
	Flow of water through ecosystems in its solid, liquid, or gaseous forms.	Evidence suggests that the Project area of AoI is not considered important for the flow of water through ecosystems.	No
	Natural soil-forming processes throughout vegetated areas.	Evidence suggests that the Project area of AoI is not considered important for natural soil forming processes.	No
	Natural spaces that maintain species populations and protect the capacity of ecological communities to recover from disturbances.	Evidence suggests that the Project area of AoI is not consider important to maintain species populations and the capacity to assist ecological communities recover from disturbances.	No

3. *ECOSYSTEM SERVICE DATA COLLECTION AND PRIORITIZATION*

Community interviews were conducted on ecosystem services assessment at the SERD site in October 2017. The summary of the results are outlined below.

3.1 *COMMUNITY SURVEYS*

ERM undertook the following consultation as part of ecosystem services assessment:

- Consultation meetings with internal SERD representatives (environment, social and management).
- Consultation with 15 local village representatives living in close proximity to Supreme Energy site location in Rantau Dedap from selected communities (3 villages); and
- Household survey questionnaires were used to gather data from the communities around SERD site locations to solicit their opinions on both the positive and negative aspects of the Project development. The data is relevant to understanding current socio-economic conditions in the Area of Influence of the Project, historical impacts associated with SERD project activities as well as potential issues associated with the on-going activities of the Project.

The topics addressed in the household surveys included:

- Basic household information (Individual);
- Group discussions focussed on the livelihoods of coffee small business women group; and
- Socio-economic system survey as a quantitative assessment of the level of reliance on natural resources by affected communities and the linkage between the subsistence economy and the livelihoods of affected communities.

Prior to conducting household surveys, an introductory meeting was convened in the host community to introduce the purpose of the consultation.

3.2 *DATA COLLECTION*

Data was collected through community meetings, household surveys and face to face discussions with stakeholders. Community meetings were arranged by Supreme Energy representatives in collaboration with the village leaders and other village representatives. The meetings provided an opportunity to gather feedback on SERD activities.

A total of fifteen (15) village representatives had discussions on their socio-economic conditions across three (3) villages with particular focus on the livelihoods of women and farmers. The details the surveys conducted are in ***Table 3-1***.

Table 3-1 The details of the surveys conducted in project area.

Date	Name of Villagers	Occupation	Villages/ Villages
06-10-17	Jutawan; H. Tawil; H. Ismail; Coffee small business woman group	Village head; community leaders	Tunggul Bute
	Markun	Head of village	Rantau Dedap
07-10-17	Edi Prayitno	Religious leader	Talang Pisang
	Kaluri	Farmer/ traditional healer	Talang Pisang

In addition to conducting face-to-face interview with local villagers, ERM also conducted field observations. The field observations include the presence of Pamsimas (Indonesian Government program in clean water access and sanitation for local communities), rivers and site visits to Supreme Energy project activities.

The questionnaire used to collect data on ecosystem services is shown in ***Table 3-2***. Data was collected on screened in ecosystem services relevant to the community. Information was collated on:

- Type of ecosystem services used by the local community;
- Sources (locations), amounts utilised and availability of alternatives;
- Condition and trends in resource availability;
- Cultural and supporting ecosystem services;
- Screened ecosystem services for erosion, and;
- Non-use value of biodiversity

Table 3-2 Ecosystem Services Questionnaire

ES Screened in	Questions
Food: wild-caught-fish and shellfish and aquaculture	• Do fishermen go fishing for fish/shellfish? How often do fishermen go fishing? Record locations of where the fishing takes place on a map.
Food: wild meat	• Do local hunters go hunting? How often do they go? What species do they target? Identify hunting areas on a map; • Do local hunters travel to other forests to undertake hunting? What species do they target? Record the species hunted and location; • Record the type and trend (increasing or decreasing)
Food: cultivated crops	• What crops are cultivated? What type of agriculture is utilized (shifting or permanent plots)? What seasonal crops are planted? Are the crops are sold locally or outside the village? Identify location of cropping areas on a map; • Do other plot owners travel to other areas to undertake cropping? Record the area of plots, species planted and location. Mark the location on a map; • Discuss any trends in quality or quantity. Record the type and trend (increasing or decreasing).
Food: herbs, mushrooms and plants	• What herbs and plants are collected from the forest? Are the herbs and plants used for consumption or sold at the market? How often are the collected? • Discuss the alternative herbs and plants are available? Where are these bought? • Have there been any changes in yield? Record the type and trend (increasing or decreasing)
Livestock farming	• What livestock are tended? Are the livestock used for consumption or sold at the market? • What alternative livestock are available? Where are these bought? • Discuss the type of livestock tended and whether there is a trend in quality or quantity. Record the type and trend (increasing or decreasing)
Timber and wood products	• What species of timber and wood collected? When is the timber collected? Is the timber and wood used in the village or sold outside the village? Identify location of collection areas on a map; • Do timber gatherers travel to other forests to undertake wood and timber collection? What is the frequency and amount of collection from alternative locations? Mark the location on a map; • What are the trends in timber volume and quality? Record the type and trend (increasing or decreasing).
Non- Timber Forest Products (NTFP)	• What species of NTFP are collected? • Discuss what other NTFP are used by households. Record the type and amounts. • Record the type and trend (increasing or decreasing) of NTFP collected.
Freshwater	• What is the uses for freshwater in the village? Where is the water collected from? Record the location of water sources; • Are there alternatives to water supply available to villagers? Where are these alternative supplies?; • Has water quality and quantity been impacted? If so what by?
Biochemical, natural medicines, pharmaceuticals	• What medicines are collected from the forest? What is the amount, uses and location of the main collection points? • Are alternatives to local medicines available? If so, what are they and where are they collected? • Are natural medicines becoming more or less available? Is the availability of medicines increasing or decreasing?

ES Screened in	Questions
Ornamental resources	• What ornamental resources are collected from the forest? What is the amount, uses and location of the main collection points? • Are alternatives to ornamental resources available? If so, what are they and where are they collected? • What is the current condition of ornamental resources in the yield (increasing or decreasing)?
Spiritual, religious or cultural value	• Are there important forest and river resources for spiritual and religious values located in the area? Record values and places; • Are there other areas used for spiritual or religious values outside of the project area that locals could use as an alternative? • Have spiritual and religious values been impacted previously? Record values and places.
Traditional practices	• Are there important forest and river resources used for traditional practices located in the area? Record values and places; • Are there other areas used for traditional practices outside the project are that locals could use as an alternative? • Have areas used for traditional practices been impacted previously? Record values and places.
Recreation and tourism	• Are there important forest and river resources used for recreation and tourism located in the area? Record values and places; • Are there other areas used for recreation and tourism values outside the project area that locals could use as an alternative? • Have recreation and tourism values been impacted previously? Record values and places.
Aesthetic value	• Are there important aesthetic values associated with the forest and river located in the area? Record values and places; • Are there other areas appreciated for aesthetic value outside of the project area that locals could use as alternative? • Have aesthetic values been impacted previously? Record values and places.
Educational and inspirational values	• Are there important educational values located in the area? Record values and places; • Are there other areas used for education values outside of the project area that locals could use as alternative? • Have educational values been impacted previously? Record values and places.
Non-use value of biodiversity (e.g. existence, bequest value)	• Are there important landscape values located in the area? Record values and places; • Are there other areas that have an importance outside of the project area that locals could use as an alternative? • Have landscape values been impacted previously? Record values and places.

3.3 *RESULTS*

The results of the survey for screened ecosystem services are outlined below.

3.3.1 *Provisioning Services*

Food: wild-caught fish and shellfish and aquaculture

The results of the survey in relation to provisioning services for food wild-caught fish and shellfish and aquaculture are outlined in ***Table 3-3*** below.

Table 3-3 Results of survey in relation to Food: wild-caught fish and shellfish and aquaculture

Name of Village	Food: wild-caught fish and shellfish and aquaculture					
	Wild-caught fish and shellfish and aquaculture from the river/lake (every catch)		Other sources of protein consumed (per month/household) from the market (bought)		Resource condition and trends	
	Type	Amount	Type	Amount (kg)	Size	Trend
Tunggul Bute, Rantau Dedap and Talang Pisang	Local fishes: mujair, nila and gold fish from Endikat River and Deduruk small lake	5 to 10 fishes every catch	Chicken	10 kg	Normal	Decrease

Food: wild-meat

The results of the survey in relation to provisioning services for food wild-meat are outlined in ***Table 3-4*** below.

Table 3-4 Results of survey in relation to Food: wild-meat

Name of Village	Food: wild-meat					
	Wild-meat		Other sources of protein consumed (per month/household) from the market		Resource condition and trends	
	Type	Amount	Type	Amount (kg)	Size	Trend
Rantau Dedap	Deer	1 with weight of 40 to 65 kg	Chicken Fish Beef	10 kg 5 to 10 kg 15-20 kg (only during Islamic festive e.g. Eid Mubarak-once a year)	Normal	Decrease

Food – Cultivated Crops

The results of the survey in relation to provisioning services for Food – Cultivated Crops are outlined in ***Table 3-5*** below.

Table 3-5 Results of survey in relation to Food – Cultivated Crops

Name of Village	Food: Cultivated Crops					
	Crops cultivated in the farm/plantation		Crops used by Household		Resource Condition and Trends	
	Name	Plot area each household	Type	Amount	Trend	
					Quality	Quantity
Tunggul Bute, Rantau Dedap, and Talang Pisang	Coffee	0.5 to 1 hectare	Coffee; Chili and Spring Union	1 to 2 tons per hectare (coffee); 10 to 20 kg per hectare (chili and spring union)	Same	For coffee is fluctuating due to unpredictable weather (dry or wet) where in the wet (decrease) and in the dry (increase); for chili and spring union are increasing.

Food: Herbs and plants

The results of the survey in relation to provisioning services for Food: Herbs and plants are outlined in ***Table 3-6*** below.

Table 3-6 Results of survey in relation to Food: Herbs and plants

Name of Village/ Village	Food: Herbs, and plants					
	Herbs and plants are collected from the farm/plantation and bought in the market		Other collected herbs and plants		Resource Condition and Trends	
	Name	Place	Frequency	Type	Amount	Trend
						Quality / Quantity
Tunggul Bute, Rantau Dedap, and Talang Pisang	Ginger, turmeric, galangal, lemongrass (for cooking ingredients) and	Farm/ plantation and bought in the market	Daily	Rumput selusuh urat (for relieve wounds)	If needed	Good / Stable

Name of Village/ Village	Food: Herbs, and plants						
	Herbs and plants are collected from the farm/plantation and bought in the market		Other collected herbs and plants		Resource Condition and Trends		
	Name	Place	Frequency	Type	Amount	Trend	
						Quality	Quantity
	herbs drink						

Food: Livestock farming

The results of the survey in relation to provisioning services for Food: Livestock farming are outlined in ***Table 3-7*** below.

Table 3-7 Results of survey in relation to Food: Livestock Farming

Name of Village/ Village	Livestock Farming						
	Livestock			Other Livestock		Resource Condition and Trends	
	Name	Grazing area	Type	Amount	Type	Trend	
						Quality	Quantity
Tunggul Bute, Rantau Dedap, and Talang Pisang	Garut goat	Rantau Dedap	Cow (small amount)	1 to 5	Garut goat	Same	Increase
			Chicken (small amount)	5 to 10	Chicken	Same	Stable

Timber and wood products

The results of the survey in relation to provisioning services for timber and wood products are outlined in ***Table 3-8*** below.

Table 3-8 Results of survey in relation to Timber and Wood Products

Name of Village/ Village	Timber and wood products						
	Wood and Timber collected from the forest			Other source of wood		Resource Condition and Trends	
	Type	Amount	Location	Type	Amount	Type	Trend
							Quantity
Tunggul Bute, Rantau Dedap, and Talang Pisang	Albasia, cemara	9 to 10 trees	In the farm/	Cinnamon, Coffee and Durian logs	5 to 6 (for cooking)	Albasia, cemara (casuarina	Decrease

Name of Village/ Village	Timber and wood products						
	Wood and Timber collected from the forest			Other source of wood		Resource Condition and Trends	
	Type	Amount	Location	Type	Amount	Type	Trend Quantity
	(casuarina equisetifolia) and meranti (Shorea sp.)		plantation			equisetifolia) and meranti (shorea sp.)	

Non-Timber Forest Product (NTFP)

The results of the survey in relation to provisioning services for Non-Timber Forest Product (NTFP) are outlined in ***Table 3-9*** below.

Table 3-9 Results of survey in relation to Non-Timber Forest Product (NTFP)

Name of Village/ Village	Non-Timber Forest Product (NTFP)					
	NTFP collected from the forest			Resource Condition and Trends		
	Type	Amount	Location	Type	Trend Quality	Trend Quantity
Tunggul Bute, Rantau Dedap, and Talang Pisang	Wild honey	1 liter	In the farm/ plantation	Wild honey	Good	Decrease

Freshwater

The results of the survey in relation to freshwater are outlined in ***Table 3-10*** below. The freshwater from river is utilized for irrigation system (paddy field) and development of micro-hydro to fulfill electricity needs due to PLN (state-owned enterprise providing electricity services for households) is not available. The irrigation system applies during dry and wet seasons. However, during the wet season, the water quantity is increasing and during the dry season, the water quantity is decreasing.

Table 3-10 Results of survey in relation to Freshwater

Name of Village/ Village	Freshwater						
	Location			Alternative location	Resource Condition and Trends		
	Type	Type	Location	When	How		Why
					Quality	Quantity	
Tunggul Bute, Rantau Dedap, and Talang Pisang	River (Endikat)	Spring water	Around villages	Pamsimas program (spring water) has been running quite long time ago.	Clear (dry season) and turbidity (wet season)	Fluctuating - decrease in dry season and increase in wet season	None

Biomass Fuel

The results of the survey in relation to biomass fuel are outlined in ***Table 3-11*** below.

Table 3-11 Results of survey in relation to Biomass Fuel

Name of Village/ Village	Biomass Fuel						
	Purpose	Alternative location			Resource Condition and Trends		
	Type	Source Type	Location	Amount	How		Other alternative location
					Quality	Quantity	
Tunggul Bute, Rantau Dedap, and Talang Pisang	Fertilizer	Cow and chicken dung	In the farm/ plantation	10 to 15 sacks per month	Good	Stable	Buy in the fertilizer store in the city (Kota Agung)

Cultural Services

Spiritual, Religious or Cultural value

The results of the survey in relation to spiritual, religious or cultural value are outlined in ***Table 3-12*** below.

Table 3-12 Results of survey in relation to spiritual, religious or cultural value

Name of Village/ Village	Spiritual, religious or cultural value						
	Purpose	Presence			Resource Condition and Trends		
	Type	Name of Places/ product	Location	Other Information	How		Other alternative location
					Quality	Quantity	
Tunggul Bute, Rantau Dedap, and Talang Pisang	Sacred sites	Puyang Lake and Belerang Hill	Nearby well pad B, C, E and I (Puyang Lake) 30 km away and it is located in other district (Belerang Hill)	Local villagers consider these two haunted places	Unknown	Unknown	Unknown

Ornamental Resources

The results of the survey in relation to ornamental resources are outlined in ***Table 3-13*** below.

Table 3-13 Results of survey in relation to ornamental resources

Name of Village/ Village	Ornamental Resources						
	Purpose	Presence			Resource Condition and Trends		
	Type	Name of product	Location	Other Information	How		Other Information
					Quality	Quantity	
Tunggul Bute, Rantau Dedap, and Talang Pisang	The art decoration such as for wedding event	Coconut leaves	In the farm/ Plantation	None	Good	Stable	None

Recreation and Tourism

The results of the survey in relation to recreation and tourism are outlined in ***Table 3-14*** below.

Table 3-14 Results of survey in relation to recreation and tourism

Name of Village/ Village	Spiritual, religious or cultural value						
	Purpose	Presence			Resource Condition and Trends		
	Type	Name of Places/ product	Location	Other Information	How		Other Information
					Quality	Quantity	
Tunggul Bute	Recreation and tourism	Sebidang Rindu waterfall	2 km from project area	The waterfall has 60 meters high	Good	Stable	To access to waterfall is very difficult and only can be accessed by walk or on foot

Regulating

Role of vegetation in regulating erosion on slopes and riparian areas

Vegetation plays an important role in maintaining soil cohesion along riparian areas and on steep slopes. It was observed at the Supreme Energy site location in Rantau Dedap has managed the erosion management on slopes and riparian areas.

Biological value: Species and areas valued globally as of high conservation value

Rantau Dedap project area is candidate critical habitat areas for global high conservation species (See SERD Critical Habitat Assessment).

4. ECOSYSTEM SERVICES PRIORITISATION

4.1 APPROACH

The WRI guidelines and IFC PS6 requires that priority ecosystem services are identified, and impacts to those services are assessed (IFC 2012). The prioritization process is aimed at identifying those services for which Project impacts would be most likely to result in adverse impacts on project affected communities and other beneficiaries. Using the information collected through the baseline data collection and stakeholder engagement processes, Ecosystem Services were prioritized according to a priority matrix ranking two criteria:

- Importance of the ecosystem service to the beneficiary which considers the intensity of use, degree of dependence and the importance expressed by the project affected communities; and
- Irreplaceability of the ecosystem service, which refers to the availability of alternatives, the accessibility, cost and appetite for those alternatives as discussed with the beneficiary.

4.2 RESULTS

After compiling baseline information on the importance and irreplaceability of each service, these ratings were combined to assign a priority rating to the service grading from *Low* to *Major* as shown in the ecosystem service prioritization matrix in ***Table 4-1***.

Ecosystem services identified as *High* priority or *Major* priority were considered Priority Ecosystem Services. The weight given to each of these components varied slightly depending upon the service, but stakeholder values were given precedence over other criteria where the rating was not clear.

In addition to the above, according to the IFC definition of priority ecosystem services, all services for which project dependencies are identified are considered priority services. The importance and irreplaceability of services relied upon by the Project was assessed through the same prioritization process outlined above, with the Project filling the role of the beneficiary.

In addition to the prioritization exercise, the baseline data collection process provided the opportunity to collect information on the status, trends and sustainability of resource use as they pertain to the habitats and species that support Ecosystem Services. This information was gathered through secondary sources and field studies by the environment team and where appropriate through engagement with local stakeholders. This information is important for the assessment of impacts on Ecosystem Services and therefore on local people as the final receptors of these changes.

Table 4-2 outlines the beneficiaries, potential sources of impact and project dependence for each service, and whether the service was scoped into or out of the Ecosystem Services assessment.

This *section* provides an assessment of the potential Project impact to ecosystem services using the criteria provided.

Table 4-1 Ecosystem Service Prioritization Matrix

Importance to Beneficiaries		**Irreplaceability**		
		High	**Moderate**	**Low**
Low	The service is used and valued by parts of the community, but it is not important in maintaining quality of life or livelihoods of Project Affected Communities.	**Low Priority**	**Low Priority**	**Moderate Priority**
Medium	The service is readily used by some members of the Project Affected Communities for income or subsistence, but they are not dependent upon the service for their livelihoods, and not everyone utilises the service.	**Low Priority**	**Moderate Priority**	**High Priority**
High	The service is highly important in maintaining the livelihoods of the Project Affected Communities, and is used by most of the community regularly.	**Moderate Priority**	**High Priority**	**Major Priority**
Essential	The service is essential to maintain the health of the Project Affected Communities, and the service is used by all members of the community.	**High Priority**	**Major Priority**	**Major Priority**
Irreplaceability definition				
High	Many spatial alternatives exist that are readily available to the Project Affected Communities, and there are no major impediments to their usage.			
Moderate	Spatial alternatives exist but are either less accessible than the affected service, or there are other barriers to their use such as distance, cost and skills required to access the service.			
Low	There are few to no spatial alternatives available to the Project Affected Communities.			

Table 4-2 Results of Prioritization

Ecosystem Services	Trends and Sustainability	Beneficiaries	Importance to Beneficiaries	Irreplaceability	Potential Alternatives	Priority?
Provisioning Services						
Food: wild-caught fishes, shellfish, and aquaculture	The populations of wild-caught fishes appears to be in decline	All villages and villages within AoI of Rantau Dedap project area	Low	High	Communities in Rantau Dedap project has ready access to alternative protein sources such as chicken	Low
Food: wild meat	The populations of wild animal (deer) caught for meat appears to be in decline.	All villages and villages within AoI of Rantau Dedap project area	Medium	High	Communities in Rantau Dedap Village have ready access to alternative protein sources such as beef, fish, and chicken.	Low
Food: cultivated crops	The amount of main crops planted (coffee) and harvested within the Project AoI (Rantau Dedap) appears to be in fluctuating (decrease in wet season and increase in dry season)	All villages within AoI of Rantau Dedap project site location	High	Moderate	Besides crops from the community coffee plantation, the local people can plant other alternative plants such as vegetables	Low
Food: herbs and plants	The amount of herbs and plants available to the community from their farm/ plantation or house yard areas within the AoIs appears to be in stable.	All villages within AoI of Rantau Dedap project area	Medium	High	Replacements for herbs and plants collected are readily available within nearby markets or planted in local people farm/plantation or house yard	Low
Food: livestock farming	The amount of livestock farming available to the community from the local villager who lives in Rantau Dedap, Bapak Masrul Rohim who owns approximately 64 "garut" goats and they are increasing. The goats are sold during Islamic festive e.g. Eid Mubarak. While other villagers do raise cows and chicken in small amount.	All villages within AoI of Rantau Dedap project area	Medium	High	There alternatives for local villagers who own small amount of cows and chicken which they are for own consumption or to be sold to the market or their neighbours when needed.	Low
Biomass Fuel	Local villagers do not utilize biomass fuel for their daily cooking fuel from their livestock. Cow and chicken dung are utilized for crops fertilizer.	All villages within AoI of Rantau Dedap project area	Medium	High	Local villagers obtain organic fertilizer from seller who live outside villages (fertilizer store)	Low
Timber and wood products	The amount of timber available to local people has been decreasing. There is a restriction from local government official (forestry) by establishing the local regulation/law to prohibit people entering forest. To overcome such issue, the timber and wood are planted in local villagers' farm or plantation.	All villages within AoI of Rantau Dedap project area	Medium	High	Potential alternatives exist for use by the villages such as bricks and cement which they can get from house building store in the city (outside Rantau Dedap) as road condition to and from the store is currently is in good condition. If the local people still need timber and wood for building houses, they buy it from house building store outside Rantau Dedap.	Low
Non- Timber Forest Products (NTFP)	Wild honey availability has been decreasing at AoI of Rantau Dedap	All villages within AoI of Rantau Dedap project area	Low	Moderate	Potential alternatives for use by villagers such as buying the honey from local market or supermarket.	Low
Freshwater	Currently, local communities utilize Deduruk small Lake and Endikat River for micro-hydro development and hygiene activities. If Rantau Dedap project utilizes local river or lake, it may likely impact to the river quantity and quality.	All villages within AoI of Rantau Dedap project area	High	Moderate	Spring water (Pamsimas program) and deep well are available for hygiene, cooking and drinking; however river water is still used for micro-hydro development.	High
Regulating Services						
Erosion regulation	The forest in Rantau Dedap project may provide stability to the slopes to reduce the chance of land slips and erosion	Supreme Energy has taken erosion management to prevent impacts of the affected villages downstream.	High	Moderate	Careful management of soil surfaces and river will be required to limit damage caused by erosion and mass movement (equipment mobilization).	High
Recreation and tourism	Sebidang Rindu waterfall. It is a nature creation and the water is not decreased even in the dry season.	Villagers who live in Tunggul Bute located within AoI of project area in Rantau Dedap (2 km)	Medium	Low	Local villagers very rarely visit the waterfall due to the location distance and access to the location is difficult.	Low
Cultural Services						
Spiritual, Religious or Cultural value	The availability of sacred sites (Puyang Lake and Belerang Hill) and they are considered as haunted places as well. Puyang Lake is located nearby well pad B, C, E, and I. While Belerang Hill is located in other district. Those places are nature and local villagers keep those two places sustainable.	All villages within AoI of project area in Rantau Dedap	Low	High	Local villagers embrace Islam and such sacred sites have never been visited by local villagers. In addition, Puyang Lake is located in Supreme Energy well pad, and there is likely a restriction to enter by the project in the future.	Low
Ornamental resources	The coconut leaves are available in the villagers' farm/plantation as the coconut trees grow wildly.	All villages within AoI of Rantau Dedap project area	Low	High	Currently, local villagers very rarely use the coconut leaves for certain event, e.g. wedding party. Due to the influence of lifestyle modernization, local villagers decorate the certain event using trinkets made from colourful paper that is sold in the accessories shop for wedding party.	Low

4.3 PRIORITY ECOSYSTEM SERVICES

The following priority ecosystem services shown in ***Table 4-3*** have been identified and will be assessed against the impact assessment procedures.

Table 4-3 Priority ecosystem services

Priority Ecosystem Service	Description
Freshwater	Evidence suggests that freshwater is used by local people from within the Project Area and AoI for irrigation system and micro-hydro development. The project may restrict or impact this activity. Impacts from the project activities may likely impact downstream due to utilization of river water, especially during the dry season due to decrease of water flows.
Erosion regulation	Evidence suggests that Rantau Dedap Project area of AoI has regulating erosion on slopes and riparian areas in the vicinity. The careful efforts in erosion control can provide stability to the slopes to reduce the chance of land slips and erosion. The land clearing and other related project activities might potentially change the river sedimentation and occurrence of erosion.

5. MITIGATION TO REDUCE IMPACTS ON THE PRIORITY ECOSYSTEM SERVICES

5.1 APPROACH

In a mitigation context, rigorous functional ecosystem services (ES) impact assessments focus not only on how supply is disrupted but also on how the delivery of services will be impacted over the lifetime of the project, and how much those changes are likely to matter to people (value). At the mitigation stage, ERM identifies options through the mitigation hierarchy to enhance or at least maintain: (1) the well-being affected beneficiaries derive from ecosystem services and (2) the performance the project derives from ecosystem services at acceptable levels.

Based on the WRI Guidelines, service mitigation measures inform project design and operations and are incorporated into the environmental and social management plans. Once ecosystem service-specific mitigation measures are identified, ensure there are no conflicts between these mitigation measures and the ones identified independently by the environmental and social practitioners.

5.2 PROPOSED MITIGATIONS

For freshwater, water-related ES that depend on catchment-scale hydrologic functions must be mitigated within the same catchment (serviceshed) to provide the same benefits to the same people. Serviceshed is determined by the area that supports biophysical service production, and allows beneficiaries both physical and institutional access to the service. If there is no biophysical supply of a service (e.g. no water purification taking place, no fish that can be caught, no forest views to enjoy), then there is no benefit. If formal (laws, regulations) or informal (social norms, cultural practices) institutions restrict beneficiaries' ability to access the biophysical supply, then there is no benefit. Institutions that limit or promote access can be very diverse, and can include protected areas, irrigation rights, land tenure, traditional rights, hunting or fishing seasonal closures, and many others.

On erosion regulation, geothermal development may be accomplished with minimal mass soil movement problems, if development sites and roads are located and constructed with full consideration of the problems involved.

The following ***Table 5-1*** indicates the mitigation actions proposed for the SERD project to reduce impacts on the priority ecosystem services:

Table 5-1 Mitigations Proposed for the SERD project to reduce impacts on the priority ES

Priority Ecosystem Services	Affected Stakeholder	Predicted Impacts on Ecosystem Service Benefit	Mitigation Measures (minimization)
Freshwater	Local villagers	Reduced water quantity and quality due to water utilization* by the SERD project where local villagers use the freshwater for hygiene activities and development of micro-hydro power.	- Freshwater use impacts can be reduced by utilizing dry cooling or by using non-freshwater sources as a cooling medium[11]. A non-freshwater sources such as utilization of groundwater; - Freshwater use impacts can be reduced by utilizing groundwater source for washing and bathroom facilities
Erosion Regulation	Local villagers	Sediment carried in waters drained from roads and also soil sedimentation** includes damage to provisioning value streams or rivers.	- Road and trail construction will not block drainage systems or water courses. Culverts or other suitable crossings will be installed in drainages, and roads will be drained or water barred as necessary to prevent erosion; - All roads planned for permanent or long-term use will be adequately gravelled or paved; - Roads, well pads, building and associated structured will be located and designed to require minimum earth movement for their construction; - All disturbed areas will be seeded, mulched, and fertilized for adequate protection from rain and run-off. Where feasible, native vegetation will be included in the prescription to restore the natural setting and to take advantage of normal ecological relationships; - Adequate erosion control and drainage measures will be required on disturbed sites to minimize soil movement and sedimentation of water courses.

*water utilization by the SERD project in smaller quantities, water may be needed on a temporary basis for well field development for things such as dust suppression, drilling fluid, and reservoir stimulation. Small amounts of water may also be needed for washing and bathroom facilities for the power plant. In some cases, most geothermal plants can use either geothermal fluid or freshwater for cooling.

**soil erosion impacts can be expected from clearing and earth movement activities associated with construction of building, well sites, pipelines, transmission lines, and roads.

[11] https://www.nrel.gov/docs/fy11osti/50900.pdf

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Annex F

Aquatic Ecosystem Assessment (ERM Dec 2017)

Fish and Macroinvertebrates Rapid Assessment in the SERD (South Sumatra) and the SEML (West Sumatra)

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Fish and Macroinvertebrates Rapid Assessment in the SERD (South Sumatra) and the SEML (West Sumatra)

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EXECUTIVE SUMMARY

The surveys in PT Supreme Energy Rantau Dedap (SERD) and PT Supreme Energy Muara Labuh (SEML) area have been done from 2th December until 4th December 2017 and 6th - 8th December 2017. The survey collected two types of fresh water fauna biodiversity, Fish and Macroinverterbrates. Total 15 sites were surveyed in both of Supreme Energy area, consist of eight sites in SERD and seven site in SEML. There are 10 Species of Fishes, include in five Family documented. In Muara Labuh, there are four species of Cyprinidae, one species of Poeciliidae, and two species of Sisoridae. In Rantau Dedap, there are two species of Balitoridae, two species of Cyprinidae and one species of Cichlidae. Species founded in both area were *Barbodes* cf *banksi* and *Tor douronensis*. The common species in Rantau Dedap was *Glyptothorax platypogon.* The other species with small number were *Tor tambroides, Xiphophorus hellerii* and *Glyptothorax platypogonides.* In Muara Labuh, the dominan species were *Homalopterula* cf. *gymnogaster* _1 and *H.* cf. *gymnogaster* _2 which is an endemic Sumatra. In addition, there was *Oreochromis niloticus* collected.
The macroinvertebrates result shows that the stream ecosystem in the SERD region is relatively undisturbed, the quality of clean water indicated by the number of genera of each river is high relatively ranges from 23-34 genera with the number of individuals range from 91 to 295 individuals, the genera diversity index ranges from 1.92 -2.94 is moderate and the water quality is classified as clean. The presence of genera in each river varies. Genera found in all streams are the *Centroptilum, Neoperla, Hydropsyche,* and *Pseudocloeon. Anthocha, Baetis, Phagocata* are not found in one river. The predominant macroinvertebrate genera are: *Centroptilum, Pseudocloeon*, *Nemouraelmis, Stenelmis, Simulium, Anthocha, Neophylax, Hydropsyche* and *Psychomya*. The stream ecosystem in the SEML region also relatively undisturbed, the quality of clean water indicated by the number of genera of each river is high relatively ranges from 19-27 genera with the number of individuals range from 95 to 206 individuals, the genera diversity index ranges from 2,00 -2, 59 is moderate and the water quality is classified as clean. The presence of genera in each river varies. Genera found in all streams are the *Centroptilum, Nemura, Hydropsyche,* but *Simulium* are not found in one river. The predominant macroinvertebrate genera are: *Simulium, Centroptilum, Pseudocloeon*, *Nemura, Orthocladinae, Hydropsyche, Neophylax* and *Melanoides*.
One genus of crab *Parathelphusa maculata* founded in SERD and SEML. That species recorded as Least Concern (LC) in the IUCN Red List.

Keywords: Fish, macroinvertebrate, diversity index, Supreme energy

I. INTRODUCTION

Biodiversity refers to the term for the degree of nature's variety or variation within the natural system, both in number and frequency. The manifestation of biodiversity are the biological resources (genes, species, organisms, ecosystems) and ecological processes of which they are part (Mutia, 2009). The variety of species are measured in term of *Species Richness* and *Species Abundance*. *Species Richness* is the total count/number of species in a defined area. While *Species Abundance* is refers to the relative numbers among species (Rawat & Agarwal, 2015).

In the level of species, the same species often show differences in phenotypic characters and may also include genetic characteristics if living under different ecological conditions

(Moyle & Cech, 2000). Keeley, Parkinson & Taylor (2005) suggest that the differences in characters that appear in response to habitat conditions will increase the variation and differentiation that can lead to speciation, especially in conditions of disconnected of gene flow between populations. There for in the future, it also important to monitor their genetic diversity.

Human activity for the purpose of harvesting natural resources for industry production and urbanization is often destroyed the natural habitats. Clearing forest areas, mining, logging, urban sprawl, construction of highways are some examples of habitat destruction and fragmentation (Agarwal et al, 2014 and Rawat & Agarwal, 2015).

PT SERD and PT SEML are Joint Ventures of Supreme Energy, Engie and Marubeni to develop a geothermal power plant with an installed capacity of 80MW. The SERD project is located in occurs within two regencies (Muara Enim and Lahat) near Pagar Alam in South Sumatra Province. The SEML project is located in Muara Labuh in Solok Selatan Regency, West Sumatra Province. Both projects consist of wellpads and interconnecting pipelines to supply steam to a power generator. A switch yard and transmission line network is also associated with the Project. Geologically, areas are located in the Barisan Mountains Zone or exactly in the active fault zone of the Great Sumatra Fault (GSF). Geomorphology of Rantau Dedap geothermal development area is dominated by volcanic mountains. This prospect hydrological concept consists of the catchment areas in volcanic mountains that have a height of 1700 - 2600 m above sea level. Consider most locations geothermal activity by PT SERD located in protected forest areas, the conservation of water catchment areas in protected forest areas need attention. PT SEML is located along the Sumatra fault system. Two geothermal sources extend along 50 km of the Sumatra fault zone, namely North Muara Labuh and South Muara Labuh. Both geothermal sources have different geothermal and recharge sources, although hydrologically interconnected with each other.

The presence of geothermal power plant project may alters river conditions, reduces connectivity, and blocks access to upstream areas with high quality habitat, abundant prey, and fewer predators. That area is often blamed for population declines of migratory fishes. According to Chaudhuri (2005), the availability of data and specific detailed information about the biodiversity of fish in various types of aquatic ecosystems is indispensable as a basis for freshwater fisheries habitat management on an ongoing basis. In other to anticipate losing diversity of fish fauna in the area to be developed in the construction of Geothermal Power Plant in SEML and SERD zones, research is conducted through a rapid assessment activities. The aim of the research is to collect, to record and to study diversity of fish species present in the rivers in that area, as a baseline data within the project zone which can to be useful for aquatic resources management of this area in the future.

Aquatic macroinvertebrates has a role as indicators of water quality. Different types of macro invertebrates tolerate different stream conditions and levels of pollution. Depending on the types of macro invertebrates found in a stream, predictions about water quality can be made. Aquatic macro invertebrates are also an important part of aquatic and terrestrial food chains. They graze on algae and break down leaves and sticks that fall into the water. They are also an important food source for fish. Macroinvertebrates samples collection able to estimate water conditions as ecologically. Population estimation, diversity, composition

and community structure of macro invertebrates able to show the description of the environment and carrying capacity in that location. (Michael, 1984; Wallace and Webster, 1996).

II. METHODOLOGY

Sampling methodology and Study area:

II.1. Sampling methodology of Fish:

Total 15 sites were surveyed in both of Supreme Energy area, consist of eight sites in SERD and seven site in SEML by following standard procedures according to Cailliet et al. (1986) using fish net and backpack electrofishing gear (12 Volt). Sampling of every available location was done in one-two hour. The characteristics of sample obtained such as body color, color fins that may be lost or changed after death will photographed. Then, samples will preserved with formaldehyde 4-10 % in plastic box during in the field and then wrap in gauze bandage when transported and taken to the laboratory. In the laboratory, all specimen preserved later in 70% ethanol. Taxonomic studies, count and measurement are based on Hubb and Lagler (1947). Measurement were made by using Vernier caliper. Classification and identification follow those texts written by (Weber & Beaufort, (1916), Roberts (1989), Kottelat et al. (1993), Kottelat & Whitten (1996), Kottelat (2013) etc. All specimens are deposited in Andalas University Museum. Upon each sampling location, the composition of riparian vegetation, river substrate, type of water level, current (using a buoy), water clarity (using a Secchi Disk), and temperature will recorded. Local weather, date, time of day, location, stream channel conditions also recorded.

II.2. Sampling metodhology of Macroinvertebrates

The sampling of Aquatic macroinvertebrate was done in six streams around the SEML Project and seven streams around the SERD Project. The sample was collected using Surber Sampling Method (with 30 cm x 30 cm in size). The sampling area in each stream is determined along 100 m which represents the characteristics of the stream. The samples collected from productive area (area most likely inhabited by macroinvertebrates) such as riffle, pool, run, leaf pack, stream margin with vegetation within the 100 m reach of the stream. Sample with a Surber net by holding the net frame firmly against the stream bottom and disturbing the substrate with our hand or digger. Dig deeply into the substrate with digger to dislodge macro invertebrates from the streambed. The macro invertebrate collected in a bottle or plastic pack and preserved by formaldehyde 4% (Michael, 1984). Sampling begins at the downstream and proceeds to the upstream. In each stream collected tree sample with Surber net on the rocky substrat is approximately faunal diversity in the area. The Surber net place on the bottom of stream with the mouth facing upstream, 20-30 cm depth. All the stone in the square are pick up and remove into the bucket. The remaining substrate in the square is disturbed by garden trowel. Dislodge organisms are washed in to the net. The stone brushed in the bucket is fill with the sufficient water to cover stone by using stiff bristle brush to release the organisms. Macroinvertebrate were filter with 250 mikron mesh sieve. The material leaf in the filter removed to jar and water added sufficiently. Preserved with 40 % formalin aranged to the concentration of the solution in the sample bottle to 5 %. Hand collection is also done that are animal not caught with the net will be found in this way. Five stone are rather large, flat and rough surface selected. The animals attached to the stone are taken with tweezers or removed with a wire brush.The

sample collected from leaf pack and steram margin with vegetation. The debris rinsed and inspected, then filtered with the same screen. The sample place into the jar. Enviroment data recorded such as: instream features, width, depth, current velocity, substrat type, water temperature, pH, riparian vegetation, aquatic vegetation.

II.3. Data Analysis

Estimation for Fih and macroinvertebrates diversity was doing with by Shannon-Wiener Diversity index:

$$H' = -\sum_{n=1}^{s} pi \ln pi$$

Where:

H' = Shannon-Wiener diversity index
Pi = ni/N
ni = Number individual of one genus
N = Total number of all individuals in the sample

II.4. Locations Surveyed

Table.1. Position of the sampling site in SERD

No.	Site Code	Stream	Position	Altitude
1	SERD 1	Indikat	S-04^{0}12'02,6" E-103^{00}27'39,7"	1500 m asl
2	SERD 2	Cawang Kiri	S-04^{0}12'48,9" E-103^{0}24'39,7"	11746 m asl
3	SERD 3	Cawang Tengah	S-04^{0}11'45,9" E-103^{0}24'29,4"	1439 m asl
4	SERD 4	Asahan	S-04^{0}11'43,7" E-103^{0}25'537,8"	1572 m asl
5	SERD 5	Cawang Kanan Hulu	S-04^{0}13'13,1" E-103^{0}22'34,5"	2097 m asl
6	SERD 6	Cawang Kanan	S-04^{0}12'33,9" E-103^{0}23'48,1"	1699 m asl
7	SERD 7	Muara Cawang	S-04°10'34,3"S E-103°23'35,1"	1178 m asl
8	SERD 8	Indikat Hilir	S-04°10'47,3" E-103°25'36,46"	1349 m asl

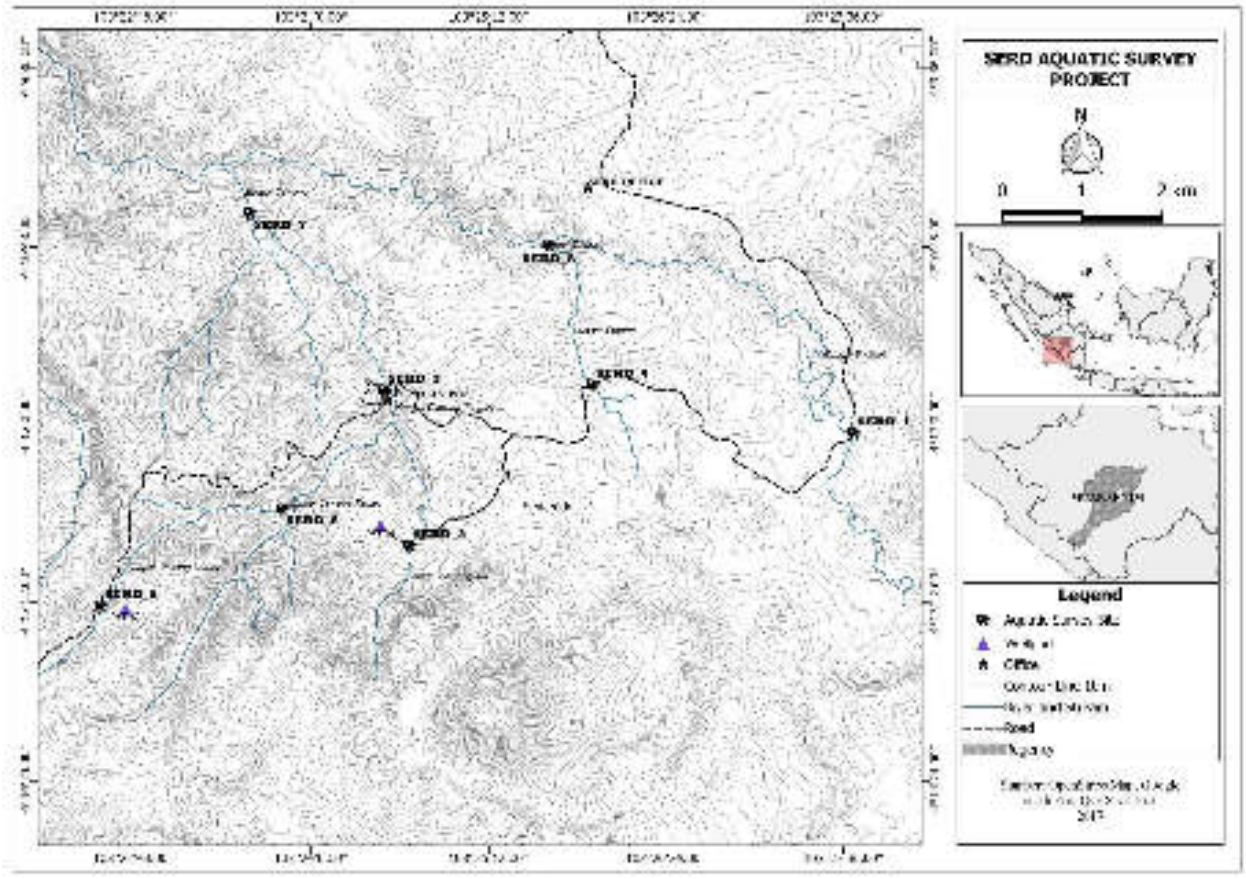

Figure 1. Location of sampling site in SERD

Table.2. Position of the sampling site in SEML

No.	Site Code	Streams	Position	Altitude
1	SEML 1	Bangko Hitam	S-01^{0}37'56,5" E-101^{00}7'40,1"	1455 m asl
2	SEML 2	Bangko Keruh	S-01^{0}36'39,4" E-101^{0}07'48,7"	1162 m asl
3	SEML 3	Muara S. Bangko Putih	S-01^{0}36'12,8" E-101^{0}07'34,0"	1055 m asl
4	SEML 4	Bangko Putih	S-01^{0}38'07,4" E-101^{0}08'07,9"	1439 m asl
5	SEML 5	Liki	S-01^{0}36'26,2" E-101^{0}09'02,4"	1003 m asl
6	SEML 6	Bangko	S-01^{0}36'31,1" E-101^{0}07'14,2"	1090 m asl

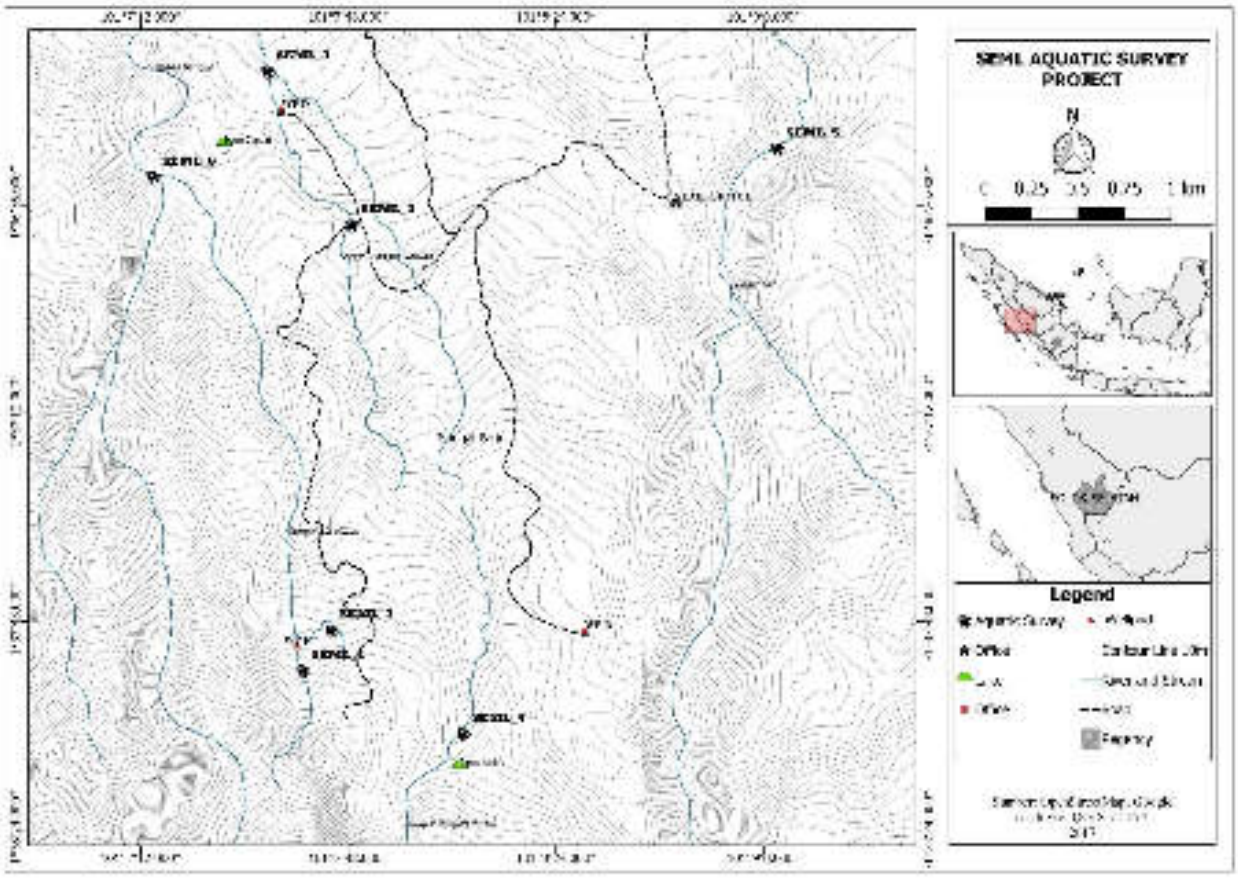

Figure 2. Location of sampling site in SEML

III. RESULT and DISCUSSION

III. 1. *An Overview* of *All Surveyed Locations*

The survey were conducted in two sites of Supreme Enegy, Supreme Energy Rantau Dedap (SERD) and Supreme Energy Muaro Labuah (SEML). The survey collected two types of fresh water fauna, Fish and Macroinverterbrata. Total 15 sites were surveyed in both of Supreme Energy area, consist of 8 sites in SERD and 7 site in SEML. The surveyed focused to the stream and river system around the Supreme Energy Company. The sampling started on 2th December until 4th December 2017 and 6th -8th December

Survey Site Description

III.1.1 SERD (Supreme Energy Rantau Dedap)

a. SERD 1

Sungai Endikat was the first surveyed site (2nd December 2017;10:45 WIB). The river has cascade type, this survey was conducted in geographical position -04°12'02,6" S and 103°27'39,7" E with elevation 1500 meter asl, width of the river 10-18 meter, a depth about 0,5-2 meter, water temperature measured was 18 °C, air temperature 24 °C, humidity 79%, velocity of river flow 0,93 m/s, pH 7, water transparency classified as turbid and cloudy weather when the survey did.This survey site lied between edge of secondary forest and

plantation. The vegetation dominated by shrubs, trees and ferns. On the right site of the river was the highly plantation activity like coffees, bananas and gourds.

b. SERD 2

Sungai Cawang Kiri was the third surveyed site (2nd December 2017; 16.20 WIB). The sites classified as stream, there were no fish has been cactched on this stream, the surveyed site closely by shortcut and road and the stream has lots of rapids. The geographical position are 04°12'48,9" S and 103°24'39,7" E, it's altitude is 1746 meter asl. The water was clear, have rocks, sand and stones substrate, 0,311 flow velocity m/s, humidity 85%, the width of the river 2-5 m, a depth about 50-100 cm, stream water ph 7. Water temperature measured was 18,5 ^{o}C. It was cloudy at the time. The vegetation around river are shrubs trees, ferns etc. This stream far from human activity.

c. SERD 3

Sungai Cawang Tengah was the fourth site that surveyed (3rd December 2017; 08.50 WIB)
The river has cascade type, has shortcut with the height 3 meters, so many rapids on this stream. This survey was conducted in geographical position 04°11'45,9" S and 103°24'29,4"E with elevation 1500 meter asl, width of the river was 3-10 meters, a depth about 1-2 meter, water temperature measured was 18 ^{o}C and air temperature was 20 ^{o}C, humidity 81%, velocity of river flow 0,327 m/s, pH 7, the water was clear. Substrates composed of rocks, sand and stones. The weather cloudy when the survey did.This survey site lied between edges of secondary forest. No fish catched from this site. The vegetation dominated by shrubs, trees and ferns. Low intensive of human activites along the river, but in the some sites showed the river excavation was did.

d. SERD 4

Sungai Asahan was the second surveyed site (2nd December 2017; 14:43 WIB)
The river has cascade type, has shortcut with the lenght about 15 meters, so many rapids on this stream especially in down stream. This survey was conducted in geographical position 04°11'43,7"S and 103°25'53,8"E with elevation 1572 meter asl, width of the river 2-3 meters, a depth about 0,5-2 meter, water temperature measured was 20 ^{o}C, air temperature was 21,5 ^{o}C, humidity 75%, velocity of river flow 1,63 m/s, pH 7. The water was clear. Substrates composed of rocks, sand and stones. The weather was cloudy when the survey did.This survey site located between edges of secondary forest. The vegetation dominated by shrubs like graminae, leguminoceae, trees and ferns. Low intensive of human activites along the river.

e. SERD 5

This site known as sungai Cawang Kanan Hulu was the fifth surveyed site (2nd December 2017; 10.30 WIB). The river has cascade type, has shortcut with the lenght about 20 meters, so many rapids on this stream especially in down stream. This survey was conducted in geographical position 04°13'13,1" S and 103°22'34,5" E with elevation 2097 meter asl. This river has 2-6 meters width, a depth about 0,5-2 meter, water temperature measured was 15 ^{o}C, air temperature was 21 ^{o}C, humidity 73%, velocity of river flow 0,377 m/s, pH 6,5, the water was clear with rocks, sand and stones as the substrates. It was cloudy weather when the survey did. This survey site located between edges of secondary forest. No fish catched

from this site, the vegetation dominated by shrubs like graminae, mosses, trees and ferns. Highly human activities and disturbance especially a pool for intac and shortcut.

f. SERD 6

This site known as sungai Cawang Kanan was the sixth surveyed site (3rd December 2017; 15:00 WIB). The river has cascade type, so many rapids on this stream especially in up and down stream. This survey was conducted in geographical position 04°12'33,9"S and 103°23'48,1" E with elevation 1699 meter asl, width of the river was 3-7 meters, a depth about 0,3-1,5 meter, water temperature measured was 18 °C, air temperature was 21 °C, humidity about 78%, velocity of river flow 0,345 m/s, pH 7, the water was clear with rocks, sand and stones as the substrates. It was sunny at the time.This survey site is secondary forest. No fish catched from this site, the vegetation dominated by trees, shrubs like graminae, mosses, trees and ferns.

g. SERD 7

Sungai Muara Cawang was the seventh surveyed site (4th December 2017; 08:54 WIB)

This study site is a confluence of all of the Cawang rivers and a small stream, the river has cascade type, so many rapids on this stream especially in up and down stream. this survey was conducted in geographical position 04°10'34,3"S and 103°23'35,1" E with elevation 1178 meter asl, width of the river was 8-12 meters, a depth about 0,1-1,5 meter, water temperature measured was 21 °C, and air temperature was 22 °C, humidity 96%, velocity of river flow was 0,335 m/s, pH 7, the water was clear. Substrates composed of rocks, sand and stones. The weather was cloudy when the survey did. This survey site located between plantation and vegetation dominated by shrubs, coffee, *Micania micranta, Piper aduncum*, graminae, small trees and ferns. Local people said taht the river was flooded seven years ago, and the flooded influenced the existence of fish and macroinvertebrata.

h. SERD 8

This site known as Sungai Endikat, the last surveyed site (4th December 2017; 14:15WIB)

This study site is a confluence of the Asahan stream and Endekat river, the river has cascade type and so many rapids.This survey was conducted in geographical position 04°10'47,3" S and 103°25'36,46" E with elevation 1349 meter asl, width of the river was 7-26 meters, a depth about 1-3 meter, water temperature measured was 19 °C, air temperature was 20 °C, humidity 87%, pH 7, the water is turbid. Substrates composed of rocks, sand and stones.The weather was cloudy when the survey did.This survey site lied between plantation and vegetation dominated of shrubs, bambos, trees *Micania micranta, Piper aduncum*,graminae, small trees and ferns.

III.1.2. SEML (Supreme Energy Muaro Labuah)

a. SEML 1

Sungai Aia hitam was the sixth surveyed site in Muara Labuah. The suvey was started in 8th December 2017 at 09:07 WIB. The river has cascade type, so many rapids on this stream especially in up and down stream. This survey was conducted in geographical position 01°37'56,5"S and 101°07'40,1" E with elevation 1455 meter asl, width of the river was 1-3 meters, a depth about 0,1-1 meter, water temperature measured was 17 °C, and air temperature 18 °C, humidity 81%, velocity of river flow 0,33 m/s, pH 7, the water is clear.

Substrates composed of rocks, sand and stones. The weather was sunny when the survey did. This survey site have any intac and human disturbance, especially for well pad operation. The vegetation dominated by small trees, shrubs like graminae, and ferns, etc.

b. SEML 2

Sungai Bangko Karuah was the fourth surveyed in Muara Labuah. The suvey was started in 7th December 2017 at 14.21WIB. The site has shortcut and small waterfall. This survey was conducted in geographical position 01°36'39,4"S and 101°07'48,7" E with elevation 1162 meter asl, width of the river was 1-5 meters, a depth about 01-0,5 meter, water temperature measured was 24 °C and air temperature 25 °C, humidity 77%, velocity of river flow 0,364 m/s, pH 7, the water is not fully clear, rocks, sand, stones as the substrates, there are some pools. It was sunny when the survey did. This survey site has human disturbance, especially for plantation and agricultural activities. The vegetation dominated by small trees, shrubs like graminae, and ferns, etc.

c. SEML 3

Sungai Bangko Putiah was the fifth surveyed site in Muara Labuah. The suvey was started in 7th December 2017 at 16.4WIB.

Different with the sites before, the river is a lower course of the Bangko karuah and Aia putiah, when the the surveyed did, the water was muddy caused the activities in up river. The stream has intensively for distrurbance and fluctuatif, when the rainy season the river will be flood and when the dry, the water will be lost. The site has shortcut and bridge. This survey was conducted in geographical position 01°36'12,8 S" and 101°07'34,0" E with elevation 1055 meter asl, width of the river 5-8 meters, a depth about 0,4-1 meter, water temperature measured was 20 °C, air temperature was 19 °C, humidity 92%, velocity of river flow 0,568 m/s, pH 6,5, the water is not fully clear. Rocks, sand, stones were the substrates of the river. There were some pools. It was sunny weather when the survey did. The vegetation dominated by trees, shrubs like graminae, and ferns, etc.

d. SEML 4

Sungai Bangko Jernih was the second surveyed site in Muara Labuah. The suvey was started in 7th December 2017 at 09:24 WIB.

The river has cascade type, there are many rapids on this stream in up and down stream. This survey was conducted in geographical position 01°38'07,4"S and 101°08'07,9"E with elevation 1439 meter asl, width of the river was 10-15 meters, a depth about 0,5-2 meter, water temperature measured was 15,5°C and air temperature was 18°C, humidity 81%, velocity of river flow 0,54 m/s, pH 6, having rocks, sand and stones substrates. The weather was sunny when the survey did. This survey site lied in secondary forest, far for human disturbance, especially for plantation. The vegetation dominated by trees, graminae, mosses and ferns, etc.

e. SEML 5

Sungai Liki is the first surveyed site in Muara Labuah. The suvey was started in 6th December 2017 at 14.03 WIB.

The river has cascade type, so many rapids on this stream especially in up and down stream. Upstream has any waterfall. This survey was conducted in geographical position

01°36'26,2"S and 101°09'02,4"E with elevation 1003 meter asl, width of the river 5-20 meters, a depth about 0,5-1,5 meter, water temperature measured was 19°C, air temperature was 22°C, humidity 84%, velocity of river flow 0,678 m/s, pH 7, the river had clear water and rocks, sand and stones substrate. The weather was sunny when the survey did. This survey site has human disturbance, especially for plantation. The vegetation dominated by small trees, shrubs like graminae, and ferns, etc.

f. SEML 6

Sungai Bangko was the last surveyed site in Muara Labuah. The suvey was started in 8th December 2017 at 14:50 WIB.

The river has cascade type, so many rapids on this stream in up and down stream. This survey was conducted in geographical position 01°36'31,1"S and 101°07'14,2"E with elevation 1090 meter asl, width of the river was 6-10 meters, a depth about 0,1-1 meter, water temperature measured was 20 °C, air temperature was 23 °C, humidity 92%, velocity of river flow 0,657 m/s, pH 6,5, have rocks, sandy and stones substrate and bright cloudy weather when the survey did. The vegetation dominated by trees, coffees, bananas graminae, mosses and ferns, etc.

g. SEML 7

This site was a small stream that closely by sungai Aia hitam. The suvey was started in 8th December 2017 at 08:36 am.

The river has cascade type has small waterfall and so many rapids on this stream in up and down stream. This survey was conducted in geographical position 01°37'49,5 S" and 101°07'45,0" E with elevation 1467 meter asl, width of the river was 1-2 meters, a depth about 0,1-0,5 meter, water temperature measured was 18°C, air temperature was 22°C, humidity 87%, pH 6,5, having rocks, sand and stones substrate. It was sunny weather when the survey did. This survey site lied in secondary forest, but it was close well pad activity, and any intac or pools was build for that. The vegetation dominated by trees, coffees, graminae, ferns, etc.

III.2. Fish and Macroinvertebrate diversity

III.2.1. Fish diversity

Survey that has been done around PT Supreme Energy Rantau Dedap (SERD) and PT Supreme Energy Muara Labuh (SEML) documented 10 Species, include in five Family. There are three Family got in Muara Labuh, including Cyprinidae (four species), Poeciliidae (one species), and Sisoridae (two species). Family founded in Rantau Dedap consist of Balitoridae (two species), Cyprinidae (two species) and Cichlidae (one species). Species founded in both locations were *Barbodes* cf *banksi* and *Tor douronensis.* The common species found in Rantau Dedap was *Glyptothorax platypogon.* Furthermore, other species got in small number were *Tor tambroides, Xiphophorus hellerii* and *Glyptothorax platypogonides.* In Muara Labuh, species collected in large number were *Homalopterula* cf. *gymnogaster* _1 and *Homalopterula* cf. *gymnogaster* _2. In addition, there was *Oreochromis niloticus* collected.

Actually, according to the villagers there are several Fish in Liki River like *Hampala macrolepidota*, *Barbodes*, *Tor*, *Glyptothorax*, *Homalopterula*, *Channa* and *Hemibgrus*. Unfortunately, in our rapid assessment we couldn't find all of them.

In this report, we named *Barbodes* cf. *banksi* because of the previous study (Roesma, 2017 in press) reported that there are variation in Sumatra *Barbodes banksi*, both at morphological and molecular levels with the sequence divergence up to 8.3% for CO1 gene. We need to analize the *Barbodes* samples from SERD and SEML morphologically and molecularly. We also write in this report that there was a *Tor* sp in SERD 8 (Endikat Hilir River), we need to check it further for those seven small samples.

Table 3. Fish Species Collected at PT. Supreme Energy Rantau Dedap (SERD)

No.	Scientific name	Vernacular name	status	Locality
A.	**Family : Cyprinidae**			
1	*Barbodes* cf *banksi* (Herre, 1940)	Spotted barb	NE	SERD-1, SERD-7, SERD-8
2	*Tor douronensis* (Valenciennes, 1842)	Semah mahseer	NE	SERD-1, SERD-7
3	*Tor tambroides* (Bleeker, 1854)	Thai mahseer	DD	SERD-8
4	*Tor* sp	-	Ni	SERD-8
B.	**Family: Poeciliidae**			
1	*Xiphophorus hellerii* Heckel, 1848	Green swordtail	NE	SERD-1
C.	**Family: Sisoridae**			
1	*Glyptothorax platypogon* (Valenciennes, 1840)	Brauner Gebrigwels	NE	SERD-1, SERD-4, SERD-8
2	*Glyptothorax platypogonides* (Bleeker, 1855)	Spotted barb	NE	SERD-1, SERD-4

Note: SERD-1= Sungai Endikat, SERD-4=Sungai Asahan, SERD-7=Sungai Cawang, SERD-8=Sungai Endikat Hilir. DD= Data Deficient, NE= Not Evaluated in IUCN Red List, Ni=could not compare to IUCN because inadequate data.

Table 4. Fish Species Collected at Supreme Energi Muara Labuh (SEML)

No.	Scientific name	Common name	Status	Location
A.	**Family: Balitoridae**			
1	*Homalopterula* cf. *gymnogaster* _1	-	Ni	SEML-1, SEML-2, SEML-5, SEML-6, SEML-7
2	*Homalopterula* cf. *gymnogaster* _2	-	Ni	SEML-1, SEML-2, SEML-3, SEML-5, SEML-6, SEML-7
B.	**Family: Cyprinidae**			
1	*Barbodes* cf *banksi* (Herre, 1940)	Spotted barb	NE	SEML: 2,3,5,6
2	*Tor douronensis* (Valenciennes, 1842)	Semah mahseer	NE	SEML: 5
C.	**Family: Cichlidae**			
1	*Oreochromis niloticus* (Linnaeus, 1758)	Nile tilapia	NE	SEML: 7

Note: SEML-1=Sungai Aia Hitam, SEML-2=Sungai Bangko Karuah., SEML-3=Sungai Bangko Putiah, SEML-5=Sungai Liki, SEML-6=Sungai Bangko, SEML-7=Sunagi Anak Aia Hitam. NE= Not Evaluated in IUCN Red List, Ni=could not compare to IUCN because inadequate data.

Table 5. Number of Individu per species collected at PT. Supreme Energy Rantau Dedap (SERD)

Spesies	SERD -							
	1	2	3	4	5	6	7	8
Barbodes banksi (Herre, 1940)	9						6	1
Glyptothorax platypogon (Valenciennes, 1840)	3			7				4
Glyptothorax platypogonides (Bleeker, 1855)	1			1				
Tor douronensis (Valenciennes, 1842)	5						2	
Tor tambroides (Bleeker, 1854)								1
Tor sp								7
Xiphophorus hellerii Heckel, 1848	1							
Total individu	19	0	0	8	0	0	8	13

Table 6. Number of Individu per species collected at PT. Supreme Energy Muara Labuh (SEML)

Spesies	SERD -						
	1	2	3	4	5	6	7
Barbodes cf *banksi* (Herre, 1940)		22	3		12	15	
Homaloptera cf. *gynogaster_1*	3	2			18	23	5
Homaloptera cf. *gynogaster_2*	13	10	5		8	22	11
Oreochromis niloticus (Linnaeus, 1758)							1
Tor douronensis (Valenciennes, 1842)					1		
Total Individu	16	34	8	0	39	60	17

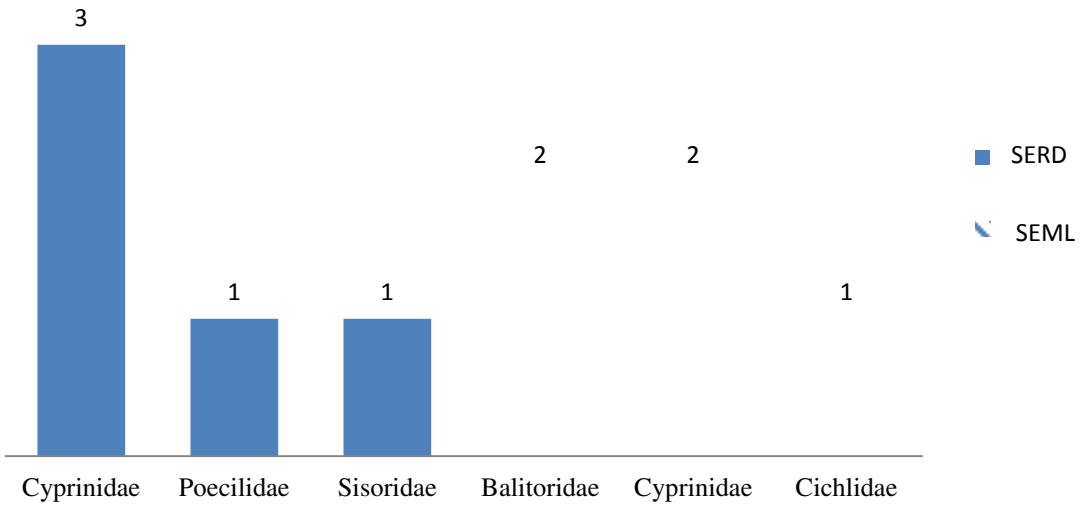

Figure 3. Number of Species per Family in both location.

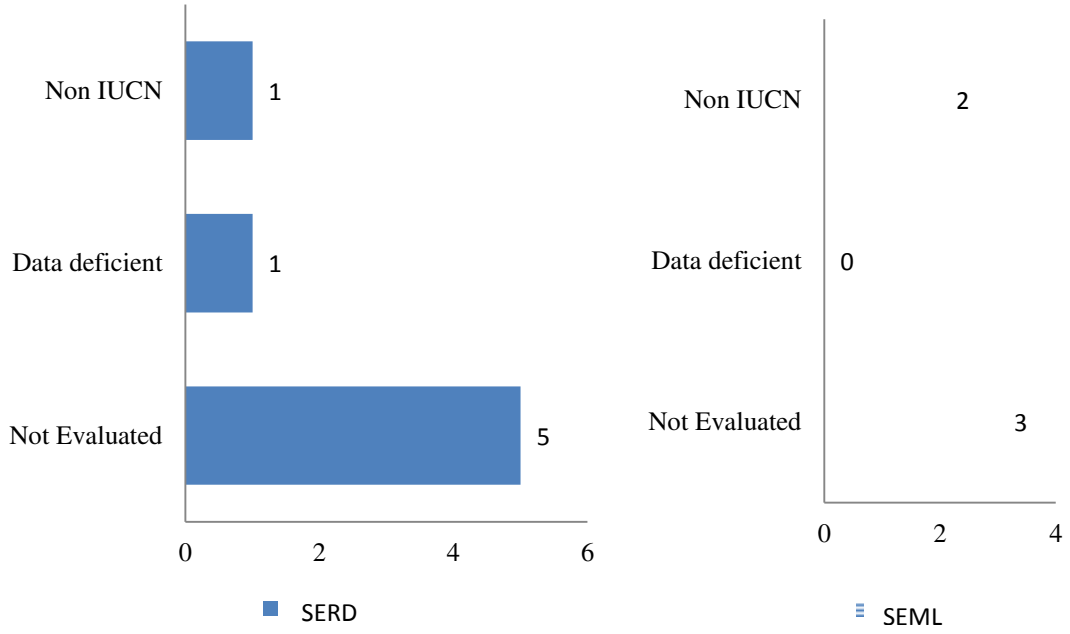

Figure 4. Number of species collected in Rantau Dedap and Muara Labuh according to IUCN conservation status.

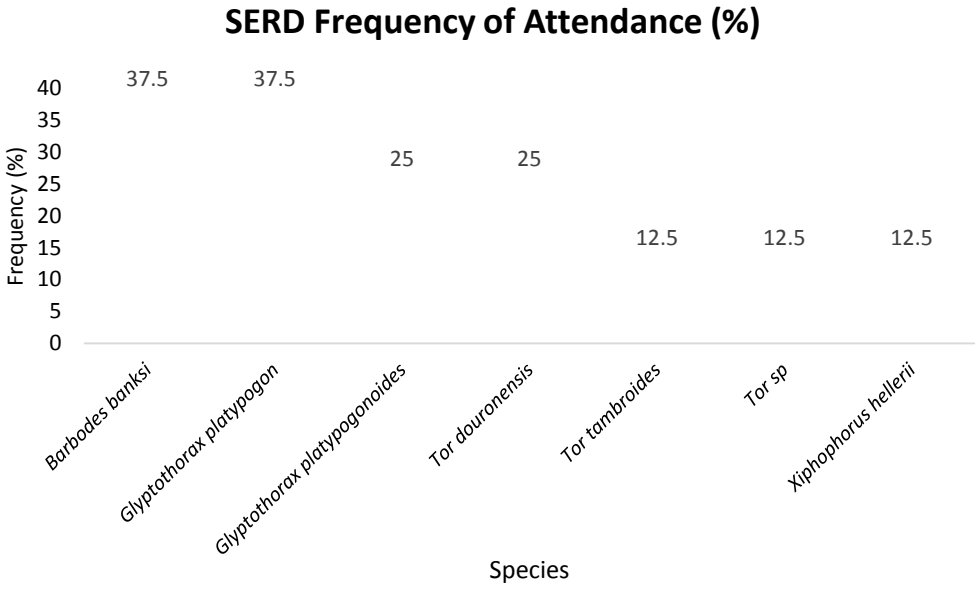

Figure 5. Frequency of attendance of fishes in SERD

The Figure 5 shows that the highest of Fish frequency in SERD (Supreme Energy Rantau Dedap) were *Barbodes* cf. *banksi* and *Glyptothorax platypogon* (F: 37,5). Followed by *Glyptothorax platypogonides* and *Tor douronensis* (F:25). *Tor tambroides, Tor* sp., *Xophophorus hellerii* were the lowest frequency (F: 12,5). While Figure 6 shows the diversity index. The Shannon-Weiner Index showed the highest of the diversity is SERD-1(H':1,19) , followed by SERD-8 (H':1,09), SERD-7 (H':0,56), and SERD-4 (H':0,3). SERD-4 and SERD-7 classfied as low diversity. In otherwise, SERD-2, SERD-3, SERD-5, SERD-6 set as uncategorized index becaused there is no one fish catched from the site.

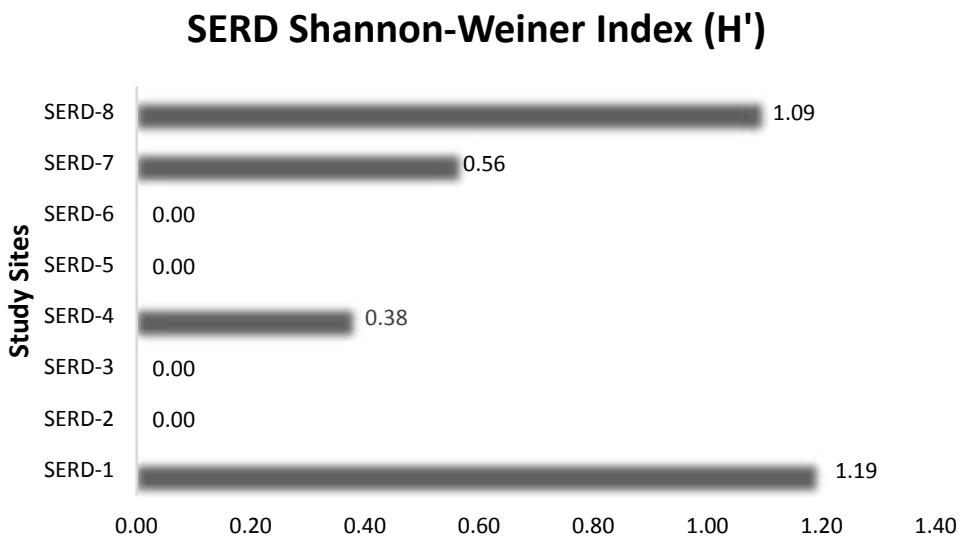

Figure 6. Shannon-Wiener species diversity in the SERD

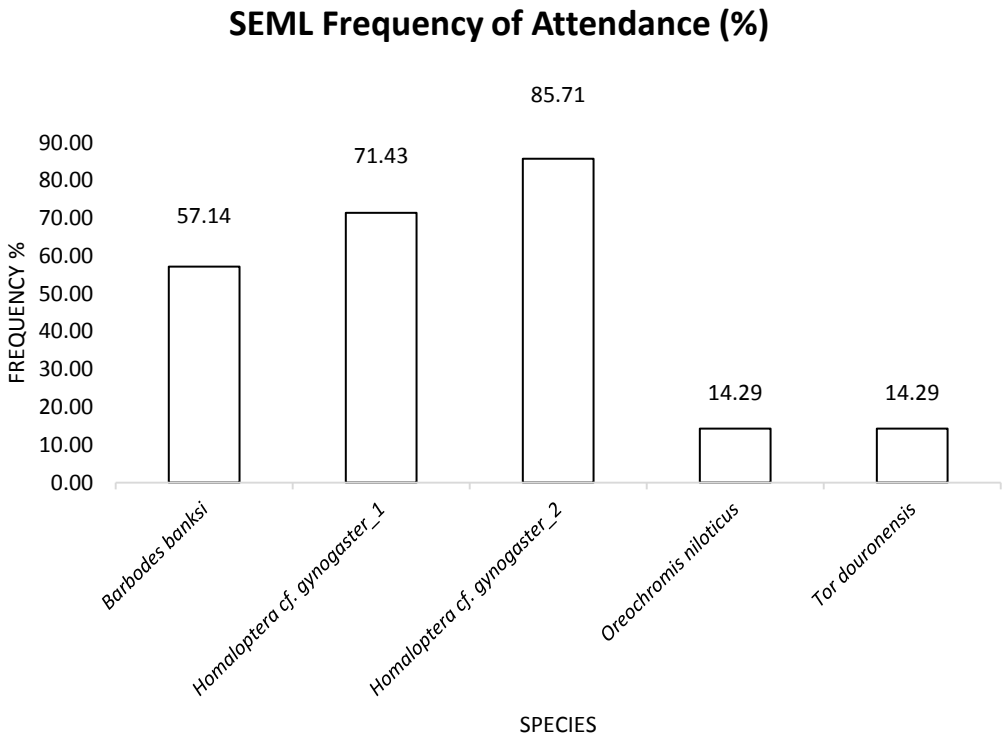

Figure 7. Frequency of attendance of fishes in SERD

Figure 7 shows the frequency attendance of fishes in SEML (Supreme Energy Muaro Labuah). The highest value was *Homaloptera* cf. *gymnogaster_2* (F: 85,71), followed by *Homaloptera* cf. *gymnogaster_1* (F:71,43), *Barbodes* cf. *banksi* (57,14), *Oreochromis niloticus* (F:14,29), and *Tor douronensis* (F:14,29).

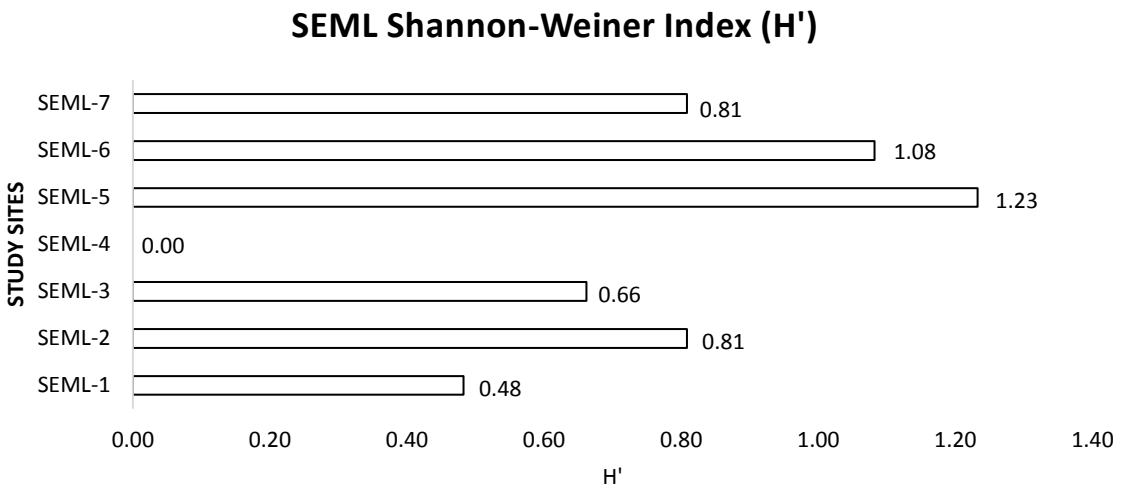

Figure 8. Shannon-Wiener species diversity in the SEML

The higher diversity index was in SEML-5 (H': 1,23), followed by SEML-6 (H':1,08) and categorized as fair diversity. SEML-7 and SEML-2 (0,81), SEML-3 (H':0,66) and , SEML-1 (H':0,48) were categorized as low diversity. There in no categorized of SEML-4 caused none of fish catched from the site (Figure 7).

III.2.2. Fish Descriptions

III.2.2.1 Family: Balitoridae

4.2.1.1 *Homalopterula gymnogaster* (Bleeker, 1853)

Classification

Kingdom : Animalia
Phylum : Chordata
Class : Actinopterygii
Order : Cypriniformes
Family : Balitoridae
Genus : Homaloptera
Species : *Homalopterula gymnogaster* (Bleeker, 1853)
Common names : Julung
Local name : Lepu

(a) (b)

Figure: (a) *Homalopterula* cf. *gymnogaster*_1, (b) (a) *Homalopterula* cf. *gymnogaster*_2

Description:
H. gymnogaster has dorsal origin behind pelvic origin, 60-73 scales along lateral line, anal origin much closer to caudal base than to pelvic base, 5-6 pectoral spines and 8-9 pectoral soft rays. There are not scales in front of pelvics. The total length of this species is 75 mm (Kottelat et al., 1993).

Habitat and Ecology:
H. gymnogaster include in highland species inhabiting riffles and 'quiet waters', which we assume to mean lakes. Most importantly the water must be clean and well-oxygenated. Base substrate can either be of gravel, sand or a mixture of both to which should be added a layer of water-worn rocks and pebbles of varying sizes (Rolland and Page, 2015).

Distribution : **Sumatra (Endemic)**
IUCN Red List Status : Not Evaluated

4.2.2 Family: Cyprinidae
4.2.2.1 *Barbodes* cf. *banksi* (Herre, 1940)
Classification
Kingdom : Animalia
Phylum : Chordata
Class : Actinopterygii
Order : Cypriniformes
Family : Cyprinidae
Genus : Barbodes
Species : *Barbodes* cf.*banksi* (Herre, 1940)
Common name : Spotted barb
Local name : Pegek (Rantau Dedap), Pareh (Muara Labuh)

Figure. *Barbodes* cf. *banksi* (Herre, 1940)

Description:
Barbodes banksi is different with Puntius binotatus in having a dark wedge-shaped marking (vs. a round spot) on the sides of the body immediately below the dorsal fin. As there seems

to to be a considerable amount of variation in the markings between populations, it also mean that banksi and binotatus represent 2 extreme color forms of a single species (Kottelat and Lim, 1995). This species has 90-110 mm in maximum standard length (seriouslyfish, 2017).

Habitat and Ecology:
Found in a variety of small streams in lowland and foothills, usually with clear water (Kottelat and Widjanarti, 2005).

Distribution : Malaysia, Singapore and Indonesia
IUCN Red List Status : Not Evaluated

4.2.2.2 *Tor douronensis* (Valenciennes, 1842)
Classification
Kingdom : Animalia
Phylum : Chordata
Class : Actinopterygii
Order : Cypriniformes
Family : Cyprinidae
Genus : Tor
2 Species : *Tor douronensis* (Valenciennes, 1842)
Common name : Semah mahseer
Local name : Cengkak (Rantau Dedap), Ikan Putih (Muara Labuh)

Figure: *Tor douronensis* (Valenciennes, 1842)

Description:
T. douronensisi has median lobe on lower lip not reaching corner of mouth and its stiff part of last simple dorsal ray as long as head without snout. Total length reaches 350 mm (Kottelat et al., 1993). It has dorsal fin with 3 spines and 9 ray; 3 spines and 5 rays of anal fin; pectoral fin consist of 1 spine and 16 rays; ventran fin with 2 spines and 8 rays; linea lateralis with 21-

24 scales. Rostral barbels about 1 ½ times, maxillary barbels about twice in eye. Pectoral slightly shorter than height of dorsal. Caudal deeply forked, its lobe pointed, about equal to head. Least height of caudal peduncle 1 ½ or more in its length, surrounded by 12 scales. Silvery, back darkish. Base of scales of back and sides darkish (Haryono, 2006).

Habitat and ecology:
This species lives on a stream of tropical forest in moderate to heavy flow and in clear waters. Found in medium to large-sized river during the dry season and migrate downstream in the rainy season. Living on the waters with basic substrates in the form of gravel and rocks (Kottelat, 2012).

Distribution : Thailand, Vietnam and Indonesia
IUCN Red List Status : Not Evaluated

4.2.2.3 *Tor tambroides* (Bleeker, 1854)
Classification
Kingdom : Animalia
Phylum : Chordata
Class : Actinopterygii
Order : Cypriniformes
Family : Cyprinidae
Genus : Tor
3 Species : *Tor tambroides* (Bleeker, 1854)
Common name : Thai mahseer
Local name : Cengkak (Rantau Dedap), Garing (Muara Labuh)

Figure: *Tor tambroides* (Bleeker, 1854)

Descripsion:
T. tambroides has dorsal fin with 3 spines and 9-10 rays; pectoral fin with 1 spine and 15-16 rays; ventral fin with 2 spines and 8 rays; anal fin wiht 3 spines and 5 rays; linea lateralis

with 23-24 scales. Lips broad, swollen, thick, continuous, the upper one generally with an anterior lobe, the lower one with a long free median lobe, which reaches to aline connecting the corners of the mouth. Maxillary barbels somewhat longer than the rostral ones, slightly or much longer than eye. Anal truncate, depressed not reaching caudal, its height somewhat less than that of the dorsal. Ventral as long as height of anal, not reaching anus, separated by 2 scales from lateral line. Pectoral slightly shorter than height of dorsal. Caudal deeply forked, its lobe pointed, the lower one the longer, equal to or longer than head (Haryono, 2006).

Habitat and ecology:
The species lives in large streams and rivers with moderate to swift flow. Adults live in deep pools and juveniles are most commonly observed in or near rapids (Kottelat, 2012). Found in rivers during dry season, moves downstream in rainy season, and spawns in mouths of small streams (Baran *et al.* 2005).

Distribution: Brunei Darussalam; China (Yunnan); Indonesia (Jawa, Kalimantan, Sumatera); Laos; Malaysia (Peninsular Malaysia, Sabah, Sarawak); Thailand.

IUCN Red List Status : **Data deficient**

4.2.3 Family: Cichlidae

4.2.3.1 *Oreochromis niloticus* (Linnaeus, 1758)

Classification
Kingdom : Animalia
Phylum : Chordata
Class : Actinopterygii
Order : Perciniformes
Family : Cichlidae
Genus : Oreochromis
4 Species : *Oreochromis nioloticus* (Linnaeus, 1758)
Common name : Nile tilapia
Local name : Nila

Figure: *Oreochromis niloticus* (Linnaeus, 1758)

Description:
O. niloticus has 15-18 dorsal spines, 11-13 dorsal soft rays, 3 anal spines, 9-11 anal soft rays and 30-32 vetebrae. Maximum standard length is 60 cm, but usually smaller (around 35 cm). Male fish develop pointed dorsal and anal fins while the females are rounded. Jaws of mature male not greadtly enlarged (29-37% of head length).The presence of regular vertical stripes throughout depth of caudal fin can be the most distinguishing characteristic (Fishbase, 2017).

Habitat and ecology:
It is an adaptable species that is found in a wide range of habitats, including rivers, streams, ponds, lakes and coastal plains. It occurs in both fresh and brackish waters and usually inhabits shallow areas. Some vegetable matter should be included in its diet. This species will eat most food offered.

Distribution :
O. niloticus has a very wide natural range and is native to (in alphabetical order) Burkina Faso, Cameroon, Chad, Egypt, Ethiopia, Gambia, Ghana, Guinea, Israel, Ivory Coast, Liberia, Mali, Niger, NIgeria, Senegal, Sierra Leone, Sudan, Togo and Uganda. It has also been introduced as a food fish in over 70 other countries and escaped or released populations now exist in many of these (seriouslyfish, 2017). Several countries report adverse ecological impact after introduction.

IUCN Red List Status : Not Evaluated
Threath to humans : potential pest

4.2.4 Family: Poeciliidae
4.2.4.1 *Xiphophorus hellerii* Heckel, 1848
Classification
Kingdom : Animalia
Phylum : Chordata
Class : Actinopterygii
Order : Cyprinodontiformes
Family : Poeciliidae
Genus : Xiphophorus
5 Species : *Xiphophorus hellerii* Heckel, 1848
Common names : Green swordtail
Local name : Ikan pedang

Figure: *Xiphophorus hellerii* Heckel, 1848

Description:

Caudal of male has a long and sharp-tipped process at its lower corner. It has various colour forms (Kottelat, 2012). This species is distinguished by having a medium to large swordtail with a long straight caudal appendage, 11-14 Anal spines, 2 additional reddish stripes may be present above midlateral line and one beneath terminal segment of gonopodial ray 3 produced into a crescent-shaped hook and blade pointed distally (Kallman et al., 2004)

Habitat and Ecology:

Natural populations are found in various types of habitat from sea level to around 1500 m altitude, including fast-flowing, rocky hasstreams, to springs, ditches, ponds, and rivers containing clear to turbid water. In most cases the water is less than 1.5 m deep and there is no aquatic vegetation.

Distribution :
The natural geographic range *X. helleri* is North and Central America: Rio Nantla, Veracruz in Mexico to northwestern Honduras. Several countries report adverse ecological impact after introduction. Introduced accidentaly from aquaria.
IUCN Red List Status : Not evaluated
Threat to humans : potential pest

4.2.5 Family: Sisoridae
4.2.5.1 *Glyptothorax platypogon* (Valenciennes, 1840)
Classification
Kingdom : Animalia
Phylum : Chordata
Class : Actinopterygii
Order : Siluriformes
Family : Sisoridae

Genus : Glyptothorax
Species : *Glyptothorax platypogon* (Valenciennes, 1840)
Common name : Brauner Gebirgswels
Local name : Lepu

Figure: *Glyptothorax platypogon* (Valenciennes, 1840)

Description:

G. platypogon has body depth 5,0-5,6 times in standart length and caudal peduncle nearly as long as deep. Its body marmorated with a faint stripe along back and body covered by coarse granulation. This species can grow to 100 mm total length (Kottelat et al., 1993). Its body is flat and adapted to the fast current of mountain streams. It has three pairs barbels, thick-based barbels at angle of mouth. Adhesive organ comprised of longitudinal plaits of skin on thorax between pectorals. It has forked caudal. Small eyes are located at the top, dorsal fin is hard and tapered.

Habitat and Ecology :Live in freshwater, include in benthopelagic fish, pH range: 6,0-7,0.

Distribution : Sumatra, Borneo, Java

IUCN Red List Status : Not Evaluated

***4.2.5.2 Glyptothorax platypognoides* (Bleeker, 1855)**

Classification
Kingdom : Animalia
Phylum : Chordata
Class : Actinopterygii
Order : Siluriformes
Family : Sisoridae
Genus : Glyptothorax

Spesies : *Glyptothorax platypogonides* (Bleeker, 1855)

Common name :

Local name : Lepu

Figure: *Glyptothorax platypogonides* (Bleeker, 1855)

Description:

G. platypogonides has body depth 5.0-5.5 times in standard length and caudal peduncle about twice as long as deep. Its body is blueish-black in life, with a conspicuous light stripe along the back. The body's covered by very fine granulation. Its total length around 120 mm (Kottelat et al., 1993).

Habitat : Live in freshwater, include in benthopelagic fish.

Distribution : West Sumatra, West Borneo

IUCN Red List Status: Not Evaluated

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III.3. Macroinvertebrate Diversity

Based on the macroinvertebrate survey that has been conducted on six streams around the geothermal Power Plant - PT. Supreme Energy Muara Labuh shows that macroinvertebrate composition varies in each stream (Table 7).

1. Bangko Hitam stream (SEML 1) which has a width of 2- 5 m, 20-100 cm deep, with rock bottom substrate, gravel and sand, current velocity is moderate (40 cm/s). In this stream found 22 genera and 95 individuals macroinvertebrata classified as 3 classes divided into 8 orders. The predominant genera in this stream are *Simulium* (Diptera; Simulidae), *Pseudocloeon* and *Centroptilum* (Ephemeroptera; Baetidae. There found two individuals of crab *Parathelphusa maculata* (C.Macostraca; O.Decapoda; F.Gecarcinucidae). A genus is said to be a predominant if it has an individual number of ≥10% in its community (Kendeigh, 1980) .The genera diversity index (H') is 2.5

2. Bangko Keruh Stream (SEML 2) which has wide stream 2-5 m, depth 50 cm, bottombase substrate consist of rock covered with algae, gravel, and sand. There was a muddy puddle under the bridge. Its currentvelocity is moderate (37 cm/s). In this stream was found 157 individuals, 27 genera macroinvertebrata classified into 5 classes and 11 orders. There found distinctive genera in calm waters and muddy substrate ie worm (Oligochaeta) 3 genera, 1 genus leech (Hirudinea), slug (Gastropoda) 4 genera. The predominant genera are Orthocladinae (Diptera: Chironomidae), *Nemoura* (Plecoptera; Nemouridae) and *Melanoides* (Gastropoda; Mesogastropoda) . Genera diversity index is 2.51

3. Muara Bangko Putih (SEML 3), has stream wide 5-8 m, depth 40-100 cm, bottom substrate consist of rock, pebbles, sand, fast current velocity (54 cm/s). In this stream found 123

individuals and 23 genera of macroinvertebrates classified into 2 classes and 8 orders. Its members are mostly of the insects with the predominant genera are *Simulium*, Orthocladinae 1 and *Hydropsyche* (Trichoptera, Hydropsychidae). Genera diversity index is 2.48

4. Bangko Putih Stream (SEML 4), has a stream width of 10-15 m, depth 50-200 cm, bottom substrate consist of stone, pebbles, sand, fast current velocity (52 cm/s). In this stream found 206 individuals and 19 genera of macroinvertebrates belonging to 1 class (Insecta) and 8 orders. The predominant genera are Orthocladinae 1, *Nemoura* (Plecoptera, Nemouridae) and *Simulium.* The genera diversity index is 2.00.

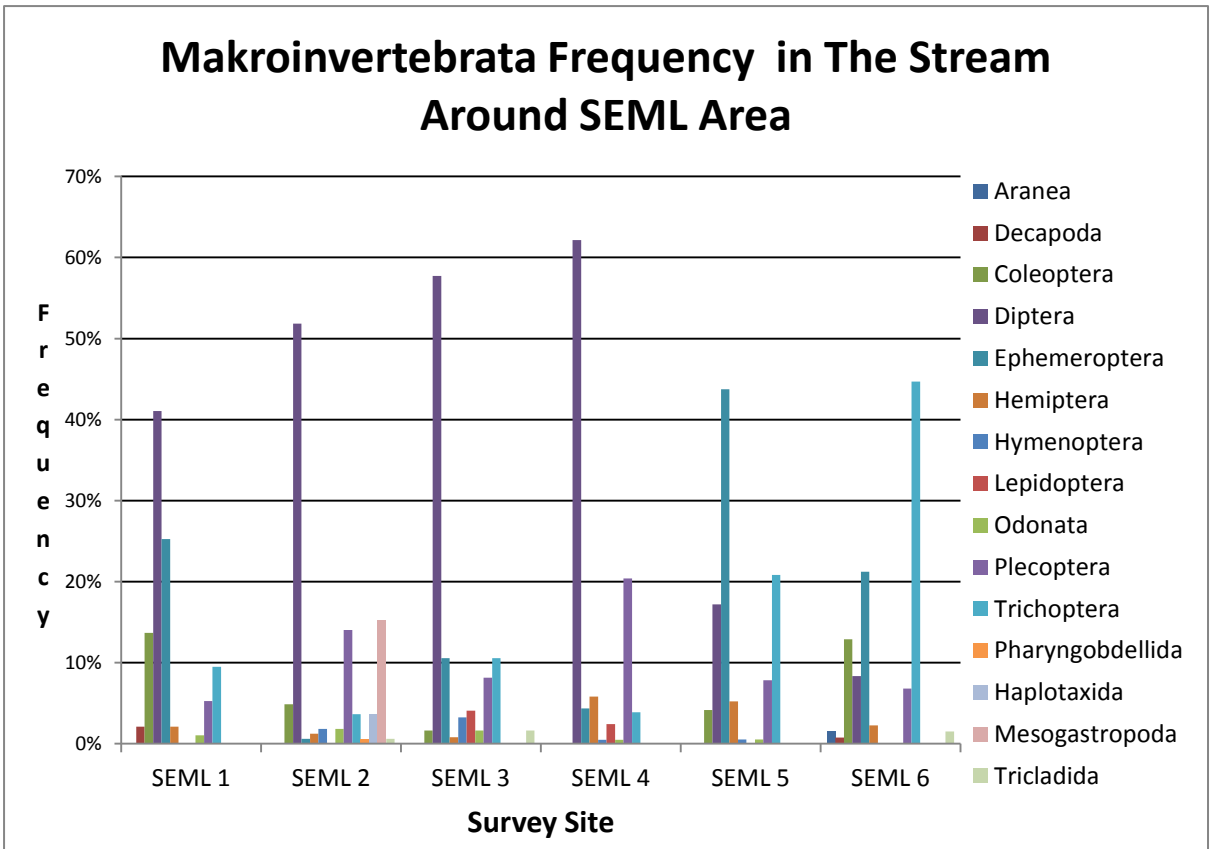
5. Liki Stream (SEML 5), has a stream width of 5-30 m, a depth of 30-200 cm, bottom substrate are stone gravel and sand, fast current velocity (95 cm/s). In this stream found only Insect 192 individuals and 27 genera classified 8 orders. The predominant genera are *Centroptilum* (Ephemeroptera; Baetidae), *Pseudocloeon* (Ephemeroptera, Baetidae), *Neophylax* (Trichoptera; Limnephilidae). Many found Neophylax and case on the stone surface. The genera diversity index is 2.59.

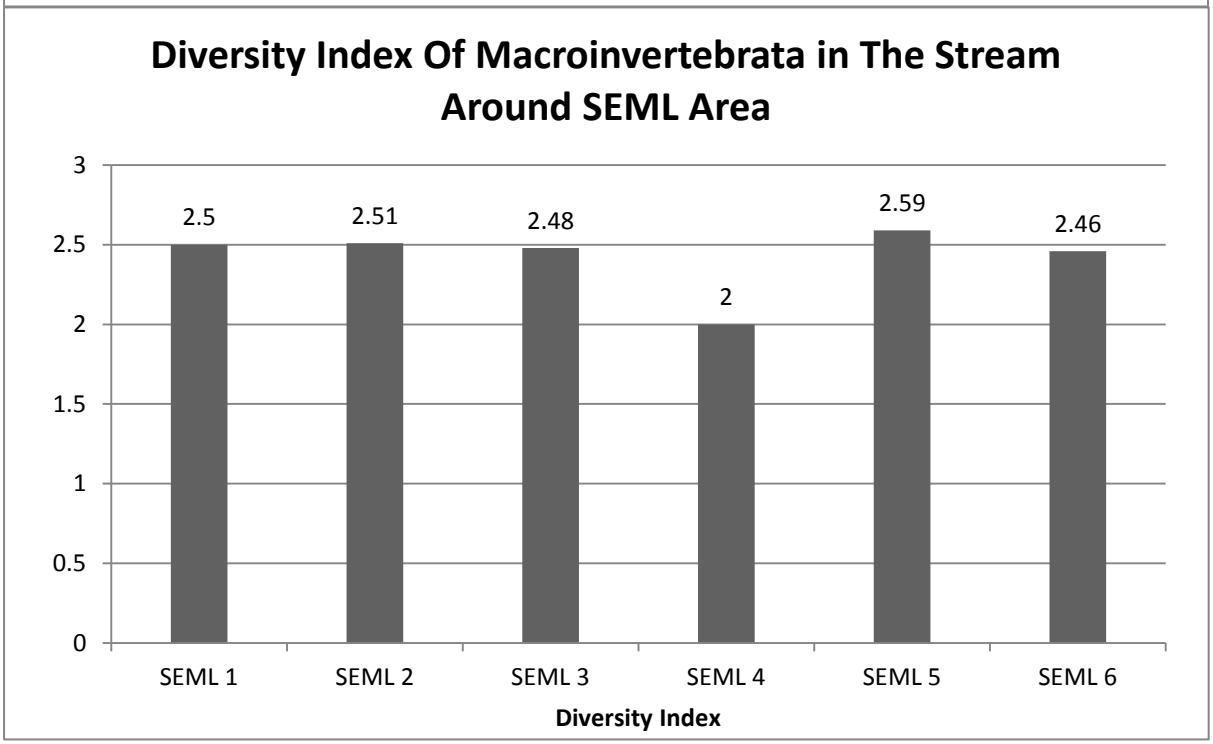
Tabel 7. Macroinvertebrata commuities in the stram around SEML area

No.	Taxa	SEML 1		SEML 2		SEML 3		SEML 4		SEML 5		SEML 6	
		S. Bangko Hitam		S. Bangko Keruh		Muara Bangko Putih		Bangko Putih		S.Liki		Sungai Bangko	
		Ind.	%	Ind.	%	Ind.	%	Ind.	%	Ind.	%	Ind.	%
	C. ARACHNIDA												
	O. Aranea												
1	*Archuphantes*											1	0.76
2	Aranea 1											1	0.76
	C. MALACOSTRACA												
	O. Decapoda												
3	*Parathelphusa maculata*	2	2.11									1	0.76
	C. INSECTA												
	O. Coleoptera												
4	*Donacia*											1	0.76
5	*Elmomorphus*					1	0.81			3	1.56	9	6.82
6	*Dineutus*											2	1.52
7	*Hydrocasis*			7	4.27					3	1.56		
8	*Nomuraelmis*									2	1.04		
9	*Promoresia*												
10	*Stenelmis*	2	2.11										
11	*Zaitzevia*	5	5.26									5	3.79
12	*Alabameubria*	2	2.11										
13	*Psephenoides*	4	4.21	1	0.61	1	0.81						
	O. Diptera												
14	*Philorus*					1	0.81						
15	*Canace*									2	1.04		
16	*Bezzia*	1	1.05										
17	*Culicoides*					1	0.81	1	0.49				
18	*Cryptochironomus*					10	8.13	6	2.91				
19	*Microspectra*			1	0.61								
20	*Polypedilum*			3	1.83			6	2.91				
21	Orthocladinae 1	5	5.26	38	**23.17**	13	**10.57**	74	**35.92**				
22	Orthocladinae 2			28	**17.07**	7	5.69	2	0.97				
23	Tanypodinae	1	1.05			1	0.81	1	0.49				
24	*Simulium*	28	**29.47**	7	4.27	36	**29.27**	36	**17.48**	14	7.29		
25	*Anthocha*			7	4.27	1	0.81	1	0.49			8	6.06

No.	Taxa	SEML 1 S. Bangko Hitam		SEML 2 S. Bangko Keruh		SEML 3 Muara Bangko Putih		SEML 4 Bangko Putih		SEML 5 S.Liki		SEML 6 Sungai Bangko	
		Ind.	%	Ind.	%	Ind.	%	Ind.	%	Ind.	%	Ind.	%
26	*Limnophila*	2	2.11							8	4.17	3	2.27
27	*Pilaria*	2	2.11	1	0.61	1	0.81	1	0.49	4	2.08		
28	Tipulidae									5	2.60		
	O. Ephemeroptera												
29	*Baetis*	2	2.11			1	0.81	3	1.46	4	2.08	1	0.76
30	*Centroptilum*	10	**10.53**	1	0.61	5	4.07	6	2.91	30	**15.63**	14	**10.61**
31	*Pseudocloeon*	11	**11.58**			7	5.69			40	**20.83**	12	9.09
32	*Caenis*											1	0.76
33	*Ecdyonurus*									1	0.52		
34	*Ephemerella*									2	1.04		
35	*Cincticostella*									3	1.56		
36	*Torleya*	1	1.05							4	2.08		
	O. Hemiptera												
37	*Geris*			2	1.22								
38	*Hydrometra*	1	1.05										
39	*Ilyocoris*									1	0.52		
40	*Pelocoris*					1	0.81	1	0.49	5	2.60		
41	*Halobates*	1	1.05							2	1.04		
42	*Rhagovelia*							11	5.34	2	1.04	3	2.27
	O. Hymenoptera												
43	*Tetramorium*					4	3.25			1	0.52		
44	*Anaplolepis*			3	1.83			1	0.49				
	O. Lepidoptera												
45	*Elophila*					5	4.07	5	2.43				
	O. Odonata												
46	*Chlorogomphus*					1	0.81						
47	*Sympecna*			1	0.61								
48	*Crocothermes*					1	0.81						
49	*Leucorrhinia*			1	0.61								
50	*Libellula*									1	0.52		
51	*Orthetrum*							1	0.49				
52	*Ephoptalmia*	1	1.05										
53	*Macromia*			1	0.61								

No.	Taxa	SEML 1 S. Bangko Hitam		SEML 2 S. Bangko Keruh		SEML 3 Muara Bangko Putih		SEML 4 Bangko Putih		SEML 5 S.Liki		SEML 6 Sungai Bangko	
		Ind.	%	Ind.	%	Ind.	%	Ind.	%	Ind.	%	Ind.	%
	O. Plecoptera												
54	*Chloroperla*			1	0.61								
55	*Neoperla*	1	1.05			2	1.63	2	0.97	11	5.73	6	4.55
56	*Nemoura*	4	4.21	22	**13.41**	8	6.50	40	**19.42**	4	2.08	3	2.27
	O. Trichoptera												
57	*Hydropsyche*	8	8.42	6	3.66	13	**10.57**	8	3.88	1	0.52	31	**23.48**
58	*Ochrotrichia*	1	1.05							2	1.04	2	1.52
59	*Neophylax*									35	**18.23**	24	**18.18**
60	*Limnephilus*									2	1.04	2	1.52
61	*Philopotamus*												
62	*Psychomya*												
	C. Hirudinea												
	O. Pharyngobdellida												
63	Erphobdella			1	0.61								
	C. Oligochaeta												
	O.Haplotaxida												
64	*Branchiura*			2	1.22								
65	Tubificidae 1			2	1.22								
66	Tubificidae 2			2	1.22								
	C. GASTROPODA												
	O. Mesogastropoda												
67	*Helicorbis*			1	0.61								
68	*Physa*			4	2.44								
69	*Bellamya*			1	0.61								
70	*Melanoides*			19	**11.59**								
	C. TURBELLARIA												
	O. Tricladida												
71	*Phagocata*			1	0.61	2	1.63					2	1.52
Total of individual		95	100.00	164	100	123	100.00	206	100	192	100.00	132	100.00
Total of Genus		22		27		23		19		27		21	
Diversity index (H')		2.50		2.51		2.48		2.00		2.59		2.46	





6. Bangko stream (SEML 6) has a stream width of 6-10 m, a depth of 60 cm, the bottom substrate is dominated by stone, very fast current velocity (121 cm/s). In this stream found as many as 132 individuals and 21 genera belonging to 4 classes and 9 orders. The predominant genera are *Hydropsyche*, *Neophylax* and *Centroptilum*. There are found a kind of crab *Parathelphusa maculata*. The genera diversity index is 2.46.

The presence of macroinverebrate genera in all streams in the SEML region varies. Genera found throughout the stream are *Centroptilum, Nemoura and Hydropsyche. Simulium* is found in five streams, not found in Muara Cawang (SEML6). However, many genera are found in one stream only, such as *Donacia, Dineutus, Nemuraelmis* and *Stenelmis* only found in Bangko Hitam (SEML1), *Microspectra* only in Bangko Keruh (SEML 2), *Phylorus, Chlorogomphus, Crocothermes, Leucorrihinia* were found only in Muara Bangko Putih (SEML3), *Orthetrum* in Bangko Putih (SEML 4), *Tanypodinae, Ecdyonurus, Ephemerella, Cincticostella, Iliocoris, Libellula* found only in Liki (SEML 5), *Archupanthes*, Aranea 1 (Arachnida) and *Caenis* found only in Bangko (SEML 6).

The six streams observed are streams located in the highlands ranging from 1003 - 1162 m. The current velocity range from medium to fast with rock-dominated substrate, except in Bangko Keruh in certain places there are calm areas with muddy substrate. The six streams are dominated by Insects. In the Bangko Keruh Stream has the moderate current velocity is found 4 genera of Gastropods which is dominated by *Melanoides*. On the edge of the stream there are rice fields, it is estimated that the gastropods found in this stream come from the fields enter with the flow of water into the stream. The stream conditions suitable for gastropod life such as algae-covered the stone in the bottom provide a food source for the organism so that it can survived in the Bangko Keruh stream. Gastropods are also found in the pool that found in this streams. In this puddle also found 3 genera of worms (Oligochaeta) which is a characteristic genera in calm waters with muddy substrate. The dominance of Insects in this stream is due to its ability to maintaining the current. Insects' larva generally has attachment devices including silk and other sticky secretion, hooks, suckers and cases (Allan, 1995).

In Bangko Hitam Stream and Bangko Stream found crabs of *Parathelphusa* obtained on stream banks with relatively slow currents when collecting fish samples using electrofishing devices, only 1 individual in each stream. *Parathelphusa* belonged to the family of Pharathelphusidae but is now classified into the Gecarcinucidae family (Klause *et al*., 2008). *Parathelphusa maculate* is included in the IUCN Red List of Threatened species as Least Concern (LC). This species prefers lowland stream and tolerant of muddy water. This animals have a highttolerance of low oxygen condition. It commons under rock, logs, vegetation, debris but also dig deep burrow on the banks of the stream. The burrow is always open into the water. Normally adult females live in burrows, but their juveniles can be found in open water (Klause et al, 2008).

In Bangko Stream found 2 genera Arachnida (Acuphantes and Aranea 1) each 1 individual. Arachnida that get this habitat is not in the water, but make a nest in plants, especially at the bottom near the surface of the soil. These genera are collected at the edge of the stream where there are plants.

The presence of macroinvertebrate genera in each stream depends on the habitat's suitability and its adaptability to the environmental conditions of the stream. Hence there are genera that can be found throughout the stream and there are also genera whose presence is rarely present only in certain streams. Streams in SEML substrates are essentially dominated by

rocks and moderate to very fast current velocities. The well-adapted genera in the stream in the SEML region are *Centroptilum, Nemoura, Hydropsyche* found throughout the stream and and *Simulium* is not found in one stream. All these genera have good morphological adaptability to fast currents, because they have the means to maintain themselves with fast currents: Centroptilum, Nemoura have a dorsoventral flat body and has strong claws, Hydropsyche has netspining, and Simulium has a circlet of hooks on posterior proleg, wich this larvae attached to the substrate, allowing the animal to climb down with the silk thread and re-attached (Allan, 2001). Genera are rarely found in the number of individuals one or two individuals. The absence of a river may be due to its small population, so the chances of getting caught are also small.

The genera diversity index of macroinvertebrates in the all streams is moderate with the index (H ') range from 2 to 2.59. Based on the criteria Lee *et al*., (1978) that streams with macroinvertebrate diversity index larger than two indicate that the stream is considered clean. The presence of EPT (Ephemeroptera, Plecoptera, Trichoptera) in the six observed streams also shows indicator of clean water quality, especially Plecoptera usually live on rocky stream upstream or low stream order which is cooler and sensitive to organic pollution and low oxygen but tolerant to acidic conditions (Giller and Malmqvist (2003).

Conclusion

1. The stram ecosystem in the SEML region is relatively undisturbed, the quality of clean water indicated by the number of genera of each river is high relatively ranges from 19-27 genera with the number of individuals range from 95 to 206 individuals, the genera diversity index ranges from 2,00 -2, 59 is moderate and the water quality is classified as clean.
2 The presence of genera in each river varies. Genera found in all streams are the *Centroptilum, Nemura, Hydropsyche,* but *Simulium* are not found in one river. The predominant macroinvertebrate genera are: *Simulium, Centroptilum, Pseudocloeon*, *Nemura, Orthocladinae, Hydropsyche, Neophylax* and *Melanoides*.
3. Found one genus of crab *Parathelphusa maculata* included in the IUCN Red List of Species Threatened 2008 as Least Concern (LC).

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Appendix

The predominant macroinvertebrates genera in stream around SEML area.

Orthocladinae 1

Orthocladine 2

Melanoides

Centroptilum

Psedocleon

Hydropsyche

Simulium

Nemoura

Neophylax

This crab included in the IUCN Red List of Threatened species as Least Concern (LC)

Parathelphusa maculata

II. Stream macroinvertebrates in the SERD project area

Based on a survey of macroinvertebrates conducted on seven streams around the geothermal Power Plant - Supreme Energy Rantau Dedap (SERD) shows that macroinvertebrate composition varies in each stream (Table 8). The number of species and individuals in the SERD is higher and the individual is larger compared to SEML macroinvertebrates.

1. Indikat stream (SERD 1) which has a width of 10-18 m, 50-200 cm depth, with rock, gravel and sand bottom substrate, fast current velocity (93 cm/s). In this stream found 28 species and 91 individuals macroinvertebrates classified as 4 classes in 10 orders. Only one genus predominant in this stream is Neophylax (Trichoptera; Limnephilidae). There is one species of crab *Parathelpusa maculate* (C. Macostraca, O. Decapoda, F. Gecarcinucidae) of one individual. Index of genera diversity is 2.94.
2. Cawang Kiri Stream (SERD 2) which has a width of 2-5 m wide, 50-100 cm deep, with bottom substrate consist of rock gravel and sand, fast current velocity (85 cm/s). In this stream found 34 species and 295 individuals macroinvertebrates classified as 2 classes in 9 orders. Predominant genera in this stream are *Centroptilum* (Ephemeroptera: Baetidae), *Stenelmis* and *Nomuraelmis*, both belong to Coleoptera; Elmidae. The genera diversity index is 2.60.
3. Cawang Tengah Stream (SERD 3) which has a width of 3-10 m, 100-200 cm deep, with rock bottom substrate, gravel and sand, fast current velocity (59 cm/s). In this stream only Insecta found 23 species and 141 individuals belonging to 7 orders. Genera is predominant in this stream are *Centroptilum*, *Hydropsyche* (Trichoptera; Hydropsychidae) and *Pseudocloeon* (Ephemeroptera; Baetidae). Index of genera diversity is 2.56.
4. Asahan Stream (SERD 4) which has a width of 2-3 m, a depth of 50-100 cm, with a bottom substrate of rock, gravel and sand, the current velocity is very fast (82 cm/s). In this stream found 24 species and 137 individuals belonging to 4 classes in 10 orders. Genera predominant in this stream are *Antocha* (Diptera: Tipulidae), *Psychomya* (Trichoptera, Psycomyidae), *Hydropsyche* and *Simulium* (Diptera: Tipulidae). Index of genera diversity is 2.3.
5. Cawang Kanan Hulu Stream (SERD 5) which has a width of 2-6 m, a depth of 50-200 cm, with a bottom substrate of rock, gravel and sand, fast current velocity is 85 cm/s. In this stream found 24 species and 196 individuals belonging to 4 classes in 10 orders. Genera is predominant in this stream Orthocladinae 1 (Diptera: Chironomidae) and *Centroptilum.* The genera diversity index is 1.92.
6. Cawang Kanan Stream (SERD 6) which has a width of 3-7m, 30-150 cm deep, with rock, gravel and sand bottom substrate, fast current velocity (70 cm/s). In this stream found 25 species and 204 individuals belonging to 2 classes in 6 orders. The predominant genera in this stream are *Pseudocleon, Centroptilum* and *Neoperla* (Pecoptera, Perlidae), genera diversity index is 2.51.

Table 8. Macroinvertebrates communities in stream around SERD area

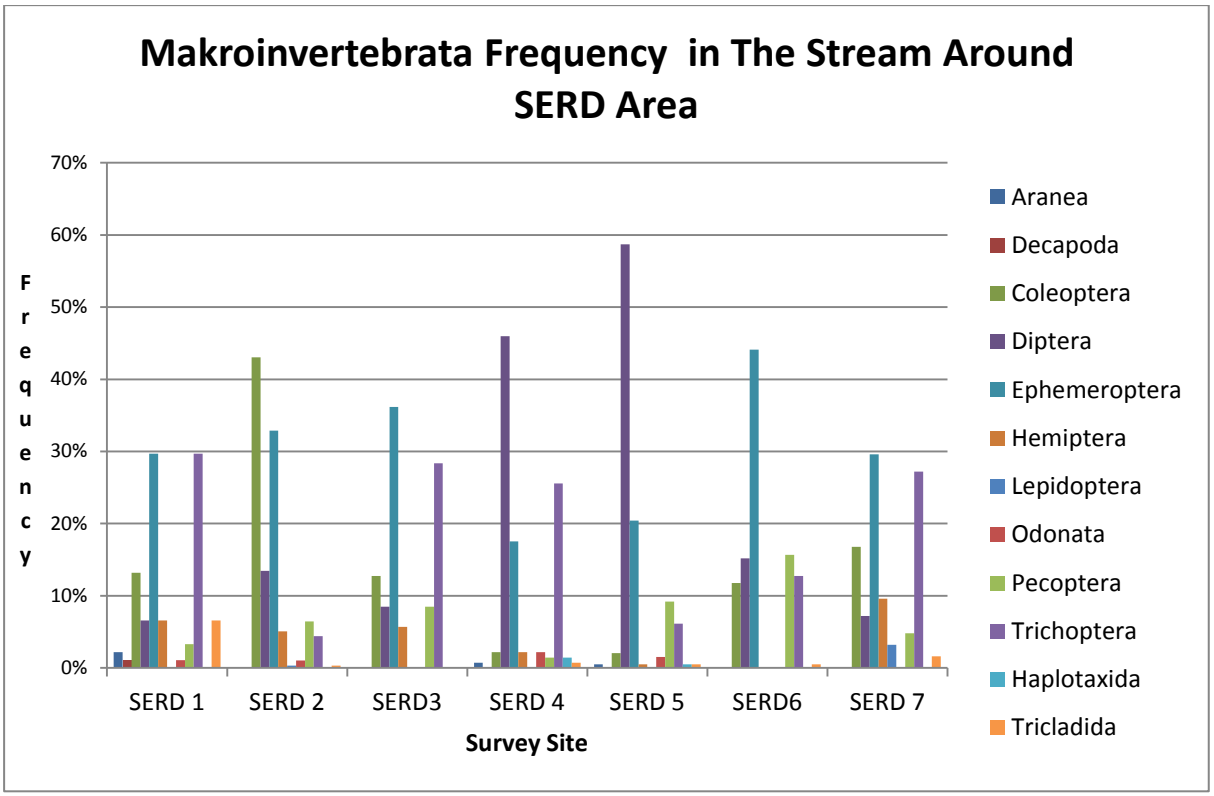
No	Taxa	SERD 1		SERD 2		SERD3		SERD 4		SERD 5		SERD6		SERD 7	
		S. Endikat		S.Cawang Kiri		S. Cawang Tengah		S. Asahan		S. Cawang Kanan Hulu		S. Cawang Kanan		Muara Cawang	
		ind	%	ind	%	ind	%	ind	%	ind	%	ind	%	ind	%
	C. ARACHNIDA														
	O.Aranea														
1	Archupanthes									1	0.51				
2	Aranea 1	2	2.20					1	0.73						
	C. MALACOSTRACA														
	O. Decapoda														
3	*Para thelphusa maculata*	1	1.10												
	C. INSECTA														
	O. Coleoptera														
4	*Donacia*									2	1.02	1	0.49		
5	*Elmomorphus*			11	3.73	5	3.55					1	0.49	7	5.60
6	*Uvarus*			5	1.69										
7	*Nomuraelmis*	1	1.10	32	**10.85**										
8	*Promoresia*	4	4.40	1	0.34	2	1.42	3	2.19			5	2.45	7	5.60
9	*Stenelmis*	1	1.10	60	**20.34**	7	4.96			2	1.02	15	7.35		
10	*Dineatus*					1	0.71					1	0.49		
11	*Gyrinus*	1	1.10			1	0.71					1	0.49	2	1.60
12	*Hydraena*			13	4.41										

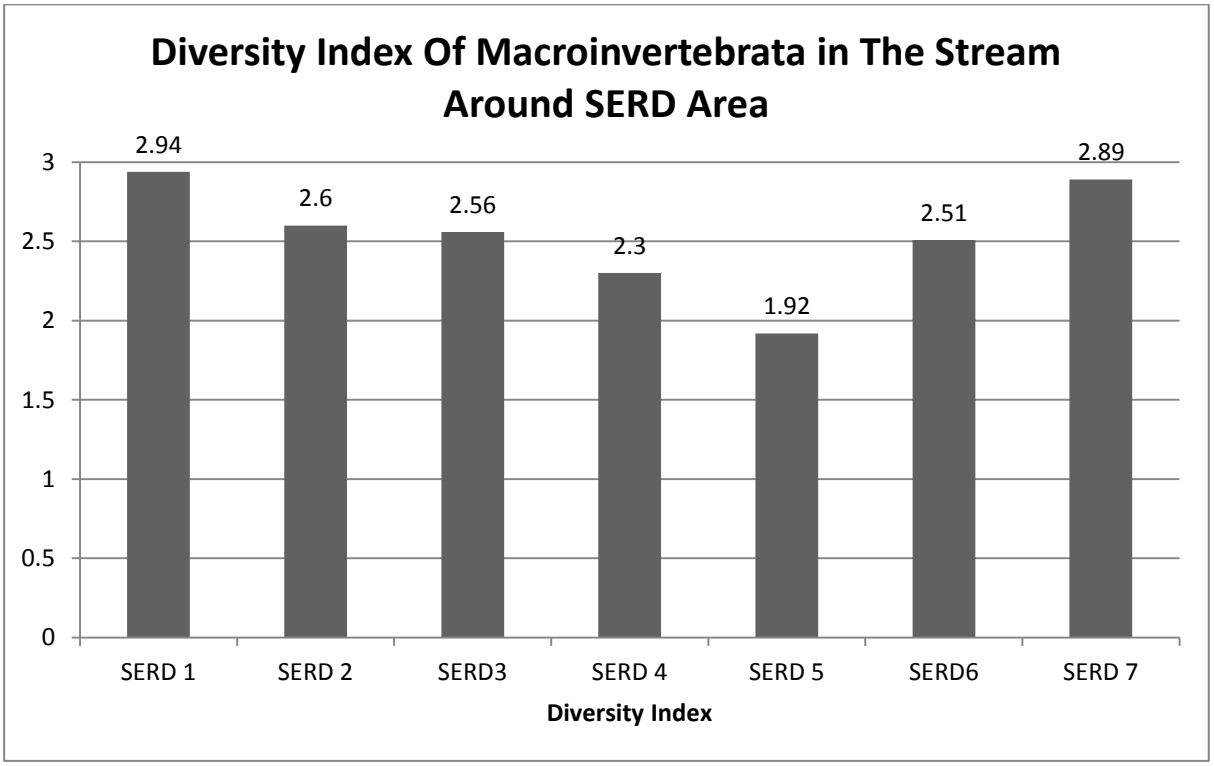
No	Taxa	SERD 1		SERD 2		SERD3		SERD 4		SERD 5		SERD6		SERD 7	
		S. Endikat		S.Cawang Kiri		S. Cawang Tengah		S. Asahan		S. Cawang Kanan Hulu		S. Cawang Kanan		Muara Cawang	
		ind	%	ind	%	ind	%	ind	%	ind	%	ind	%	ind	%
13	*Hydrocasis*			1	0.34	2	1.42								
14	*Hydriphilus*			1	0.34										
15	*Psephenoides*	5	5.49	3	1.02									5	4.00
	O. Diptera														
16	*Philorus*			1	0.34										
17	*Canace*			3	1.02										
18	*Dasyhelea*											1	0.49		
19	*Cryptochironomus*									2	1.02			2	1.60
20	*Microspectra*											1	0.49		
21	*Polypedilum*									1	0.51				
22	*Orthocladinae 1*							1	0.73	98	**50.00**	7	3.43		
23	*Orthocladinae 2*									1	0.51				
24	*Coryneura*									1	0.51				
25	*Tanypodinae*			1	0.34										
26	*Atherix*			3	1.02	5	3.55			7	3.57	1	0.49		
27	*Simulium*			2	0.68	1	0.71	14	**10.22**			7	3.43	4	3.20
28	*Anthocha*	4	4.40			5	3.55	47	**34.31**	5	2.55	11	5.39	1	0.80
29	*Limnophila*			1	0.34			1	0.73			1	0.49		
30	*Pilaria*	2	2.20	8	2.71							2	0.98	2	1.60

No	Taxa	SERD 1		SERD 2		SERD3		SERD 4		SERD 5		SERD6		SERD 7	
		S. Endikat		S.Cawang Kiri		S. Cawang Tengah		S. Asahan		S. Cawang Kanan Hulu		S. Cawang Kanan		Muara Cawang	
		ind	%	ind	%	ind	%	ind	%	ind	%	ind	%	ind	%
31	*Prionocera*					1	0.71								
	O. Ephemeroptera														
32	*Baetis*	1	1.10	2	0.68			2	1.46	1	0.51	5	2.45	11	8.80
33	*Centroptilum*	9	9.89	73	**24.75**	30	**21.28**	9	6.57	28	**14.29**	23	**11.27**	18	**14.40**
34	*Pseudocloeon*	3	3.30	9	3.05	17	**12.06**	6	4.38	9	4.59	55	**26.96**	5	4.00
35	*Caenis*			1	0.34										
36	*Ecdyonurus*	3	3.30	1	0.34					1	0.51			1	0.80
37	*Heptogenia*											5	2.45	1	0.80
38	*Rhitrogena*	3	3.30									2	0.98		
39	*Ephemerella*	2	2.20	1	0.34			4	2.92					1	0.80
40	*Cincticostella*					1	0.71								
42	*Torleya*	4	4.40	5	1.69	2	1.42			1	0.51				
43	*Choroterpes*	1	1.10	5	1.69	1	0.71	2	1.46						
44	*Paraleptophlebia*	1	1.10					1	0.73						
	O. Hemiptera														
45	*Geris*	1	1.10					1	0.73					1	0.80
46	*Mesovelia*	1	1.10											2	1.60
47	*Rhagovelia*							1	0.73	1	0.51			2	1.60
48	*Ilyocoris*	2	2.20	15	5.08	6	4.26							3	2.40

No	Taxa	SERD 1		SERD 2		SERD3		SERD 4		SERD 5		SERD6		SERD 7	
		S. Endikat		S.Cawang Kiri		S. Cawang Tengah		S. Asahan		S. Cawang Kanan Hulu		S. Cawang Kanan		Muara Cawang	
		ind	%	ind	%	ind	%	ind	%	ind	%	ind	%	ind	%
49	*Pelocoris*	2	2.20			2	1.42	1	0.73					4	3.20
	O. Lepidoptera														
50	*Elophila*			1	0.34									4	3.20
	O. Odonata														
51	*Cordulia*									3	1.53				
52	*Chlorogomphus*	1	1.10	3	1.02										
53	*Macromia*							3	2.19						
	O. Pecoptera														
54	*Chloroperla*							1	0.73						
55	*Neoperla*	3	3.30	13	4.41	3	2.13	1	0.73	15	7.65	23	**11.27**	6	4.80
56	*Nemoura*			6	2.03	9	6.38			3	1.53	9	4.41		
	O. Trichoptera														
57	*Hydropsyche*	5	5.49	2	0.68	26	**18.44**	14	**10.22**	9	4.59	18	8.82	19	**15.20**
58	*Ochrotrichia*					1	0.71							5	4.00
59	*Athripsodes*			6	2.03										
60	*Neophylax*	19	**20.88**			5	3.55	1	0.73			1	0.49		
61	*Limnephilus*			1	0.34	8	5.67			1	0.51			7	5.60
62	*Philopotamus*	3	3.30					1	0.73					3	2.40
63	*Psychomya*			4	1.36			19	**13.87**	2	1.02	7	3.43		

No	Taxa	SERD 1		SERD 2		SERD3		SERD 4		SERD 5		SERD6		SERD 7	
		S. Endikat		S.Cawang Kiri		S. Cawang Tengah		S. Asahan		S. Cawang Kanan Hulu		S. Cawang Kanan		Muara Cawang	
		ind	%	ind	%	ind	%	ind	%	ind	%	ind	%	ind	%
	C. OLIGOCHAETA														
	O. Haplotaxida														
64	Tubificidae 1							2	1.46	1	0.51				
	C. TURBELLARIA														
	O. Tricladida														
65	*Phagocata*	6	6.59	1	0.34			1	0.73	1	0.51	1	0.49	2	1.60
Total individu		**91**	**100**	**295**	**100**	**141**	**100**	**137**	**100**	**196**	**100**	**204**	**100**	**125**	**100**
Total Genus		**28**		**34**		**23**		**24**		**24**		**25**		**26**	
H′		**2,94**		**2,60**		**2,56**		**2,30**		**1,92**		**2,51**		**2,89**	





7. Muara Cawang (SERD 7) which has a width of 8-12m, depth of 80 cm, with bottom substrate consist of rock, gravel and sand. The current velocity moderate classified (50 cm / s). In this stream found 26 species and 289 individuals belonging to 2 classes in 8 orders. The predominant genera in this stream are *Hydropsyche* and *Centroptilum*. Index of genera diversity is 2.89.

The presence of genera macroinverebrate in all streams in the SERD region varies. Genera found throughout the stream are *Centroptilum, Pseudocloeon, Neoperla* and *Hydropsyche*. There are one genera that always found in all stream around SEML ie *Nemura* replaced by *Neoperla* where both genera are classified as Plecoptera. Several genera are found in six streams observed such as Centroptilum, Pseudocloeon, *Anthocha, Phagocata* not found in S. Cawang Tengah (SEML 6) and *Baetis* not found in S. Cawang Kiri (SERD 2). However, many genera are found only one stream, such as *Elophila, Archupanthes, Parathelphusa maculata*, found only in Indikat (SERD 1), Orthocladinae, *Hydraena*, *Uvarus* and *Athripsodes* found only in Cawang Kiri (SERD 3), *Macromya* found in Asahan (SERD 4), *Polypedilum* and *Coryneura* in Cawang Kanan Hulu (SERD 5) and *Dasyhelea* in Muara Cawang (SERD 6)

Discussion

The seven streams observed are streams located in the highland range from 1178 - 2097 m. The streams generally have a current velocity range from medium to very fast with rock-dominated substrates. The seven streams are dominated by Insects. On the Stream Indikat found crabs *Parathelphusa maculata* one individuals that obtained at stream banks with relatively slow current velocity when collecting fish sampling using electrofishing devices. *Parathelphusa maculata* belonged to the family of Pharathelphusidae but is now classified into the Gecarcinucidae family (Klause *et al*., 2008). This crab included in the IUCN Red List of Threatened species as Least Concern (LC). Cawang Kanan Hulu Stream (SERD 5) with the highest elevation among the other streams (2097 m) is dominated by Orthocladinae 1 (50%). This genus is found alongside the stream with a substrate covered with algae mat. The mat provides microhabitat and a food source for Orthocladinae. Members of Orthocladinae may occurred in very high densities, especially in association with filamentous algae. Orthocladinae feed on living vascular plant and macroalgae, and sher leaf litter (Giller and Malmqvist 2003). In addition to the closed subtrates algae mat also found one genus of worm (Oligochaeta) from the family tubificidae only one individual.On the Indikat and Asahan Stream found Arachnida each stream 2 and 1 individual respectively. Arachnida that get this habitat is not in the water, but make nests in plants, especially at the bottom near the surface of the soil. These genera are collected at the edge of the stream where plants are present.

The genera diversity index of macroinvertebrates in the all streams classified as moderate with an index (H ') ranging from 1.92 to 2.94. Based on the criteria Lee, *et al*. (1978) that streams with macroinvertebrate diversity index greater than two indicate that the stream is considered clean water. In general streams in the SERD area is classified as clean. The presence of EPT (Ephemeroptera, Plecoptera, Trichoptera) on the seven streams that observed also shows indicator of clean water quality, especially Plecoptera usually live in rocky upstream or low stream order where temperatures are cooler. This nymph sensitive to organic pollution and low oxygen, but tolerant of acidic conditions (Giller and Malmqvist (2003).

The presence of macroinvertebrate genera in each stream depends on the habitat's suitability and its adaptability to the environmental conditions of the stream. Hence there are genera that can be found throughout the stream and there are also genera whose presence is rarely present only in certain streams. The well-adapted genera in the Stream in the SERD region are *Centroptilum, Pseudocloeon, Hydropsyche* and *Neoperla*. There are three genera whose presence on six streams of seven streams observed ie *Anthocha* not found in Cawang Kiri (SERD 2), *Baetis* and *Phagocata* not found in Cawang Tengah (SERD 3). All of these genera

have good morphological adaptability to strong currents, because they have body shape and tools to maintain themselves with strong currents: *Centroptilum, Baeti, Pseudocloeon* and *Neoperla* have dorsoventral flat bodies, steamlining and strong claws. Hydropsyche has net spining, and Anthocha has a circlet of hooks on the abdomen proleg, wich attached to rock substrate by the larvae, (Allan, 2001). Genera are rarely found in the number of individuals one or two individuals. The absence of a river may be due to its small population, so the chances of getting caught are also small.

Conclusion

1. The stream ecosystem in the SERD region is relatively undisturbed, the quality of clean water indicated by the number of genera of each river is high relatively ranges from 23-34 genera with the number of individuals range from 91 to 295 individuals, the genera diversity index ranges from 1.92 -2.94 is moderate and the water quality is classified as clean.
2 The presence of genera in each river varies. Genera found in all streams are the *Centroptilum, Neoperla, Hydropsyche,* and *Pseudocloeon. Anthocha, Baetis, Phagocata* are not found in one river. The predominant macroinvertebrate genera are: *Centroptilum, Pseudocloeon*, *Nemouraelmis, Stenelmis, Simulium, Anthocha, Neophylax, Hydropsyche* and *Psychomya*
3. There found one genus of crab *Parathelphusa maculate* included in the IUCN Red List of Species Threatened 2008 as least concern (LC).

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Appendix

Predominan macroinvertebrates genera in stream around SERD area

		
Pseudocloeon	**Nemuraelmis**	**Steinelmis**
		
Anthocha	**Centroptilum**	**Simulium**
		
Hydrosyche	**Neophylax**	**Psychomya**

This crab included in the IUCN Red List of Threatened species as Least Concern (LC)

Parathelphusa maculata

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FINAL REPORT

FLORA SURVEY IN PROJECT AREA OF PT SUPREME ENERGY RANTAU DADAP SOUTH SUMATERA PROVINCE

PT Environmental Resource Management

Jakarta 2017

I. INTRODUCTION

1.1 Background

PT. Supreme Energy Rantau Dedap (PT SERD) is a joint Venture of Supreme Energy, Engie and Marubeni to develop a geothermal power plant two regencies Muara Enim and Lahat and one city (Pagar Alam) in South Sumatra Province.

A flora survey is to be conducted at the areas of a (i) transmission line and (ii) brine line. The purpose of this survey is to obatain further information on biodiversity especially flora at the above mentioned areas and improve understanding of the conditions of these areas. While the surveys do not need to be conducted along entire transmission line and brine pipeline route, they should be targeted at areas where natural biodiversity values are likely to be present. Adequate levels of sampling should be carried out to representative understanding of the biodiversity values, especially flora, and condition along transmission line and brine pipeline.

1.2 Flora Target

Keys species that focused for the flora surveys were redlist IUCN species, species protected in Indonesian Law, endemicity and potential invasive species.

1.3 Objective of the Study

The objectives of flora survey in Enim project area, South Sumatra Province were to :

1. Determine the plant species of conservation significance, endemicity, and invasive species along the transmission line and brine pipeline route
2. Vegetation class mapping at the survey area.

1.4 Time of Flora Survey

Flora survey conducted in 9-15 May 2017 along the transmission line and brine pipeline route area of PT Supreme Energy Rantau Dadap (SERD), Muara Enim, South Sumatera.

II. METHODS

2.1 Location and Time

The suvey conducted at PT SERD project area Muara Enim District, South Sumatra Province. At least 8 days field observation for get data and information related to composition and flora diversity, from 9-15 May 2017. The observations focused at forested area of PT SERD area, Patah Mount. The location of sample plots were tranmission line (T 01- T 037) and brain line (Fig. 1).

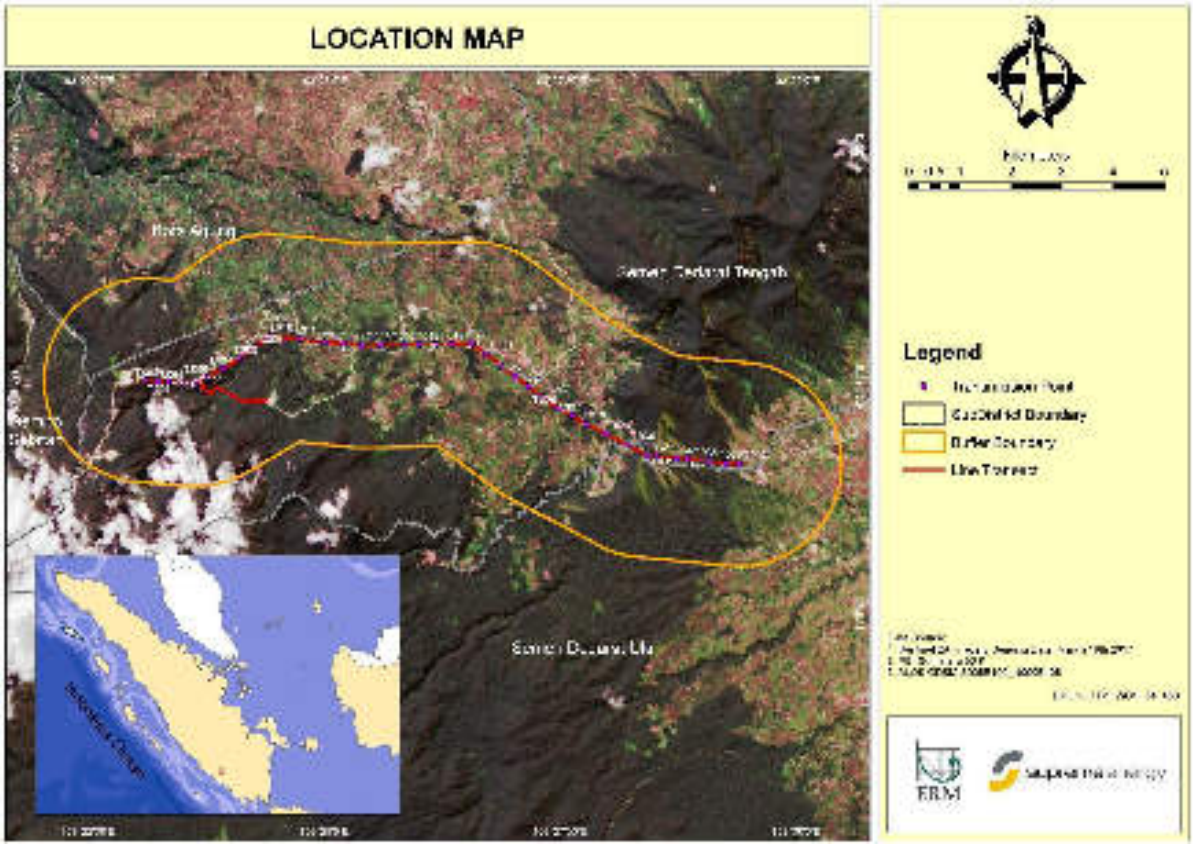

Fig. 1 Location map

2.2 Tools and Materials

Tools and materials used in this survey: Map of study location, GPS, compass, camera, plastic bag, alcohol, cutter, herbarium tools.

2.3 Sampling Design

The vegetation of the survey area designed transect 20 m at right side and 20 m at left side along the tranmission line and the brine line, especially in forest area.

2.4 Data Collection

Data of vegetation recorded i.e. : species name (local/scientific name), distribution, conservation status, endemicity, and invasiveness.

2.5 Data Analysis

2.5.1 Conservation Status and Endemicity

Conservation status of flora species based on IUCN Red List of Threathen Species and Indonesian Law for Protected Species (Government Decree No. 7/1999). Beside that, endemicity of species at the study area evaluated.

2.5.5 Invasive Species

Identification of invasive plant species based on some literatures, including : Weber (2005), Setyawati *et el*. (2015) and Tjitrosoedirdjo (2016).

III RESULT AND DISCUSSION

Vegetation Type

Vegetation type or forest in survey area located at 1278 – 1984 m above sea level, belong to tropical mountain rain forest (Van Steenis 1935 cit in Soerianegara & Indrawan, 2013).

Generally, condition of vegetation type or vegetation cover along survey transect of tranmission line consists of primary mountain rain forest, secondary forest, shrub, and coffee plantation (Fig 2-5). Whereas along transect of brine line, vegetation condition was tropical mountain rain forest (Patah Mount).

Fig. 2 Primary forest

Fig. 3 Secondary forest

Fig. 4 Shrub

Fig. 5 Coffee plantation

Shrub is vegetation like sunlight or intolerant, therefore shrub prefer grow at open area or degraded forest. While coffee plantation is main agriculture commodity of local community at open area. Coffee plantation managed intensively by local community.

In general, vegetation cover every segment along tranmission line (T 01 – T 037) at survey area can be seen at Table 1.

Table 1 Vegetation cover at every segment in transmission line area T 01 – T 037

No.	Segmen	Vegetation cover
1	T 01 – T 07	Primary forest
2	T 07 – T 08	Shrub, coffee plantation, primary forest, coffee plantation
3	T 08 - T 09	Coffee plantation, primary forest, coffee plantation, secondary forest
4	T 09 – T 10	Secondary forest, coffee plantation
5	T 10 – T 11	Coffee plantation, shrub, secondary forest
6	T 11 – T 12	Coffee plantation
7	T 12 – T 13	Coffee plantation
8	T 13 – T 14	Coffee plantation, secondary forest
9	T 14 – T 15	Secondary forest
10	T 15 – T 16	Secondary forest, shrub
11	T 16 – T 17	Shrub, coffee plantation
12	T 17 – T 18	Coffee plantation, shrub
13	T 18 – T 19	Shrub
14	T 19 – T 20	Coffee plantation, shrub, plantation
15	T 20 – T 21	Open area, shrub, garden
16	T 21 – T 22	Garden, shrub
17	T 22 – T 23	Shrub, coffee plantation
18	T 23 – T 24	Coffee plantation, shrub, coffee plantation
19	T 24 – T 25	Coffee plantation, shrub
20	T 25 – T 26	Coffee plantation
21	T 26 – T 27	Coffee plantaion, shrub, secondary forest
22	T 27 – T 28	Secondary forest, coffee plantation, shrub

23	T 28 – T 29	Shrub, secondary forest
24	T 29 – T 30	Secondary forest, shrub
25	T 30 – T 31	Secondary forest
26	T 31 – T 32	Secondary forest, shrub
27	T 32 – T 33	Shrub, secondary forest
28	T 33 – T 34	Shrub
29	T 34 – T 35	Shrub, secondary forest
30	T 35 – T 36	Secondary forest
31	T 36 – T 37	Secondary forest, shrub, coffee plantation

Survey result identified 47 trees species, 33 orchids species and flowering plant and 36 species of shrubs / ground vegetation (Appendix 1). Trees species of primary forest found along survey transect among others : *Dacrycarpus imbricatus*, *Podocarpus rubens*, *Schima wallichii*, *Quercus sumatrana*, *Altingia excelsa*. Whereas, trees species at secondary forest like *Macaranga gigantea*, *Macaranga* sp.

Species *Dacrycarpus imbricatus* was main tree species at tropical mountain rain forest, they found at all transect segment, both transmission line and brine line. *Dacrycarpus imbricatus* widely distributed at tropical mountain rain forest in Indonesia. *Dacrycarpus imbricatus* has habitus big and tall tree, therefore *Dacrycarpus imbricatus* was dominant at forest canopy (Fig. 6).

Fig. 6 Tree of *Dacrycarpus imbricatus* at tropical mountain rain forest

The condition of mountain rain forest of Patah Mount was moist constitute suitable habitat for growing of orchids, both terrestrial orchids and ephypite orchids. Survey result identified 33 species of orchids along survey transect, especially in primary mountain rain forest (Fg. 7).

Fig. 7 Tree as habitat of orchids at mountain rain forest

Vegetation of shrubs along survey transect identified among others: *Austroeupatorium inulaefolium, Pteris tripartica, Lantana camara*, *Melastoma malabatrichum*, *Clidemia hirta, Anaphalis longifolia*. Shrub vegetation many grow in disturbed forest and coffee plantation of local community.

Different with other shrub species, *Anaphalis longifolia* is shrub with endemic habitat at mountain rain forest (Fig. 8). *Anaphalis longifolia* found at two survey locations that were transmission line, point T 01 and segment T 10 – T 11, and brine line, near Well Pad I. Habitat condition of *Anaphalis longifolia*, generally open area with high sun light intensity. Habitat slope of *Anaphalis longifolia* at survey location has variation from slightly to steep. *Anaphalis longifolia* found at 1200 m to 1800 m above sea level. This species distribute in Java, Sumatera, Nusa Tenggara (Lesser Sunda Islands), South Sulawesi, Morotai (van Steenis 2010).

Fig. 8 Species of *Anaphalis longifolia*

Map of land cover based on RSNI-1b BSN (Badan Standar Nasional/ National Standard Agency) available at Appendix 2. Based on this map, many of survey areas were dry area agriculture, especially coffee plantation of local community.

Conservation Status

Flora species identified at survey locations many of them were abundant species, they had no conservation status, only a little flora species had conservation status, especially IUCN redlist, endemicity, and protected by Indonesian Law or Government Decree No. 7/1999.

Flora Species belong to IUCN redlist with vulnerable category that was *Saurauia cauliflora* Noronha ex DC and least concern category that was *Podocarpus ruben*. Endemic species of Sumatera identified *Amorphophalus beccarii* (Govaerts & Frodin 2002). Beside that identified South Sumatera endemic that was *Vanda foetida* (Comber 2001). Whereas one species protected by Government Decree No. 7/1999 that was *Nepenthes rafflesiana.*

Species *Saurauia cauliflora* is known local name Ingo-ingo belukar. This species found in transmission line at 1800 m above sea level, segment T.31 – T.32, ecotone between shrub and secondary forest.

Species *Podocarpus rubens* found in brine line that was segment EB-04 and EB-35 at 1677 m above sea level. Habitat condition of this species belong to primary forest with steep slope. Local name of *P. rubens* is kayu taji. Geographical position of *P rubens* found at 4° 12' 30.6059" SL 103° 23' 50.7299" EL.

Species *Amorphophalus beccarii* in survey location found at both primary forest and secondary forest. *Amorphophalus beccarii* found at transmission line and brine line. At transmission line found at some segments, from point T 01 to T 11 and other segments in secondary forest found. This species found at altitude 1788 m until 1970 m above sea level. Generally, this species grow in open canopy at primary forest and secondary forest. Habitat slope of this species was slightly until steep (Fig. 9).

Fig. 9 Species *Amorphophalus beccarii*

Orchid species of *Vanda foetida* found at primary forest. This orchid species grow at trees or epiphyte. Species *V. foetida* only found at transmission line, segmen 17-18. This species located at altitude 1588 m above sea level, it found epiphyte on dead tree in shrub area where dominated by *Austroeupatorium inulaefolium*. Geographical location found *V. foetida* at point 4° 12' 2.79" LS 103° 26' 7.55" BT (Fig. 10)

Fig. 10 Species *Vanda foetida*

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Species of pitcher plant or *Nephenthes rafflesiana* in survey location found at primary forest. Species *N. rafflesiana* grow on the soil. This species found at primary forest of transmision line segment T03-T04, altitude 1987 m above sea level. Species *N. rafflesiana* grow epiphyte on decayed of wood. Slope condition of *N. rafflesiana* habitat is steep.

Species *N rafflesiana* also found in survey area of brine line that was segement EB-04 and EB-35, with altitude 1726.m above sea level, and steep slope. This species grow on the soil around shrub at primary forest. Geographical position found this species that was at 4^{o} 12' 27.23" LS 103^{o} 23' 16.82" BT and 4^{o} 12' 32.53" LS 103^{o} 23' 50.18" BT. Based on GD (PP) No. 7/1999, all species of pitcher plants protected (Fig. 11).

Fig. 11 Species *Nephenthes rafflesiana*

Endemic plant species or pretected species, they are dependent on the presence of other plant species, especially trees. Therefore, if their habitat change drastically, for example cutting trees, this condition will influence to sustainable of this species. Nevertheles, to decrease habitat change impact, it can be tried by plant breeding.

Spasial distribution of IUCN red list, endemic and protected species available at Appendix 3.

Invasive Species

Shrub vegetation grow at disturbed forests or open areas, especially coffee plantation, many of them were invasive species They identified 35 invasive species or potentially invasive, native or alien species. Invasive alien species in the survey area, especially tranmission line among others : *Austroeupatorium inulaefolium, Musa acuminata, Pteris tripartita,* and *Clidemia hirta* (Appendix 4).

Plant species of *Austroeupatorium inulaefolium* is invasive alien species come from Tropical America (Setyawati *et al.* 2015). This species grow at disturbed forest, plantation and perennial crops, roadside. Prefer moist condition, they can grow near sea level to 2100 m altitude (Fig. 12).

Fig. 12 Species *Austroeupatorium inulaefolium*

Flora species of *Musa acuminata* known local name as pisang hutan (Fig. 13). This species is prefer moist or wet condition. In survey location found overflow near river or wet area with open forest canopy, both at tranmission line and brine line. *Musa acuminata* is plant invasive species in Indonesia come from South East Asia (Tjitrosoedirjo *et al*. 2016)

Fig. 13 Species *Musa acuminata*

Species *Pteris tripartita* is plant from fern family (Fig. 14). In suvey location found overflow at disturbed forest and coffee plantation of local community. This plant is potentially as invasive species. As reported, in Cuba this species belong to invasive species (Oviedo PR, Herrera OP, Caluff MG et al. 2012 in CABI 2017).

Fig. 14 Species *Pteris tripartita*

In survey location, species *Clidemia hirta* found at open area, especially coffee plantation of local community (Fig. 15) This species belong to invasive alien species and come fromi South Amerika (Setyawati *et al*. 2015).

Fig. 15 Species *Clidemia hirta*

The presence of invasve species, native or alien, in survey location there are very important to attention because they can to become seriously problems to ecology, economic and social.

Controling of plant invasive species can be done through eradication or physic, chemistry, and biology method depend on environmental condition, fund, tool and available facility.

CONCLUSSION

Flora Species in survey location belong to IUCN redlist with vulnerable category that was *Saurauia cauliflora* and least concern category that was *Podocarpus ruben*. Endemic species of Sumatera identified *Amorphophalus beccarii,* and South Sumatera endemic that was *Vanda foetida. Anaphalis longifolia* had endemic habitat in mountain rain forest. Whereas one species protected by Government Decree No. 7/1999 that was *Nepenthes rafflesiana*.

Vegetation covers in survey location consist of primary mountain forest, secondary forest, shrub vegetation and coffee plantation of local community at around areas.

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Appendix 1 Flora species in study area

Appendix 1a. Tree Species List

No.	Famili	Local name	Species	Landcover								Status				Location	
				PDF	SDF	Bu	UC	UCB	BL	BuA	PF	WB	E	IU	RI	Brine Line	Transmision Line
1	Araliaceae	Kayu gebong	*Acanthopanax sp.*		•												07,08
2	Lauraceae	Medang layar	*Actinodaphne sp.*		•												30,31
3	Lauraceae	Medang keladi	*Actinodaphne sp.*	•													06,07
4	Lauraceae	Medang kuning telur	*Actinodaphne sp.*	•													06,07
5	Meliaceae	Bekeu serian	*Aglaia sp.*		•	•											29,30
6	Meliaceae	Berenai	*Aglaia sp.*		•												30,31
7	Lauraceae	Kayu bekeu	*Aglaia sp.*		•												06,07
8	Altingiaceae	Cemage	*Altingia excelsa* Noronha			•											08,09
9	Primulaceae	Mata kandil	*Ardisia crispa* (Thunb.) A.DC.	•	•												01,02,03,04
10	Primulaceae	Beruas	*Ardisia sp.*	•	•												01,02,06,07
11	Fagaceae	Kayu Pasang	*Castanopsis acuminatissima* (Blume) A.DC.	•													01,02
12	Lauraceae	Medang kayu manis	*Cinnamomum heyneanum* Nees		•	•											30,31
13	Podocarpaceae	Lengkenai Daun	*Dacrycarpus imbricatus var. curvulus* (Miq.) de Laub.	•													01,02
14	Cannabaceae	Ringu-ringu rimba	*Gironniera sp.*		•	•											31,32
15	Euphorbiaceae	Delenge	*Homalanthus populneus* (Geiseler) Pax			•											05,06
16	Fabaceae	Medang cempaka	*Inocarpus fagifer* (Parkinson) Fosberg	•	•												14,15
17	Fagaceae	Udang udang	*Lithocarpus sp.*		•	•											26,27
18	Lauraceae	Pasang Babi	*Litsea sp.*		•	•											26,27
19	Lauraceae	Medang kapur	*Litsea sp.*		•												26,27
20	Euphorbiaceae	Sepat	*Macaranga gigantea* (Rchb.f. & Zoll.) Müll.Arg.			•											05,06
21	Euphorbiaceae	Mahang	*Macaranga sp.*			•											08,09

No.	Famili	Local name	Species	Landcover									Status			Location	
				PDF	SDF	Bu	UC	UCB	BL	BuA	PF	WB	E	IU	RI	Brine Line	Transmision Line
22	Meliaceae	Kuku biawak	*Melia sp.*			•											26,27
23	Meliaceae	Merkawe	*Melia sp.*	•												•	
24	Meliaceae	Bekeu duku	*Melia sp.*		•	•						•					26,27
25	Rubiaceae	Kekawe	*Nauclea sp.*			•											25,26
26	Rubiaceae	Sp. A	*Neonauclea sp.*			•											07,08
27	Euphorbiaceae	Tabernaemontana	*Neoscortechinia nicobarica* (Hook.f.) Pax & K.Hoffm.	•	•											•	35,36
28	Lauraceae	Medang cantik	*Notophoebe sp.*	•													01,02,03,04,05,06
29	Lauraceae	Medang paoh	Persea sp.		•												07,08
30	Lauraceae	Pinggiran punai	*Phoebe sp.*		•	•											26,27
31	Piperaceae	Seserehan	*Piper aduncum* L.			•											10,11
32	Lechytidaceae	Kerido	*Planchonia sp.*		•							•					06,07,08
33	Podocarpaceae	Kayu Taji	*Podocarpus rubens* de Laub.	•										LC		•	
34	Fagaceae	Pasang gasing	*Quercus sumatrana* Soepadmo	•													01,02
35	Actinidaceae	Tilam	*Saurauia asperifolia* Stapf ex E. G. Baker	•	•											•	15,16,01,02
36	Actinidaceae	Ingo Ingo Belukar	*Saurauia cauliflora* Noronha ex DC.		•									VU			31,32
37	Theaceae	Medang liut	*Schima wallichii*	•													26,27
38	Myrtaceae	Kelat daun kecil	*Syzygium antisepticum* (Blume) Merr. & L.M.Perry	•													01,02
39	Myrtaceae	Kayu kelat	*Syzygium sp.*	•													02,03,04
40	Myrtaceae	Kelat jambu	*Syzygium sp.*	•												•	
41	Meliaceae	Serian	*Toona sureni* (Blume) Merr.		•												05,06
42	Podocarpaceae	Lengkenai ekor tikus	*Dacrycarpus imbricatus* (Blume) de Laub.	•												•	
43	Rubiaceae	Kayu Labu	*Nauclea sp.*		•												26,27
44	Theaceae	Medang basah	*Schima wallichii*	•													01,01

No.	Famili	Local name	Species	Landcover									Status				Location
				PDF	SDF	Bu	UC	UCB	BL	BuA	PF	WB	E	IU	RI	Brine Line	Transmision Line
45	Lauraceae	Pasang Putih	*Phoebe sp.*		•												26,27
46	Euphorbiaceae	Semantong	*Macaranga sp.*	•												•	
47	Rutaceae	Sepungul	*Melicope denhamii* (Seem.) T.G.Hartley		•	•											26,27

Appendix 1b. Orchids and flowering plant Species List

No.	Famili	Species	Landcover									Status				Location
			PDF	SDF	Bu	UC	UCB	BL	BuA	PF	WB	E	IU	RI	Brine Line	Transmision Line
1	Araceae	*Amorphophallus beccarii* Engl.	•	•	•							✔			•	02,03,06,07,15,16
2	Nepenthaceae	*Nepenthes rafflesiana* Jack	•										LC		•	01,02
3	Orchidaceae	*Appendicula ramosa* Blume	•												•	
4	Orchidaceae	*Appendicula reflexa* Blume		•											•	15,16,30,31
5	Orchidaceae	*Arundina graminifolia* (D.Don) Hochr			•			•			•					7,8,19,20,31,32
6	Orchidaceae	*Ascidieria cymbidifolia* (Ridl.) W.Suarez & Cootes			•											29,30
7	Orchidaceae	*Calanthe pulchra* (Blume) Lindl	•													05,06
8	Orchidaceae	*Calanthe rigida* Carr	•												•	
9	Orchidaceae	*Calanthe transiens* J.J.Sm	•												•	
10	Orchidaceae	*Calanthe triplicata* (Willemet) Ames	•		•											06,07,08
11	Orchidaceae	*Calanthe flava* (Blume) C.Morren			•											15,16
12	Orchidaceae	*Calanthe ceciliae* Rchb.f.	•		•										•	32,33
13	Orchidaceae	*Chelonistele sulphurea* (Blume) Pfitzer	•													01,02
14	Orchidaceae	*Coelogyne contractipetala* J.J.Sm	•												•	
15	Orchidaceae	*Coelogyne cuprea* H.Wendl. & Kraenzl	•												•	

No.	Famili	Species	Landcover									Status				Location	
			PDF	SDF	Bu	UC	UCB	BL	BuA	PF	WB	E	IU	RI	Brine Line	Transmision Line	
16	Orchidaceae	*Dendrobium crumenatum* Sw	•													01,02	
17	Orchidaceae	*Dendrobium mutabile* (Blume) Lindl	•													02,03	
18	Orchidaceae	*Dendrobium pedicellatum* J.J.Sm	•													03,04	
19	Orchidaceae	*Eria palmifolia* Ridl		•												15,16	
20	Orchidaceae	*Eria robusta* (Blume) Lindl	•													01,02	
21	Orchidaceae	*Goodyera repens* (L.) R.Br	•													01,02	
22	Orchidaceae	*Liparis crenulata* (Blume) Lindl		•												35,36	
23	Orchidaceae	*Liparis nervosa* (Thunb.) Lindl		•											•	14,15	
24	Orchidaceae	*Liparis viridiflora* (Blume) Lindl	•	•	•	•	•								•	03,04,05,15,16,26,27,30,31,33,34	
25	Orchidaceae	*Mycaranthes latifolia* Blume	•												•		
26	Orchidaceae	*Phaius callosus* (Blume) Lindl	•	•											•	06,07,15,16	
27	Orchidaceae	*Pinalia bractescens* (Lindl.) Kuntze		•												15,16	
28	Orchidaceae	*Podochilus microphyllus* Lindl		•												34,35	
29	Orchidaceae	*Saccolabium rantii* J.J.Sm				•										26,27	
30	Orchidaceae	*Spathoglottis plicata* Blume			•										•	10,11	
31	Orchidaceae	*Vanda foetida* J.J.Sm			•							✔				17,18	
32	Orchidaceae	*Oberonia disticha* (Lam.) Schltr.	•	•											•		
33	Asteraceae	*Anaphalis longifolia* (Blume) Blume ex DC.			•	•						✔			•	01,02,10,11	

Appendix 1c. Shrubs / ground vegetation Species List

No.	Famili	English Name	Species	Landcover									Status				Location		Notes
				PDF	SDF	Bu	UC	UCB	BL	BuA	PF	WB	E	IU	RI	Brine Line	Transmision Line	
1	Asteraceae	Marsh para cress	*Acmella paniculata* (Wall. ex DC.) R.K.Jansen								•			LC			04,05	Alien invasive
2	Asteraceae	Mistflower	*Ageratina riparia* (Regel) R.M.King & H.Rob.			•						•					24,25	Alien invasive

No.	Famili	English Name	Species	Landcover									Status			Location		Notes
				PDF	SDF	Bu	UC	UCB	BL	BuA	PF	WB	E	IU	RI	Brine Line	Transmision Line	
3	Fabaceae	Billy goat weed	*Ageratum conyzoides* (L.) L.			•	•	•	•								07,08	Alien invasive
4	Asteraceae	Austroeupatorium	*Austroeupatorium inulaefolium* (Kunth) R.M.King & H.Rob.		•	•		•				•				•	06,07,08,16, 17,18,19,20, 21,22,23	Alien invasive
5	Asteraceae	Hairy beggar-ticks	*Bidens pilosa* L.				•	•			•						07,08	Alien invasive
6	Papilionaceae	Butterfly pea	*Centrosema pubescens* Benth.			•											10,11	Alien invasive
7	Asteraceae	Cunambi*	*Clibadium surinamense* L.						•								10,11	Alien invasive
8	Melastomataceae	Soapbush	*Clidemia hirta* (L.) D. Don			•	•	•									23,24	Alien invasive
9	Asteraceae	Orfireweed	*Crassocephalum crepidioides* (Benth.) S.Moore				•	•									07,08	Alien invasive
10	Fabaceae	Pepper elder	*Crotalaria pallida* Aiton						•								10,11	Alien invasive
11	Asteraceae	Tassel flower	*Emilia sonchifolia* (L.) DC. ex DC.				•	•									07,08	Alien invasive
12	Fabaceae	Mother of cocoa	*Gliricidia sepium* (Jacq.) Walp.						•								10,11	Alien invasive
13	Poaceae	Blady grass	*Imperata cylindrica* (L.) Raeusch.			•	•	•	•								07,08	Native invasive
14	Lamiaceae	Wild sage	*Lantana camara* L.			•	•	•									37,38,40	Alien invasive
15	Fabaceae	Coffe bush	*Leucaena leucocephala* (Lam.) de Wit				•	•	•								09,10,18,19	Alien invasive
16	Onagraceae	Peruvian primrose	*Ludwigia peruviana* (L.) H.Hara			•						•					26,27	Alien invasive
17	Melastomataceae	Banks melastoma	*Melastoma malabathricum* L.			•		•									07,08	Native invasive
18	Asteraceae	Bitter vine	*Mikania micrantha* Kunth					•	•								09,10	Alien

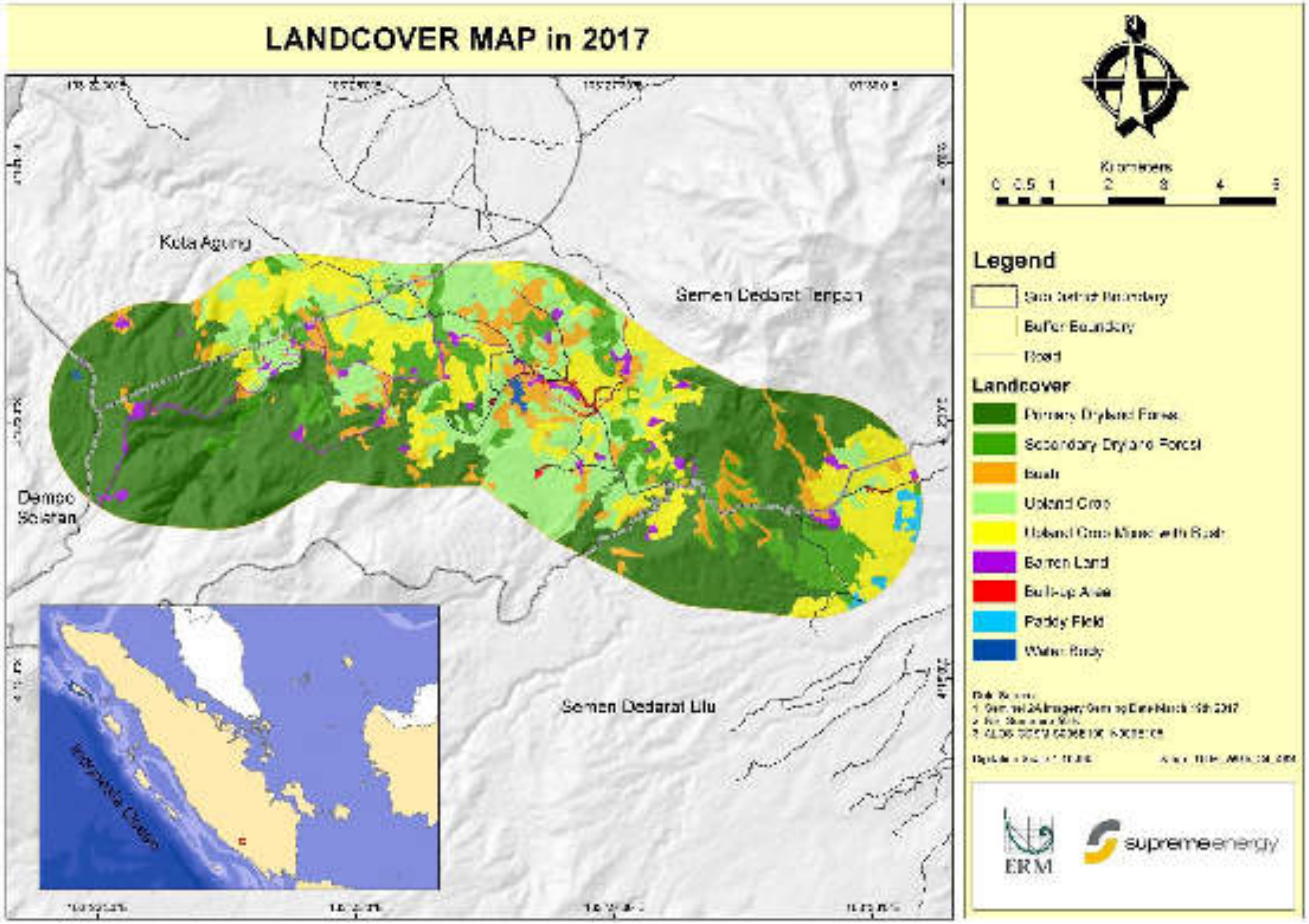
No.	Famili	English Name	Species	Landcover										Status		Location		Notes
				PDF	SDF	Bu	UC	UCB	BL	BuA	PF	WB	E	IU	RI	Brine Line	Transmision Line	
																		invasive
19	Fabaceae	Giant sensitive plant	*Mimosa diplotricha* Sauvalle						•								09,10	Alien invasive
20	Fabaceae	Bashful plant	*Mimosa pigra* L.						•								09,10	Alien invasive
21	Fabaceae	Touch-me-not	*Mimosa pudica* L.						•					LC			09,10	Alien invasive
22	Musaceae	Banana trees	*Musa acuminata* Colla		•		•	•									06,07	Native invasive
23	Passifloraceae	Passion fruit	*Passiflora edulis* Sims		•	•	•	•	•								06,07,	Alien invasive
24	Passifloraceae	Sweet granadilla	*Passiflora ligularis* Juss.		•	•	•	•	•								06,07,	Alien invasive
25	Poaceae	Elefante grass	*Pennisetum purpureum* Schumach.				•	•						LC			07,08,18,19	Alien invasive
26	Piperaceae	Bamboo piper	*Piper aduncum* L.						•								10,11	Alien invasive
27	Pteridaceae	Helecho*	*Pteris tripartita* Sw.			•	•	•	•								06,07,08,09, 17,18	Native invasive
28	Euphorbiaceae	Castor bean	*Ricinus communis* L.				•	•									16,17	Alien invasive
29	Acanthaceae	Minnie root	*Ruellia tuberosa* L.									•					26,27	Alien invasive
30	Poaceae	Wild sugarcane	*Saccharum spontaneum* L.						•					LC			07,08	Alien invasive
31	Caesalpiniaceae	Rambling senna	*Senna bicapsularis* (L.) Roxb.				•	•						LC			37,38,40	Alien invasive
32	Malvaceae	Jelly leaf	*Sida rhombifolia* L.						•			•					26,27	Native invasive
33	Solanaceae	Giant devil's fig	*Solanum chrysotrichum* Schltdl.				•	•									07,08	Alien invasive
34	Rubiaceae	Winged False	*Spermacoce alata* Aubl.				•	•									07,08,40	Alien

No.	Famili	English Name	Species	Landcover									Status			Location		Notes
				PDF	SDF	Bu	UC	UCB	BL	BuA	PF	WB	E	IU	RI	Brine Line	Transmision Line	
		Buttonweed																invasive
35	Lamiaceae	Indian snake weed	*Stachytarpheta indica* (L.) Vahl						•								09,10	Alien invasive
36	Cyatheaceae	Treefern	*Sphaeropteris glauca* (Blume) R.M. Tryon	•	•	•	•									•	01, 02, 03, 04, 05	-

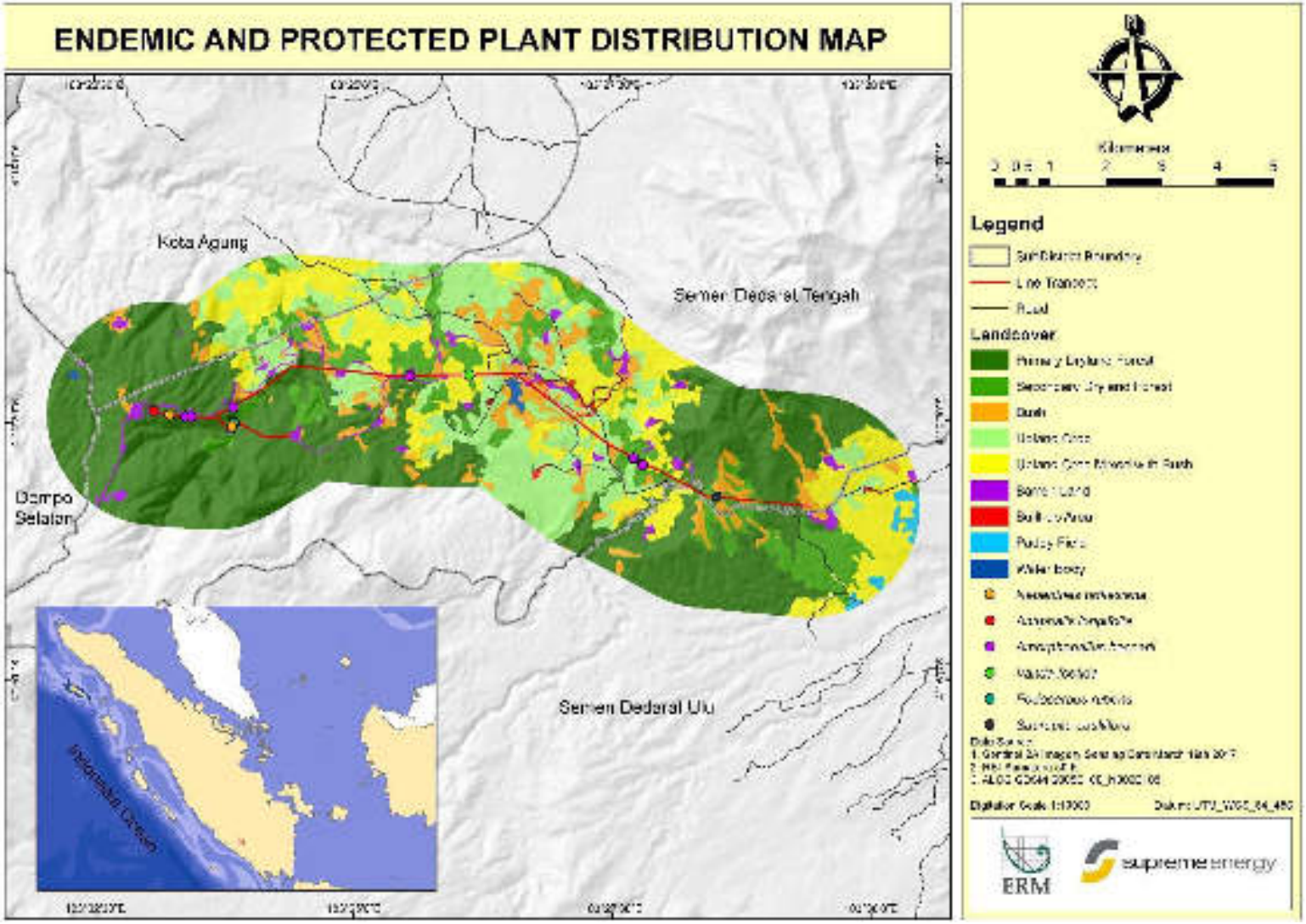
Notes

PDF	Primary Dryland Forest
SDF	Secondary Dryland Forest
Bu	Bush
UC	Upland Crop
UCB	Upland Crop with Bus
BL	Barren Land
BuA	Built-up Area
PF	Paddy Field
WB	Water Body
IUCN	IUCN Red List
RI	PP No.7 Thn 1999
E	Endemic
*	Local name in it's native region

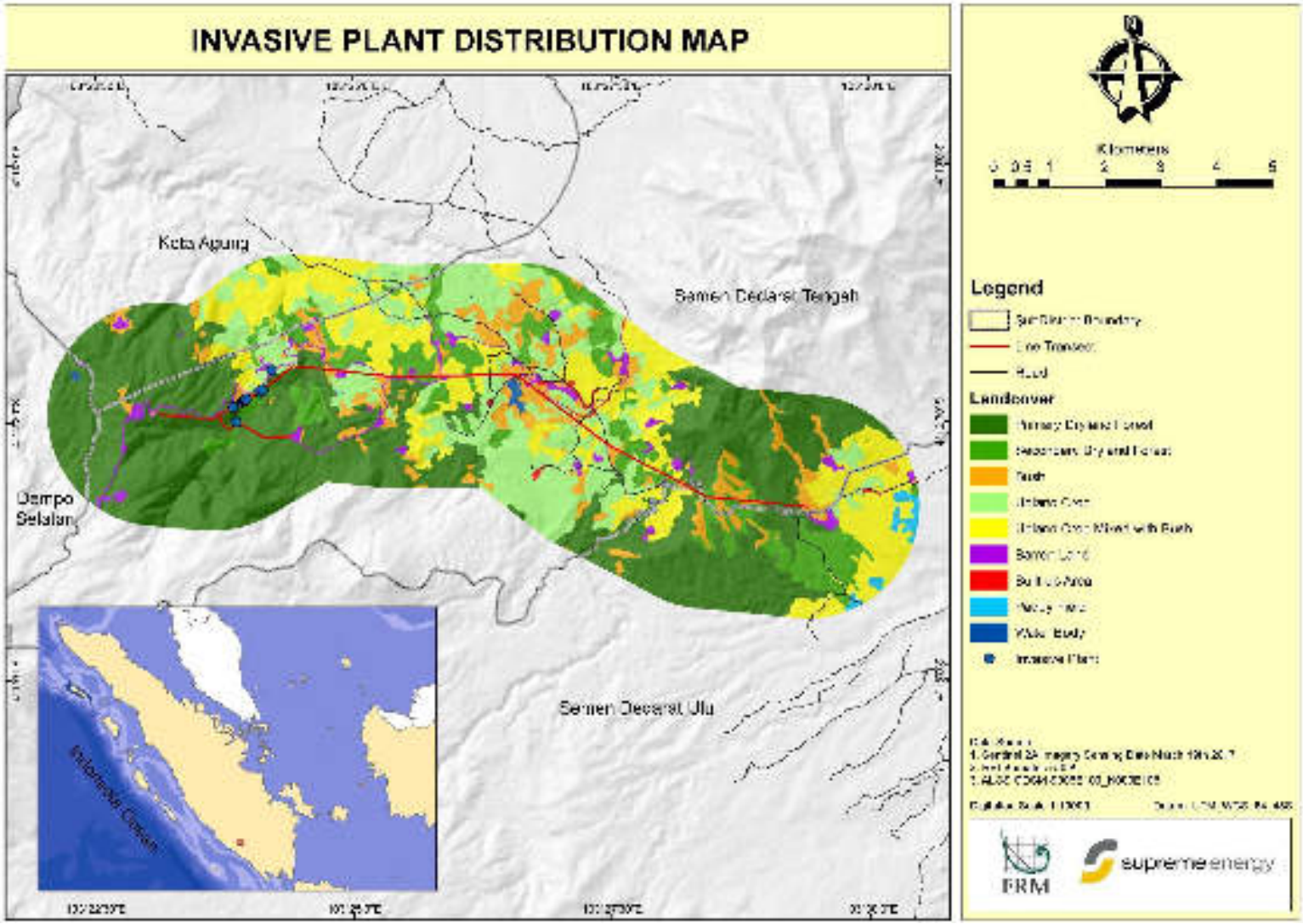
Appendix 2 Land cover



Appendix 3 Distribution of redlist, endemic and protected plant species



Appendix 4 Distribution of inavasive plant species



Herbarium Photo Log

No	Photo	Photo Location	GPS Point	Notes
1		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Saurauia asperifolia*
2		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Saurauia cauliflora*
3		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of Spesies kayu kapas (Malvaceae)
4		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Syzygium sp.*

5		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Quercus sumatrana*
6		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Homalanthus populneus*
7		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Ardisia crispa*
8		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Nothophoebe sp.*

9		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of Kayu cabe (Myrtaceae)
10		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Syzygium sp.*
11		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Macaranga gigantea*
12		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Altingia excelsa*

13		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Persea sp.*
14		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Acanthopanax sp.*
15		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Actinodaphne sp.*
16		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Inocarpus fagifer*

17		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Actinodaphne sp.*
18		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Aglaia sp.*
19		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Macaranga sp.*
20		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Melia sp.*

21		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Litsea sp.*
22		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Litsea sp.*
23		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Nauclea sp.*
24		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Phoebe sp.*

25		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Schima wallichii*
26		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Neonauclea sp.*
27		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Litsea sp.*
28		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Melia sp.*

29		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Macaranga sp.*
30		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Neoscortechinia nicobarica*
31		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Melia sp.*
32		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Syzygium sp.*

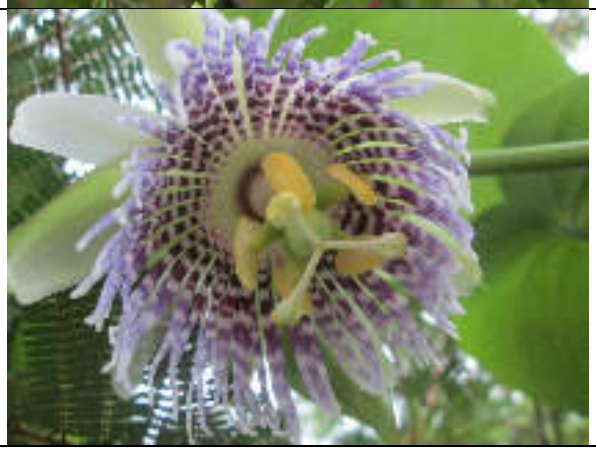
33		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Neonauclea sp.*
34		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Aglaia sp.*
35		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Litsea sp.*
36		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Aglaia sp.*

37		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Gironniera sp.*
38		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Actinodaphne sp.*
39		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Cinnamomum heyneanum*
40		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Castanopsis acuminatissima*

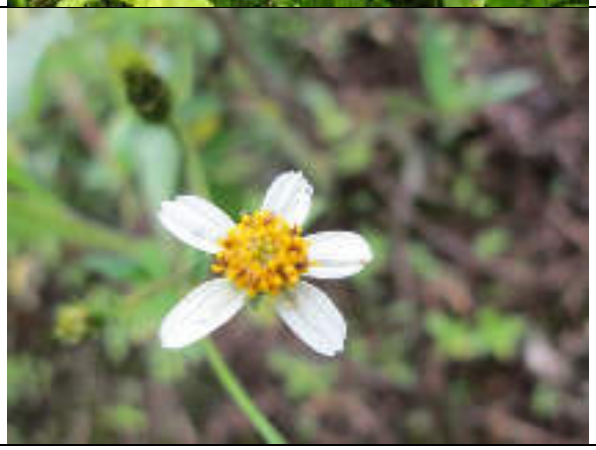
41		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Persea declinata*
42		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Toona sureni*
43		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Dacrycarpus imbricatus*
44		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Dacrycarpus imbricatus var curvulus*

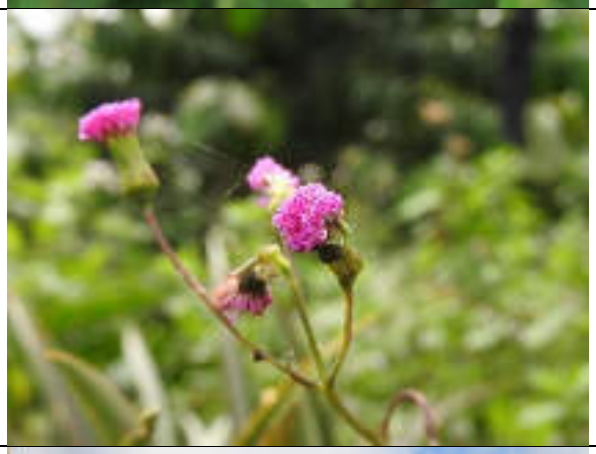
45		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Podocarpus rubens*
46		SERD Main Office	S4° 10.373' E103° 25.921'	Herbarium of *Melicope denhamii*

Invasive Plant Photo Log

N0	Photo	Location	GPS Point	Note
1		Segment T06 and T07	E : -4,205796 S : 103,397382	Invasive plant species *Musa acuminata* Colla
2		Brineland	E : -4,208208 S : 103,397833	Invasive plant species *Austroeupatorium inulaefolium* (Kunth) R.M.King & H.Rob.
3		Segment T07 and T08	E : -4,20493 S : 103,398793	Invasive plant species *Passiflora ligularis* Juss.

4		Segment T07 and T08	E : -4,204956 S : 103,398821	Invasive plant species *Passiflora edulis* Sims
5		Segment T07 and T08	E : -4,204717 S : 103,399207	Invasive plant species *Ageratum conyzoides* (L.) L.
6		Segment T07 and T08	E : -4,204717 S : 103,399207	Invasive plant species *Melastoma malabathricum* L.

7		Segment T07 and T08	E : -4,2046 S : 103,399216	Invasive plant species *Crassocephalum crepidioides* (Benth.) S.Moore
8		Segment T07 and T08	E : -4,2046 S : 103,399216	Invasive plant species *Solanum chrysotrichum* Schltdl.
9		Segment T07 and T08	E : -4,20451 S : 103,399358	Invasive plant species *Bidens pilosa* L.

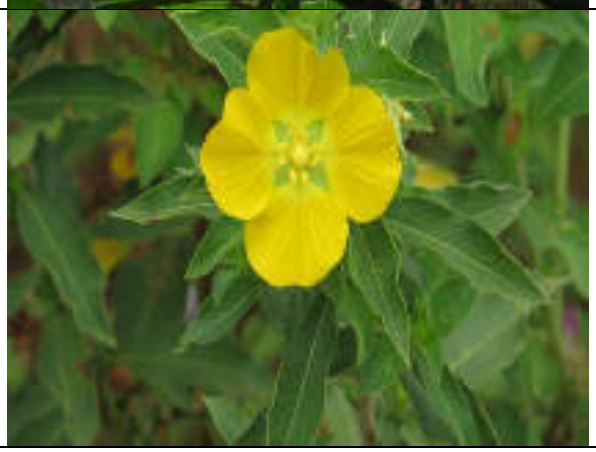
10		Segment T07 and T08	E : -4,203252 S : 103,40151	Invasive plant species *Spermacoce alata* Aubl.
11		Segment T07 and T08	E : 4,121158 S : 103,245195	Invasive plant species *Emilia sonchifolia* (L.) DC. ex DC.
12		Segment T08 and T09	E : -4,203078 S : 103,402083	Invasive plant species *Pteris tripartita* Sw.

13		Segment T09 and T10	E : -4,199829 S : 103,403579	Invasive plant species *Mikania micrantha* Kunth
14		Segment T09 and T10	E : -4,199829 S : 103,403579	Invasive plant species *Leucaena leucocephala* (Lam.) de Wit
15		Segment T09 and T10	E : -4,199814 S : 103,403652	Invasive plant species *Mimosa pudica* L.

16		Segment T09 and T10	E : -4,198947 S : 103,405205	Invasive plant species *Stachytarpheta indica* (L.) Vahl
17		Segment T09 and T10	E : -4,115619 S : 103,251886	Invasive plant species *Centrosema pubescens* Benth.
18		Segment T09 and T10	E : -4,198857 S : 103,405571	Invasive plant species *Mimosa pigra* L.

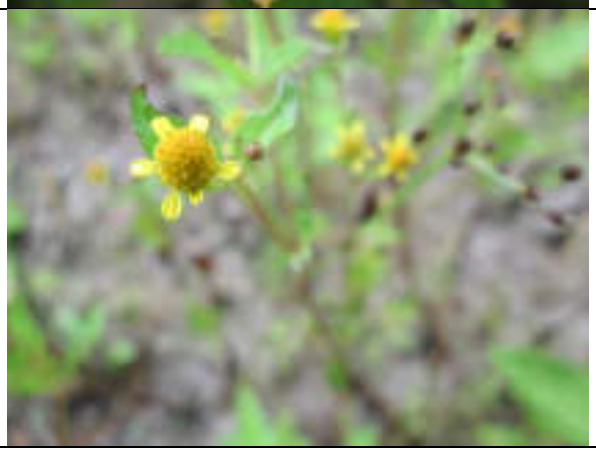
19		Segment T09 and T10	E : -4,198838 S : 103,40575	Invasive plant species *Mimosa diplotricha* Sauvalle
20		Segment T10 and T11	E : -4,198791 S : 103,406521	Invasive plant species *Clibadium surinamense* L.
21		Segment T10 and T11	E : -4,195481 S : 103,408728	Invasive plant species *Gliricidia sepium* (Jacq.) Walp.

22		Segment T10 and T11	E : -4,195481 S : 103,408728	Invasive plant species *Saccharum spontaneum* L.
23		Segment T10 and T11	E : -4,195312 S : 103,409015	Invasive plant species *Piper aduncum* L.
24		Segment T10 and T11	E : -4,195312 S : 103,409015	Invasive plant species *Crotalaria pallida* Aiton

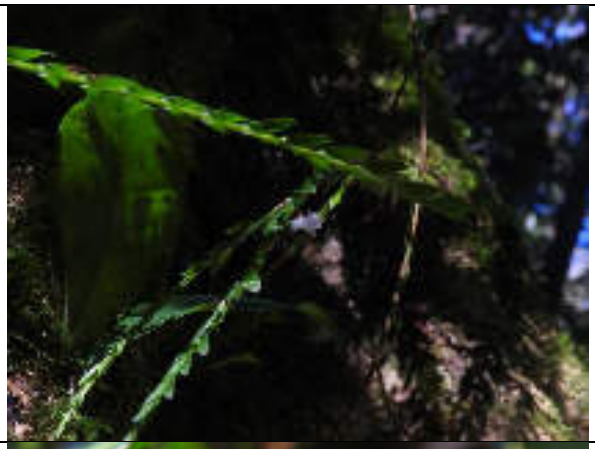
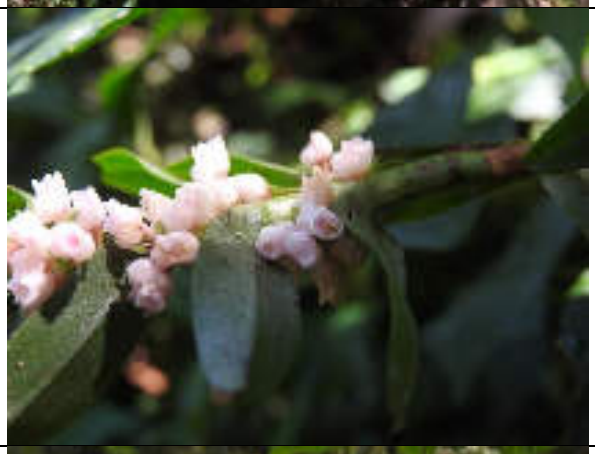
25		Near T12	E : -4,200189 S : 103,416817	Invasive plant species *Ruellia tuberosa* L.
26		Between T16 and T17 segment	E : 4,123497 S : 103,255239	Invasive plant species *Ricinus communis* L.
27		Between T18 and T19 segment	E : -4,122670 S : 103,261549	Invasive plant species *Ludwigia peruviana* (L.) H.Hara

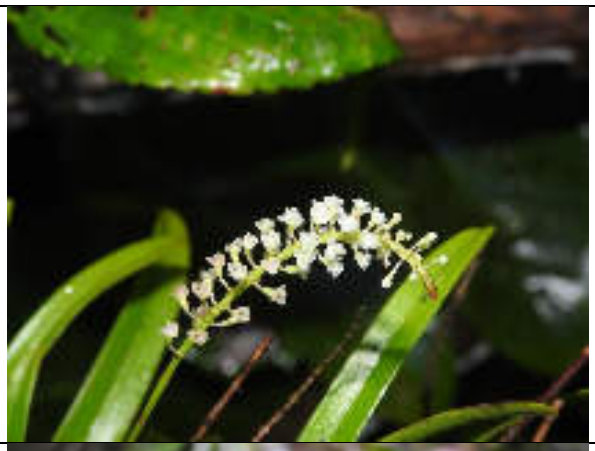
28		Segment T20 and T21	E : -4,121606 S : 103,265413	Invasive plant species *Sida rhombifolia* L.
29		Segment T19 and T20	E : -4,20075 S : 103,438864	Invasive plant species *Pennisetum purpureum* Schumach.
30		Near T20	E : -4,200599 S : 103,442971	Invasive plant species *Imperata cylindrica* (L.) Raeusch.

31		Segment T23 and T24	E : -4,207709 S : 103,452432	Invasive plant species *Clidemia hirta* (L.) D. Don
32		Segment T24 and T25	E : -4,123149 S : 103,271359	Invasive plant species *Ageratina riparia* (Regel) R.M.King & H.Rob.
33		Near T40	E : -4,138266 S : 103,295809	Invasive plant species *Senna bicapsularis* (L.) Roxb.

34		Near T40	E : -4,138682 S : 103,295850	Invasive plant species *Lantana camara* L.
35		Near T54	E : -4,202914 S : 103,538974	Invasive plant species *Acmella paniculata* (Wall. ex DC.) R.K.Jansen

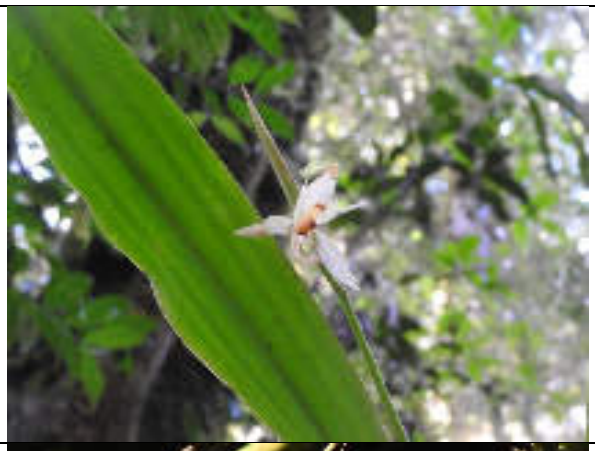
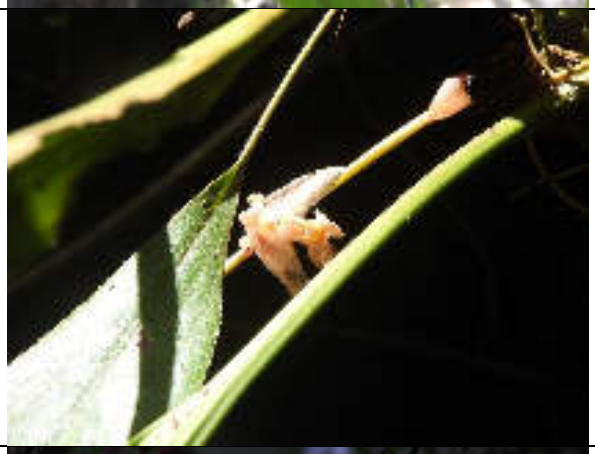
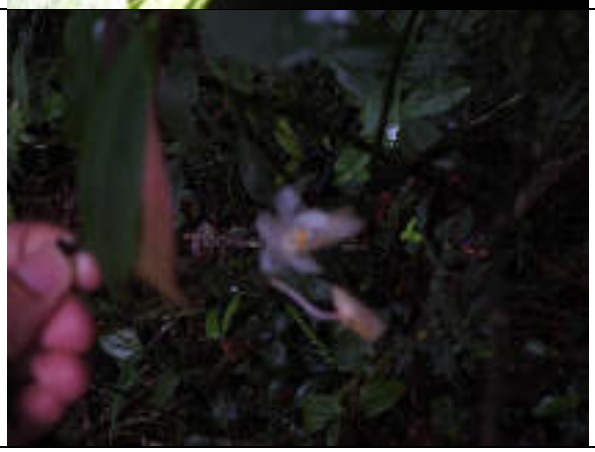
Orchids and Flowering Plants

No	Photo	Location	GPS Point	Note
1		Brine line	E : -4,208355 S : 103,3953033	Species *Appendicula ramosa* Blume
2		Segment T.15-T.16 and Segment T.31-T.32	E : -4,200381667 S : 103,4297467	Species *Appendicula reflexa* Blume
3		Segment T.07-T.08,T.19-T.20,T.31-T.32	E : -4,203563333 S : 103,4007783	Species *Arundina graminifolia* (D.Don) Hochr

4		Segment T.29-T.30	E : -4,218633333 S : 103,4704483	Species *Ascidieria cymbidifolia* (Ridl.) W.Suarez & Cootes
5		Segment T.32-T.33	E : -4,209426667 S : 103,396725	Species *Calanthe ceciliae* Rchb.f
6		Segment T.15-T.16	E : -4,173311667 S : 103,430755	Species *Calanthe flava* (Blume) C.Morren

7			Segment T.05-T.06	E : -4,207555 S : 103,3945833	Species *Calanthe pulchra* (Blume) Lindl
8			Brine line	E : -4,208521667 S : 103,3974983	Species *Calanthe rigida* Carr

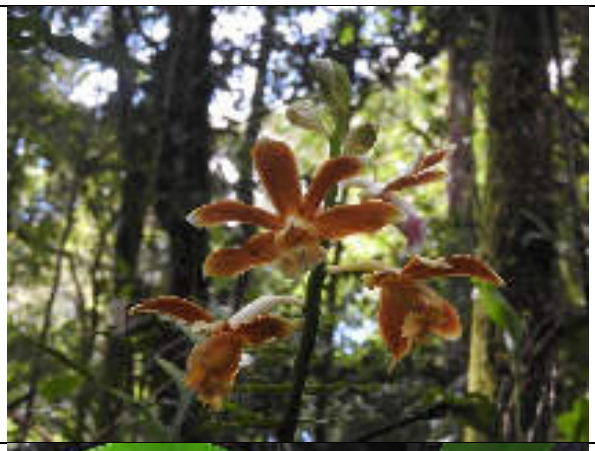
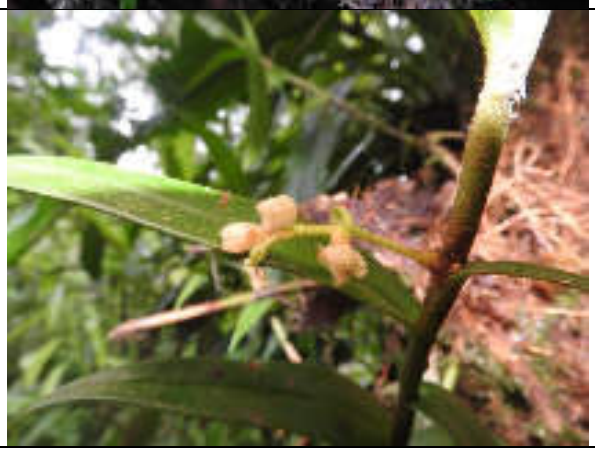
9		Brine line	E : -4,20836 S : 103,3982333	Species *Calanthe transiens* J.J.Sm
10		Segment T.06-T.07, and T.07-T.08	E : -4,20602 S : 103,3968617	Species *Calanthe triplicata* (Willemet) Ames
11		Segment T.01-T.02	E : -4,20707 S : 103,386475	Species *Chelonistele sulphurea* (Blume) Pfitzer

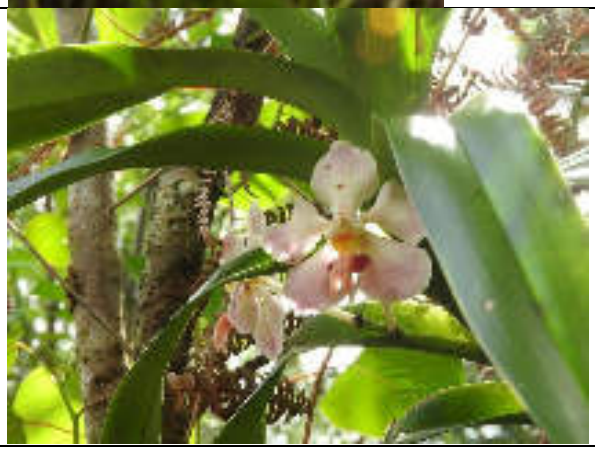
12		Brine line	E : -4,209421667 S : 103,39676	Species *Coelogyne contractipetala* J.J.Sm
13		Brine line	E : -4,20893 S : 103,3972283	Species *Coelogyne cuprea* H.Wendl. & Kraenzl
14		Segment T.01-T.02	E : -4,207111667 S : 103,3855167	Species *Dendrobium crumenatum* Sw

15		Segment T.02-T.03	E : -4,207298333 S : 103,387985	Species *Dendrobium mutabile* (Blume) Lindl
16		Segment T.03-T.04	E : -4,207928333 S : 103,39042	Species *Dendrobium pedicellatum* J.J.Sm
17		Segment T.15-T.16	E : -4,200695 S : 103,430065	Species *Eria palmifolia* Ridl

18		Segment T.01-T.02	E : -4,207415 S : 103,3847217	Species *Eria robusta* (Blume) Lindl
19		Segment T.01-T.02	E : -4,20703 S : 103,38526	Species *Goodyera repens* (L.) R.Br
20		Segment T.35-T.36	E : -4,22179 S : 103,48632	Species *Liparis crenulata* (Blume) Lindl

21		Segment T.14-T.15	E : -4,20088 S : 103,4266783	Species *Liparis nervosa* (Thunb.) Lindl
22		Segment T.03-T.04, T.04-T.05, T.15-T.16, T.26-T.27, T.30-T.31, T.33-T.34	E : -4,20794 S : 103,3926717	Species *Liparis viridiflora* (Blume) Lindl
23		Brine line	E : -4,210918333 S : 103,402525	Species *Mycaranthes latifolia* Blume

24		Brine line and Segment T.06-07, T.15-T.16	E : -4,206285 S : 103,3962433	Species *Phaius callosus* (Blume) Lindl
25		Segment T.15-T.16	E : -4,200845 S : 103,4297283	Species *Pinalia bractescens* (Lindl.) Kuntze
26		Segment T.34-T.35	E : -4,221231667 S : 103,483285	Species *Podochilus microphyllus* Lindl

27		Segmet T.26-T.27	E : -4,21231 S : 103,4583967	Species *Saccolabium rantii* J.J.Sm
28		Brine line and Segment T.10-T.11	E : -4,210818333 S : 103,4065417	Species *Spathoglottis plicata* Blume
29		Segment T.17-T.18	E : -4,200775 S : 103,4354317	Species *Vanda foetida* J.J.Sm

30		Brine line, Segment T.01-T.02, and T.10-T.11	E : -4,206448333 S : 103,3846583	Species *Anaphalis longifolia* (Blume) Blume ex DC
31		Brine line and Segment T.01-T.02	E : -4,207566667 S : 103,3880067	Species *Nepenthes rafflesiana* Jack
32		Brine line and Segment T.02-T.03,T.06-T.07, T.15-T.16	E : -4,205921667 S : 103,397355	Species *Amorphophallus beccari* Engl.

INCIDENTAL FAUNA SURVEY
AT PT SUPREME ENERGY RANTAU DADAP
SOUTH SUMATERA PROVINCE

Survey Results

SERD is a geothermal energy company located in Lahat, South Sumatra Province. This company lie in a highland up to 1800 meter asl. In this location, a transmission line and a brine line will be built to develop the company. An incidental fauna survey was held on both area to measure the ecological impact and to help the company build plan to mitigate those impact.

Transmission line will be built as far as 40 km, run through several habitat type and most of them is outside of the company's area. On that line will be built 119 electrical towers with distance between towers varies between 200 to 500 meter. Most of the transmission line is lie in the modified habitat in the form of paddy field and upland crop, mostly coffee plantation. Disturbed forest and secondary forest will be crossed by transmission line as it getting closer to the company, and the transmission line will be ended at primary forest where the company facility lies. The differences of varying landcover become the base of the sampling for the survey.

This incidental survey was held for 5 days from May 10th to 14th 2017 along the transmission line and brine line. It was done based on the reconnaissance survey method. Surveyors were walked along the path and recorded the name, number, and noted of every species encountered by visual and/or auditory detection. Survey started at 7 a.m. and ended in 4 p.m. or until impossible to continue because of the weather or terrain. This method was chosen to attain the target in rapid time, which were gain information of species with conservation significance and the threats facing them. The species with conservation significance are the fauna which is included in CR/EN/VU of IUCN Red List and/or in Indonesian Law of protected species and/or endemic species up to national level. Those species then divided into three taxa (mammals, birds, and herpetofaunas) to be analyzed further.

Sampling area ran through 8 different types of landcover, which are primary dry forest; secondary dry forest; bush; upland crop; upland crop with bush; barren land; built-up area; paddy field; and water body. Although most of the location consists of modified habitat, this survey was focused on the natural habitat (primary and secondary forest), and several sample in the upland crop and paddy field. The reason for that sampling is that most of the fauna with conservation significance needs forest as their natural habitat so that the survey that held in that location will represent overall location. Therefore, this surey focused on 37 of the first tower points which for the most part still covered by forest. More than that, sampling was done until tower point 54 to dig optimal data.

After 5 days of survey was done, 11 species of mammals, 36 species of birds, and 10 species of herpetofauna was observed. Below is the detail explanation of faunas, especially with conservation significance, which was found during the survey.

Mammals

Survey activity showed that 11 mammals species within 8 families was found throughout the transmission line and brine line. All of the species was found in 5 type of landcovers from 8 type surveyed. Most of them (7 species) identified in primary forest. Hereafter, 5 species identified in secondary forest, 4 species in upland crop type, and one species in each bush and upland crop with bush type of landocver. Wild boar was the cosmopolite species that it was found in three different types of landcover.

Five out of eleven mammals identified as species with conservation significance. This consist of 2 species considered as endangered, 2 species as vulnerable, 4 species protected by Indonesian law, and one species is endemic in Sumatra.

Below is the list of mammals with conservation significance which identified on incidental survey.

Table 1. List of mammals species with conservation significance

No.	Famili	Name	Scientific Name	Status		
				IUCN	UU	E
1	Bovidae	Sumatran Serow	*Capricornis sumatraensis*	VU	✔	
2	Cervidae	Barking Deer	*Muntiacus muntjak*	LC	✔	
3	Cercopithecidae	Sumatran Surili	*Presbytis melalophos*	EN		✔
4	Hylobatidae	Siamang	*Symphalangus syndactylus*	EN	✔	
5	Ursidae	Malayan Sun Bear	*Helarctos malayanus*	VU	✔	

Sumatran Serow

Sumatran serow is a species of goat-antelope native to mountain forests. It inhabits steep mountain slopes between 200 and 3,000 m, covered by both primary and secondary forests. The serow is predominantly a browser. It is usually solitary in nature, but small groups of up to seven have been observed. It may occupy seasonal ranges and use well marked trails that often run along ridges of steep hills. Sumatran serow feed in the early hours of the morning and in late evenings, sheltering under overhanging cliffs and rocks during the rest of the day.

This species species is found in Indonesia (Sumatra), Malaysia (Peninsular Malaya), and Thailand (south of about 9°S latitude), In Indonesia (Sumatra), limited almost entirely to the volcanic mountain chain of the Barisan mountains which runs along the western spine of Sumatra from Aceh in the north to Lampung in the south. Sumatran serow population believed to be in significant decline altough in protected areas like Gunung Leuser National Park appears to be healthy and increasing. Nonetheless, this species carries threats of poaching and habitat destruction. The second one is the real danger for the population of Sumatran Serow. The principal causes of habitat destruction are forest conversion for agriculture, limestone quarry, and the indiscriminate extraction of timber for export. Poaching is not uncommon, and serows are caught in snares set for other game species, as well as shot, for local consumption of the meat, and for use of body parts in traditional medicines.

Indonesia protected this species since 1932. It also included in IUCN Red List as Vulnerable since 2008. However, poaching and habitat destruction still occur and threaten the life of Sumatran serow but their population seems to be well in protected areas.

In the SERD area, sumatran serow was found in animals track in the steep hill within brine line. It was identified from the stroke from its horn in the bottom part of the log. This species was well known as an elusive species so its quite hard to find. There was not enough information to get overview about this species in this area so its just showed that this animal is exist in the brine line area.

Barking Deer

Barking deer is a small deer of the genus *Muntiacus*. This species is associated with forest, but occurs widely even in heavily degraded forest and, in areas adjacent to forest, in plantations of coffee, rubber, sugarcane, cassava, coconut, and teak. It occupies part of the Thai–Malay peninsula and occurs on the main islands of the Greater Sundas (Borneo, Java, Bali and Sumatra) and on various small islands.

This species is listed as Least Concern because it remains common throughout most of its range, is resilient to hunting and increases in numbers with logging and presumably other forms of forest disruption, and survives even almost complete conversion of forest to at least some crop plantations. Densities are probably widely below carrying capacity, particularly where habitat is highly fragmented.

Habitat encroachment and hunting are both the major threats for barking deer's population. They are widely hunted for meat, skins, and as a source of traditional remedies. To overcome those threats, Barking deer is protected by Indonesian forestry law.

This animal was found only in the brine line area in the form of foot prints. It was found in two different location but nearby. All of them is in the edge of primary forest, near the secondary forest and barren land. Eventhough it was known that this animal is tolerant to live in modified habitat, there was no sign of this species in other location.

Sumatran Surili

Sumatran surili is a leaf eater monkey which primarily folivorous, but will also consume fruits, flowers, and seeds. It inhabit lowland and submontane dipterocarp and evergreen forests and also found on the margins of rivers. This species live in groups consisting of one male and five to seven females. Males identify the group's territory with vocalizations and displays. It is an arboreal, means that it spend most of its time in the understory of the forest, leaping between small branch supports and are primarily active during the day.

This species is endemic to Sumatra. It is relatively common in its remaining and appropriate habitat. This species is tolerant of habitat conversion to a degree, and can be found in disturbed and secondary forest areas. It has also been found in primary and secondary hill rainforest, shrub forest and plantations. However, its occurrence is very patchy and fragmented so by IUCN Red List, this species is considered Endangered due to ongoing population declines driven by habitat conversion and illegal collecting for the pet trade. Indonesian government protected this species to evercome those threats.

From this survey, at least four groups of sumatran surili was found. This group usually consist of 2 to 5 individuals. They were discovered at transmission line (segment T10-11, T15-16, and T29-30) and in brine line. All of them was found in primary and secondary forest. As noted in description above, surili are arboreal so they need trees to sustain their life. Eventhough they can survive in modified habitat, coffee plantation seems not fit to them because the trees are short and it is highly monocultur so its hard for surili to fulfill their needs.

Siamang

Siamang is an arboreal black-furred gibbon native to the forests of Malaysia, Thailand, and Sumatra. The largest of the gibbons, the siamang can be twice the size of other gibbons, reaching 1 m in height, and weighing up to 14 kg. It has large gular sac, which is a throat pouch that can be inflated to the size of the siamang's head, allowing it to make loud, resonating calls or songs.

Siamang inhabits the forest remnants of Sumatra Island and the Malay Peninsula, and is widely distributed from lowland forest to mountain forest and can be found at altitudes up to 3800 m. The

siamang lives in groups of up to six individuals (four individuals on average) with an average home range of 23 hectares.

This species is threatened by forest conversion and opportunistic collection for pet trade on Sumatra, where both of these threats extend to populations in national parks and protection forests. Between 1995 and 2000, almost 40% of the habitat for this species on Sumatra was damaged or destroyed by logging, road development (barrier and hunting) and conversion to agriculture or plantations. Forests, where they remain, are extremely fragmented. Coffee plantations present an increasing threat. The siamang is one of the most heavily traded gibbon species for illegal pet trade.

Listed as Endangered as, there is reason to believe the species has declined by at least 50% over the past 40 years (three generations) due primarily to hunting for pet trade and continued rates of habitat loss (mainly as a result of expanding agriculture and road building). This species is also protected by Indonesian law.

Siamang is quite easy to spot because of their loud noise. From this survey, they were spotted in 6 locations. However, there were at least 5 groups of siamang from those locations based on the 3 visual encounter and voice distance estimation. Each group usually consist of 2 to 4 individuals, usually as family. They were found in the transmission line (segment T06-07, T18-19, T28-29, T35-36) and brine line. All of the siamang were recognized at primary and secondary forest. They were much more arboreal than sumatran surili. This species need a lot of high trees because they have to swing from one branch to another so they need quite vast forest where its branch is connected. Their situation is in danger because some of their groups are fragmented by coffee plantation and in long term it will degrade their genetics.

Malayan Sun Bear

The Malayan **sun bear** is a bear found in tropical forest habitats of Southeast Asia. It is also known as the **"honey bear"**, which refers to its voracious appetite for honeycombs and honey. However, Sun bears are omnivores, feeding primarily on termites, ants, beetle larvae, bee larvae and honey, and a large variety of fruit species, especially figs (*Ficus* spp.), when available.

Sun bears occur in mainland Southeast Asia as far west as Bangladesh and northeastern India (Chauhan 2006), as far north as southern Yunnan Province in China, and south and east to Sumatra and Borneo, respectively. It now occurs very patchily through much of its former range, and has been extirpated from many areas, especially in mainland southeast Asia. Sun bears rely on tropical forest habitat.

The two major threats to sun bears are habitat loss and commercial hunting. Sun bears are mainly threatened by the loss of forest habitat and forest degradation arising from: clear-cutting for plantation development, unsustainable logging practices, illegal logging both within and outside protected areas, and forest fires. Commercial poaching of bears for the wildlife trade is also a considerable threat but it usually occurs outside Indonesia. Other motivations for killing bears include: preventing damage to crops, subsistence use, fear of bears near villages, and capture of cubs for pets (the mother being killed in the process).

IUCN Red List state this species as vulnerable due to the large-scale deforestation that dramatically reduced suitable habitat for this species. Sun bear is also protected under national laws throughout their range including Indonesia.

This sun bear was only found once in this survey, that was in the form of teared up tree where the sun bear was find honey inside the log. This mark was found in the coffee plantation near the main road. It is common that Malayan sun bear can be found among plantation as long as a patch of forest is still available nearby. Nevertheless, its life is in danger because of the risk of living among human.

Birds

Survey activity showed that 36 birds species within 20 families was found throughout the transmission line and brine line. Those species was found in 7 type from 8 type of landcovers surveyed. Most of them found in primary and secondary forest which 26 and 19 species was identified respectively.

Sooty-headed Bulbul, Long-tailed Shrike, and Ashy Drongo were the most common species and can be found in five types of landcover. The crested serpent-eagle was recorded to be found in 7 different kinds of landover but actually it was identified by it's cries which can reach a great distance.

Among 36 species of birds found within survey, only three of them considered as species with conservation significance, that is crested serpent-eagle and collared kingfisher which are protected by Indonesian law, and sunda minivet which is endemic in Indonesia (Sumatra and Java).

Below is the list of birds with conservation significance which identified on incidental survey.

Table 2. List of birds species with conservation significance

No.	Famili	Name	Scientific Name	Status		
				IUCN	UU	E
1	Accipitridae	Crested Serpent Eagle	*Spilornis cheela*	LC	✔	
2	Alcedinidae	Collared Kingfisher	*Halcyon chloris*	LC	✔	
3	Campephagidae	Sunda Minivet	*Pericrocotus miniatus*	LC		✔

Crested Serpent Eagle

The **crested serpent eagle** (*Spilornis cheela*) is a medium-sized bird of prey that is found in forested habitats along tropical Asia. This eagle, as its English name suggests, is a reptile eater which hunts over forests, often close to wet grassland, for snakes and lizards. It has also been observed to prey on birds, amphibians, mammals and fishes.

The call is a distinctive Kluee-wip-wip with the first note being high and rising. They call a lot in the late mornings from their perches where they spend a lot of time and they rise on thermals in the mornings. It is found mainly over areas with thick vegetation both on the low hills and the plains. This species is a resident species, but in some parts of their range they are found only in summer.

This eagle described as widespread and common throughout its distribution. The population is suspected to be stable in the absence of evidence for any declines or substantial threats. However, Indonesia government protect this species along with all under Accipitridae family for their role as top predator.

This eagle were found in 5 locations in the transmission line and most of them were recognized by its loud voice, just one of them was visually encountered in segment T14-15. They were located in 7 different types of landcover among the transmission line. Their range is far and their voice is loud so they can be spotted far from their real location. However, this species still need forest to lay its egg in the emergence tree so it will be hard to find in area where there is no forest nearby.

Collared Kingfisher

The collared kingfisher is a medium-sized kingfisher belonging to the subfamily Halcyoninae, the tree kingfishers. Its size is 22 to 29 cm (8.7 to 11.4 in) long and weighs 51 to 90 g (1.8 to 3.2 oz). It varies from blue to green above while the underparts can be white or buff. There is a white collar around the neck, giving the birds its name. It also can be easily identified by its call which is loud, harsh and metallic and is repeated several times.

It is most commonly found in coastal areas, particularly in mangrove swamps. It also inhabits farmland, open woodland, grassland and gardens. In some parts of its range, especially on islands, it

can be seen further inland, ranging into forest or into mountain areas. This species has an extremely large range over the world.

The global population size has not been quantified, but the species is reported to be very widespread and common to abundant. Despite the fact that the population trend appears to be decreasing, the decline is not believed to be sufficiently rapid. IUCN put this species into Least Concern. Nonetheless, it is protected under Indonesia law for its role in ecosystem.

Similiar to the crested serpent eagle, collared kingfisher has distinctive sound that easy to recognized. In that way, they were found in 4 location and in 4 different types of landcover among the transmission line. The only visual encounter was when this bird was crossing the lake in segment T19-20.

Sunda Minivet

The sunda minivet is passerine bird belonging to the genus Pericrocotus in the cuckoo-shrike family Campephagidae. Its size is fairly small, slender birds with long tails and an erect posture. It has bright red markings making it can be easily seen in the field. They feed mainly on insects, foraging in groups in the tree canopy.

This species is endemic in Indonesia and just occupy two main islands, Sumatra and Java. However, the sunda minivet population is suspected to be stable in the absence of evidence for any declines or substantial threats. IUCN put this species into Least Concern in their Red List.

This bird was visually recognized in 3 locations among 2 different types of forest. This bright red bird usually found in open area hanging in group at the tree crown. This species is quite common in forest and sometimes fly to the edge and found in the open area but still near the forest.

Herpetofauna

Survey activity showed that 6 amphibian species and 4 reptilia species was found throughout the transmission line and brine line. Those species was found in 4 type from 8 type of landcovers surveyed. Most of them found in primary and secondary forest.

From 10 species of herpetofauna identified during the survey, none of them is considered as species with conservation significance. All of them is common species which can easily be found and the population is abundant throughout their distribution.

Threats

The existence of fauna with conservation significance in the transmission line and brine line threaten by several threats which can be dangerous to their population. SERD location is not an prohibited area so that people still can be easily access the habitat of the fauna. Human existence among the fauna living place usually create the contradictive relationship because of human needs which usually the opposite of the fauna necessities. In this case, human existence brought two major threats, which are habitat degradation and hunting and poaching.

Most of the area around the company location are upland crop for the coffee plantation. People there still tend to expand their plantation to increase their income. They don't hesitate to clear the forest away to plant their high value comodity. The clearance of the land, of course, leads to habitat degradation that will threaten the existence of the fauna.

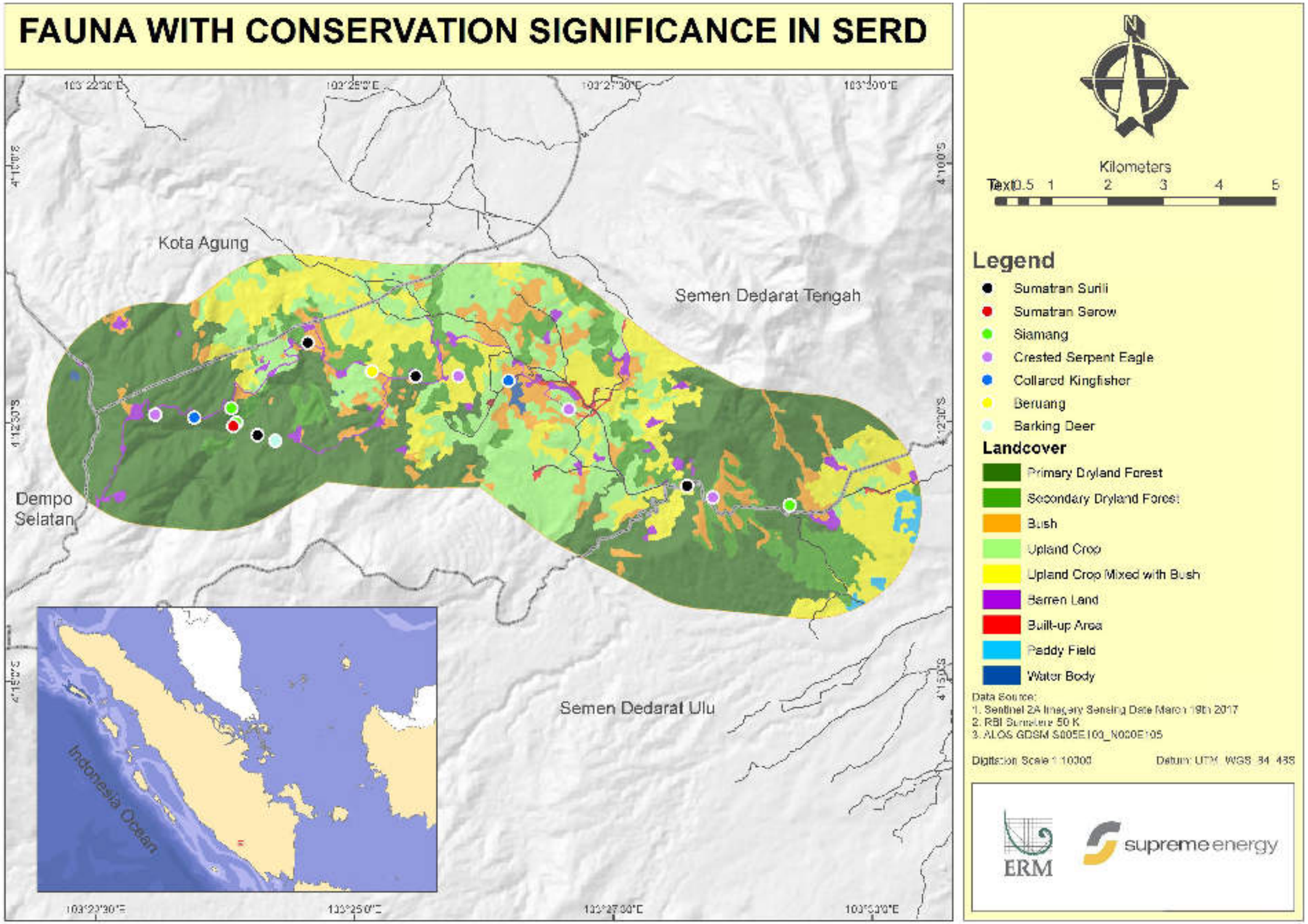
Land that cleared by community sometimes got abandoned. It brought another problem in the form of invasive flora species exposure that easily strike that open field and causing another habitat degradation. The previously heterogeneous area of forest is replaced by shrubs and makes the area

neglected. It is certainly disserve for the environment because that habitat will be no longer inhabited by plenty number of fauna species.

The next threat for habitat is illegal logging. Some evidence showing illegal logging activity can be seen in several area of forest, both primary or secondary, eventhough not in massive scale. Uncontrolled logging activity causing the difficulty to measure ecological impact and usually it will be ruin the forest and inflict degradation of forest quality as fauna habitat.

Another major threats is poaching and hunting. In general, poaching and hunting activity in area around the company is quite minimal. However, there was still found some evidences of poaching in the form of small rope trap to catch bird. People also still entering forest area frequently to fishing in the river or gathering non timber forest product. That activity if not monitored properly will open the chance to occasionally poach fauna with conservation significance considering their high value in black market.

Map of Fauna Distribution



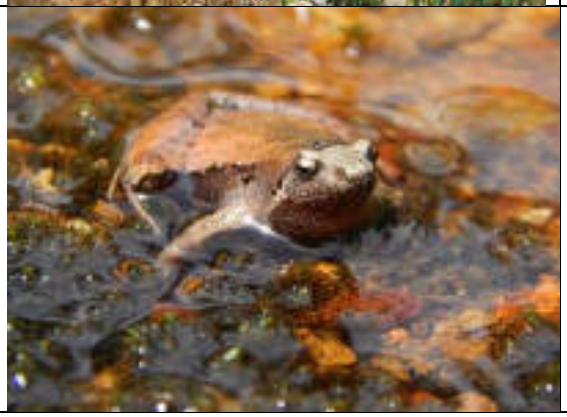
Fauna Records

				Landcover									Status		Location			Notes				
No.	**Famili**	**Name**	**Scientific Name**	**PDF**	**SDF**	**Bu**	**UC**	**UCB**	**BL**	**BuA**	**PF**	**WB**	**IUCN**	**RI**	**E**	**Encounter**	**Brine Line**	**Transmision Line**	PDF	Primary Dryland Forest			
1	Bovidae	Sumatran Serow	*Capricornis sumatraensis*	•									VU	✔		I	•		SDF	Secondary Dryland Forest			
2	Cervidae	Barking Deer	*Muntiacus muntjak*	•									LC	✔		I	•		Bu	Bush			
3	Suidae	Wild Boar	*Sus scrofa*			•	•	•					LC			I		24;30;32;34	UC	Upland Crop			
4	Sciuridae	Plantain Squirrel	*Callosciurus notatus*				•						LC			D		15;	UCB	Upland Crop with Bush			
5	Sciuridae	Slender Squirrel	*Sundasciurus tenuis*	•	•								LC			D	•	3;15;	BL	Barren Land			
6	Sciuridae	Black-striped Squirrel	*Callosciurus nigrovittatus*	•	•								NT			D	•	2;	BuA	Built-up Area			
7	Sciuridae	Low's Squirrel	*Sundasciurus lowii*	•	•								LC			D	•	6;	PF	Paddy Field			
8	Cercopithecidae	Sumatran Surili	*Presbytis melalophos*	•	•								EN		✔	D	•	10;15;29;	WB	Water Body			
9	Hylobatidae	Siamang	*Symphalangus syndactylus*	•	•								EN	✔		I/D	•	1;6;18;28;35;	IUCN	IUCN Red List	B	6	35
10	Ursidae	Malayan Sun Bear	*Helarctos malayanus*				•						VU	✔		I		12;	RI	PP No.7 Thn 1999			
11	Viverridae	Masked Palm Civet	*Paguma larvata*				•						LC			I		26;	E	Endemic			
																			I	Indirect			
																			D	Direct			

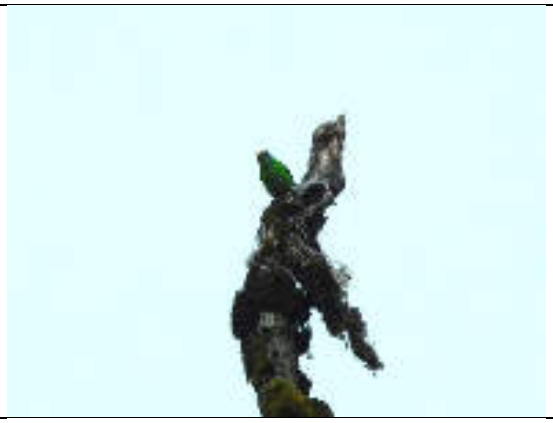
				Landcover										Status		Location			Notes	
No.	**Famili**	**English**	**Species**	**PDF**	**SDF**	**Bu**	**UC**	**UCB**	**BL**	**BuA**	**PF**	**WB**	**E**	**IU**	**RI**	**Encounter**	**Brine Line**	**Transmision Line**	PDF	Primary Dryland Forest
1	Acanthizidae	Golden-bellied Geryone	*Gerygone sulphurea*	•	•		•	•						LC		I/D		1;	SDF	Secondary Dryland Forest
2	Accipitridae	Crested Serpent Eagle	*Spilornis cheela*	•	•	•	•	•	•	•				LC	✔	I/D		1;14;17;23;31;	Bu	Bush
3	Alcedinidae	Collared Kingfisher	*Halcyon chloris*	•			•			•		•		LC	✔	I/D		3;15;19;25;	UC	Upland Crop
4	Campephagidae	Bar-winged Flycatchershrike	*Hemipus picatus*		•				•					LC		D		1;4;19;	UCB	Upland Crop with Bush
5	Campephagidae	Sunda Minivet	*Pericrocotus miniatus*	•	•								✔	LC		D		4;7;14	BL	Barren Land
6	Capitonidae	Black-browed Barbet	*Megalaima oorti*	•	•									LC		I	•		BuA	Built-up Area
7	Capitonidae	Golden-whiskered Barbet	*Megalaima chrysopogon*	•	•									LC		I	•	1;6;15;	PF	Paddy Field
8	Capitonidae	Blue-eared Barbet	*Megalaima australis*	•	•									LC		I/D	•	6;	WB	Water Body
9	Columbidae	Wedge-tailed Green Pigeon	*Treron sphenura*	•										LC		D		2;	IUCN	IUCN Red List
10	Columbidae	Spotted Dove	*Streptopelia chinensis*						•	•				LC		D		23;	RI	PP No.7 Thn 1999
11	Cuculidae	Lesser Coucal	*Centropus bengalensis*			•		•	•					LC		I		14;	E	Endemic
12	Cuculidae	Large Hawk-Cuckoo	*Cuculus sparverioides*	•										LC		I/D	•	1;3;6;	I	Indirect
13	Cuculidae	Plaintive Cuckoo	*Cacomantis merulinus*				•	•	•	•				LC		I		11;19;23;	D	Direct
14	Dicruridae	Lesser Racquet-tailed Drongo	*Dicrurus remifer*	•										LC		D		14;		
15	Dicruridae	Ashy Drongo	*Dicrurus leucophaeus*	•	•		•	•	•					LC		I/D	•	15;23;		
16	Eurylaimidae	Long-tailed Broadbill	*Psarisomus dalhousiae*	•										LC		D	•			
17	Hirundinidae	Pacific Swallow	*Hirundo tahitica*							•				LC		D		14;		
18	Irenidae	Asian Fairy Bluebird	*Irena puella*	•										LC		D		4;		
19	Laniidae	Long-tailed Shrike	*Lanius schach*			•	•	•	•	•				LC		I/D		10;11;24;		
20	Muscicapidae	Large Niltava	*Niltava grandis*	•	•									LC		I/D	•	4;		
21	Muscicapidae	Little Pied Flycatcher	*Ficedula westermanni*	•	•									LC		D		1;		
22	Muscicapidae	Snowy-browed Flycatcher	*Ficedula hyperythra*	•										LC		D		8;		
23	Muscicapidae	Grey-headed CanaryFlycatcher	*Culicicapa ceylonensis*	•	•									LC		D	•	3;		
24	Muscicapidae	Indigo Flycatcher	*Eumyias indigo*	•	•									LC		D		27;		
25	Ploceidae	Eurasian Tree Sparrow	*Passer montanus*							•				LC		D		21;		
26	Pycnonotidae	Orange-spotted Bulbul	*Pycnonotus bimaculatus*	•										LC		D		1;		
27	Pycnonotidae	Sooty-headed Bulbul	*Pycnonotus aurigaster*			•	•	•	•	•				LC		I/D		7;10;14;23;25;		
28	Pycnonotidae	Yellow-vented Bulbul	*Pycnonotus goiavier*				•	•	•	•				LC		I/D		10;23;		
29	Rhipiduridae	White-throated Fantail	*Rhipidura albicollis*	•	•									LC		D	•	1;6;15;27;		
30	Sittidae	Blue Nuthatch	*Sitta azurea*	•	•									LC		D	•			
31	Sylviidae	Yellow-bellied Warbler	*Abroscopus superciliaris*	•	•									LC		D	•	14;		
32	Sylviidae	Yellow-breasted Warbler	*Seicercus montis*	•										LC		D	•	15;		
33	Timaliidae	Pygmy Wren-Babbler	*Pnoepyga pusilla*	•	•									LC		I	•	1;6;15;35;		
34	Timaliidae	Grey-throated Babbler	*Stachyris nigriceps*	•	•									LC		I/D		6;		
35	Timaliidae	Spot-necked Babbler	*Stachyris striolata*	•	•									LC		I/D		30;		
36	Turdidae	Chestnut-naped Forktail	*Enicurus ruficapillus*		•							•		NT		D		28;		

			Landcover									Status				Location		Notes	
No.	**Famili**	**Scientific Name**	**PDF**	**SDF**	**Bu**	**UC**	**UCB**	**BL**	**BuA**	**PF**	**WB**	**IUCN**	**RI**	**E**	**Encounter**	**Brine Line**	**Transmision Line**	PDF	Primary Dryland Forest
1	Microhylidae	*Microhyla palmipes*	•									LC			D		1;	SDF	Secondary Dryland Forest
2	Dicroglossidae	*Occidozyga sumatrana*		•								LC			D		18;	Bu	Bush
3	Dicroglossidae	*Fejervarya limnocharis*										LC			D		18;	UC	Upland Crop
4	Microhylidae	*Kalophrynus pleurostigma*		•								LC			D		26;	UCB	Upland Crop with Bush
5	Agamidae	*Bronchocela cristatella*		•								LC			D		15;	BL	Barren Land
6	Scincidae	*Eutropis multifasciata*						•				LC			D		10;	BuA	Built-up Area
7	Ranidae	*Hylarana chalconota*									•	LC			D		19;	PF	Paddy Field
8	Bufonidae	*Bufo sp.*	•												D		10;	WB	Water Body
9	Natricidae	*Unidentified Snake*	•												D	•		IUCN	IUCN Red List
10	Agamidae	*Gonocephalus sp.*		•											D		15;	RI	PP No.7 Thn 1999
																		E	Endemic
																		I	Indirect
																		D	Direct

Fauna Survey Photolog

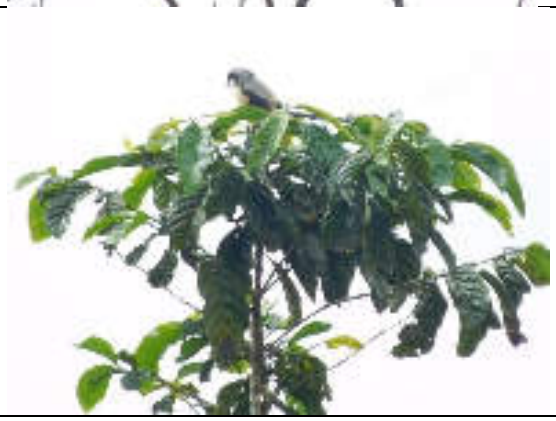
	Photo	Location	GPS Point	Notes
		SERD Main Office	S4° 10.373' E103° 25.921'	HSE Induction and Pre Survey Discussion with SERD Staff (Erwin & Dian)
		Segment T01-02	S4° 12.416' E103° 23.085'	Edelweiss flower in the side of the road
		Segment T01-02	S4° 12.416' E103° 23.085'	Microhyla palmipes in the small stream

		Segment T01-02	S4° 12.421' E103° 23.164'	View of primary montane forest with moss covering the trees
		Segment T-01-02	S4° 12.426' E103° 23.197'	Steep track across the survey area in transmission line
		Segment T03-04	S4° 12.434' E103° 23.369'	Indigo flycatcher in the primary forest

		Segment T04-05	S4° 12.447' E103° 23.539'	Black-browed Barbet in dead tree near the road
		Segment T08-09	S4° 12.036' E103° 24.197'	View of highground coffee plantation as a modified habitat
		Segment T09-10	S4° 12.061' E103° 24.260'	Evidence of bird trap in secondary forest

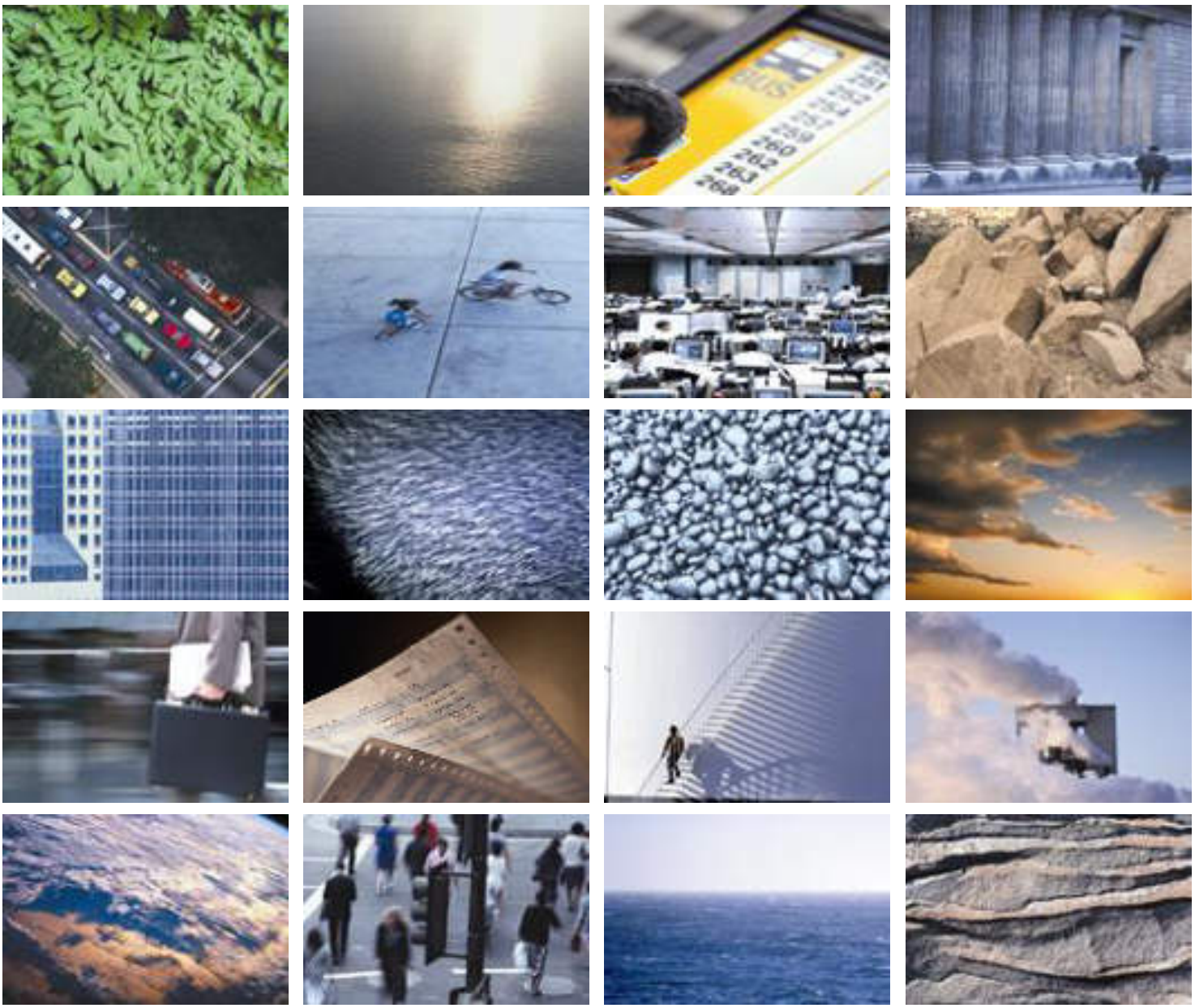
		Segment T10-11	S4° 11.821' E103° 24.333'	Prohibition sign of protected forest in SERD area
		Segment T10-11	S4° 11.721' E103° 24.560'	Sumatran surili in secondary forest near the road
		Segment T12-13	S4° 12.003' E103° 25.179'	Tree with bear slash in coffee plantation

		Segment T14-15	S4° 12.034' E103° 25.538'	Sunda minivet, the Indonesian endemic which still abundant in this area
		Segment T14-15	S4° 12.045' E103° 25.554'	Lesser Racquet-tailed Drongo without the racquet found in the secondary forest
		Segment T14-15	S4° 12.053' E103° 25.549'	Low's Squirrel found in the forest floor of secondary forest
		Segment T14 – 15	S4° 12.050' E103° 25.598'	Ashy Drongo found in opened forest. This is a common species found in the edge of forest.

		Segment T14 – 15	S4° 12.054' E103° 25.599'	White-throated Fantail captured in secondary forest
		Segment T19-20	S4° 12.132' E103° 26.460'	View of natural lake in the SERD area
		Segment T19-20	S4° 12.094' E103° 26.497'	Bar-winged Flycatchershrike standing in dead tree near the lake
		Segment T24-25	S4° 12.525' E103° 27.274'	Long-tailed Shrike, common species which usually found in open area around coffee plantation

		Segment T25-26	S4° 12.599' E103° 27.311'	Digging of wild boar finding worms in plantation area
		Segment T26-27	S4° 12.801' E103° 27.629'	Forest clearing by people to be converted into plantation. There are several location opened by community around SERD area.
		Brine Line	S4° 12.536' E103° 23.838'	Sumatran serow's horn scratch in the primary forest

		Brine Line	S4° 12.521' E103° 23.743'	Siamang in the primary forest. The siamang not scared with people, it seems that they have been habituated because the forest is frequently visited by people.
		Brine Line	S4° 12.605' E103° 24.035'	Large Niltava, beautiful blue singing bird found in primary forest
		Brine Line	S4° 12.647' E103° 24.141'	Tracks of barking deer found in primary forest
		Segment T34-35	S4° 13.279' E103° 28.887'	Faeces of wild boar in the bushes of ex burned forest



Supreme Energy Rantau Dedap Ecosystem Services Assessment

PT Supreme Energy Rantau Dedap (SERD)

November 2017

www.erm.com

The business of sustainability

ERM

FINAL REPORT

Supreme Energy Rantau Dedap (SERD)

Ecosystem Services Assessment

November 2017

0383026

Prepared by: ERM-Siam Co Ltd

For and on behalf of ERM-Siam Co Ltd

Approved by: Kamonthip Ma-oon

Signed: _____

Position: Partner

Date: 22 November 2017

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EXECUTIVE SUMMARY

PT Supreme Energy Rantau Dedap (SERD) plans to develop a Geothermal Power plant project at the geothermal field in Rantau Dedap, South Sumatra ('the Project'). The concession is located approximately 91km south of Muara Enim, 225km to the southwest of Palembang, the capital city of South Sumatra Province and 100km southeast of Bengkulu, the capital of Bengkulu Province.

The concession for the Rantau Dedap geothermal project was awarded to Supreme Energy in early December 2010 and the Mining Area License was granted to the project company PT Supreme Energy Rantau Dedap (SERD) at the same time. SERD has received the assignment from the Minister of Energy and Mineral Resources through assignment letter No. 5834/26/MEM.L/2011 September 30, 2011.

The Asian Development Bank (ADB) identified that an ecosystem services assessment was necessary to assist with compliance with the ADB's Safeguard's Policy Statement (SPS) in relation to the identification and management of Critical Habitats. Previous assessments undertaken for the SEML project had not specifically undertaken assessments for ecosystem services. As a result, an ecosystem service assessment was identified as a gap and an action as part of the SERD Biodiversity Action Plan (BAP) (ERM 2017) (v.10 S/N 39).

Environmental Resources Management (ERM) was contracted to conduct an ecosystem services assessment of the SERD concession. This assessment was undertaken as required by the SERD Biodiversity Action Plan to satisfy the requirements of the Asian Development Bank (ADB) Safeguards Policy Statement (SPS).

In accordance with the World Resources Institute Guidelines (WRI 2013), ERM conducted ecosystem screening assessment in order to determine the likely ecosystem service values that could be potentially important to affected communities within 5km of the SERD concession area. This assessment was done using existing sources of data, including information obtained during the scoping visit. This visit was held in October 2017 and consisted of initial interviews with SERD representatives as well as with local community representatives in the following villages: Tunggul Bute, Rantau Dedap, and Talang Pisang.

There are three categories of ecosystem services that were found when ERM conducted the ecosystem services assessment: (1) provisioning services; (2) regulating services; and (3) cultural services.

For provisioning aspect, the ecosystem services assessment included: (a) *Food: wild-caught fish and shellfish and aquaculture; (b) Food: wild meat; (c) Food: cultivated crops; (d) Food: herbs and plants; (e) Livestock farming; (f) Biomass fuel; (g) Timber and wood products; (h) Non-timber forest products.* For regulating

aspect, the ecosystem services assessment included *freshwater utilization, soil control and forest protection*. For the cultural aspect, the ecosystem services assessment included *spiritual, religious or cultural value*.

After conducting screening on ecosystem services prioritization, ERM identified two priority ecosystem services: freshwater and erosion regulation. ERM considered that SEML project may likely impact to such both priority ecosystem services. To reduce the impacts on the priority ecosystem services, ERM proposed mitigations. At the mitigation stage, ERM identifies options through the mitigation hierarchy to enhance or at least maintain: (1) the well-being affected beneficiaries derive from ecosystem services and (2) the performance the project derives from ecosystem services at acceptable levels.

ERM has determined that the application of these mitigations is sufficient to reduce the impact to these ecosystem services to negligible or minor. As a result, no residual impacts have been identified on ecosystem services that require additional mitigation and offsetting.

1. PROJECT BACKGROUND

PT Supreme Energy Rantau Dedap (SERD) plans to develop a Geothermal Power plant project at the geothermal field in Rantau Dedap, South Sumatra ('the Project'). The concession is located approximately 91km south of Muara Enim, 225km to the southwest of Palembang, the capital city of South Sumatra Province and 100km southeast of Bengkulu, the capital of Bengkulu Province.

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PT ERM Indonesia was appointed by PT Supreme Energy to conduct an ecosystem services assessment for its geothermal energy site in South Sumatra. The field assessment to define ecosystem services at the site was conducted for the period of 5 to 8 October 2017.

1.1 DEFINING ECOSYSTEM SERVICES

Ecosystem services are defined as the benefits that people, including businesses, derive from ecosystems (IFC 2012). These services are substantial and varied, underpinning basic human health and survival needs as well as supporting economics activities, the fulfillment of people's potential, and enjoyment of life.

In order to provide a uniform basis to assess the status of all major global habitat across all of the word's bioregions, the United Nation's Millennium Ecosystem Assessment (UN 2005) combine diverse Ecosystem Services typologies into a consistent classification scheme.

There are four categories of ecosystem services defined in Millennium Ecosystem Assessment as outlined in IFC Performance Standard 6:

- **Provisioning Services**; these services that can be extracted from ecosystem to support human needs. This term is more or less synonymous with the term " **Ecosystem Goods**" that was used in some prior classification schemes, including such tangible assets as fresh water, food, fiber, timber and medicinal plants;
- **Regulating Services**; the benefit obtained from an ecosystem's control of the natural environment, including of the regulation of surface water purification, carbon storage, and sequestration, climate regulation, protection from natural hazard, air quality, erosion and pests;
- **Cultural Services**; non-material benefits including diverse aspect of aesthetic, spiritual, recreational, and others cultural value;
- **Supporting services**; the natural process essential to the maintenance of the integrity, resilience, and functioning of ecosystem, thereby supporting the delivery of all other benefits. They include soil formation, nutrient cycling, and primary production.

1.2 APPLICABLE STANDARDS AND GUIDELINES

The ADB SPS requires that ecosystem services are assessed when determining whether a project triggers the requirements for Critical Habitat. The definition of Critical Habitat under the SPS (Clause 151 of the ADB Source Book) specifically references ecosystem services as a component of Critical Habitat. Clause 183 of the ADB Source Book also identifies ecosystem services as a component necessary for assessment in relation to sustainable natural resource management (ADB 2012).

The International Finance Corporation's (IFC) performance standards require projects to assess and preserve the benefits from ecosystem services. The IFC also requires that the environmental and social risks and impacts identification process considers a project's dependence on ecosystem services. A fundamental component is to apply the mitigation hierarchy to determine measures to limit impacts on ecosystem services.

ERM has utilized the World Resources Institute (WRI) Guidelines: *Weaving Ecosystem Service into Impact Assessment* to guide the approach used to assess ecosystem services in relation to the project.

The Ecosystem Services Review was undertaken following a five-stage approach (WRI 2014):

- ***Screening assessment*** to Identify Ecosystem Services that may occur within the study area;
- ***Data Collection and prioritization*** for 'screened in' Ecosystem Services;
- ***Scoping***; to refine the list of ecosystem services based on those identify in the study area and potentially impacted by the project;
- ***Prioritization*** to identify Ecosystem services importance to beneficiaries; and;
- ***Impact Assessment*** to identify the impacts to ecosystem services and their human beneficiaries as a result of the project.

2. *ECOSYSTEM SERVICES SCREENING AND SCOPING*

2.1 APPROACH

An ecosystem services screening assessment was undertaken to determine the likely ecosystem service values that could be potentially important to affected communities.

The scoping exercise was undertaken in order to refine the list of Ecosystem Services that:

- **Potential Beneficiaries**: Known and potential beneficiaries for a service were identified and where possible identifying people at the local, national, and / or global level;
- **Sources of Impact**: Potential sources of impact were considered based on the critical habitat assessment report conducted by ERM for SERD;
- **Project Dependence:** IFC PS-6 requires that the Ecosystem Services assessment take into consideration any services that the Project may rely upon during construction, operation and/or decommissioning. Therefore all services for which there is a potential project dependency were scoped into the prioritisation stage.

The goal of the scoping exercise was to identify a list of Ecosystem Services to be assessed during through the surveys.

2.2 RESULTS

This assessment was done using existing sources of data, including information gleaned during the scoping visit. This visit was held in October 2017 and consisted of initial interviews with SERD representatives as well as with local community representatives

The results of the scoping assessment are contained in ***Table 2-1***.

Table 2-1 Ecosystem Services Screening Assessment

Ecosystem Service Type	Description, Examples	Current Known Ecosystem Services	Screened in?
Provisioning Services			
Food: wild-caught fish and shellfish & aquaculture	Fish caught for subsistence or commercial sale; Fish, shellfish, and/or plants that are bred and reared in ponds, enclosures, and other forms of fresh- or salt-water confinement for harvesting	Villagers do not catch fishes in local rivers/creeks/small lake on regular basis. Instead, villagers do fishing as an entertaining activities (not main source of livelihood/fulfill protein needs). For that reason, few villagers catch fishes in Deduruk small lake and Endikat river where local fishes such as mujair, nila, and gold fish. According to the information provided by local villager, to fulfill protein needs from fishes, villagers bought fishes in the market sold by sellers who live outside and price of fish bought from local market is ranging from Rp. 30,000 to Rp. 35,000 per kilogram. In addition to that, some villagers have fishponds in their house yards (small quantity of production) for their own consumption or sell to other neighbors when needed. Types of fish that are in the fish pond (local name): mujair, nila and catfish. Fish seeds are supplied from outside Kota Agung District. There are rules for local villagers who are fishing in Deduruk small lake that they are not allowed to use fish net or electric shock for catching fishes. And fishing undertaken is limited to areas outside of the Project area. Therefore, the project is unlikely to have a significant impact on this service.	No
Food: wild meat	Animals hunted for primarily for food (recreational hunting covered under cultural services)	Villagers still do catch wild animals (such as wild boar and deer) in the protected forest (Bukit Jambul Gunung Patah) occasionally as they do it for fun/entertainment. They hunt deer for own consumption and to be sold if their neighbors need for protein needs which bought with sincere price (sukarela). The weight of deer is approximately 40-65 kilograms. While hunting wild boar is carried out every Saturday or Sunday. If the wild boars are dead, local villagers bury them or their dogs eat them as local villagers do not eat wild boars due to religious beliefs which all local villagers are Moslem. Wild boars are pest and they like eating potatoes, and cabbage which local villagers' planted. Evidence suggests that there is currently hunting by local people for wild meat within the Project Area and AoI.	Yes
Food: cultivated crops	Annual and permanent crops grown for subsistence use and commercial sale	95% of local villagers' livelihood is relied on coffee plantation. Type of coffee is robusta. In addition to that, local villagers also plant vegetables such spring union, chili and potatoes. Type of agriculture is permanent plot as each villager has various size of land ranging from 0.25 hectare to four hectares. For coffee, there are few middle men who live in village and some others come from outside village and help local villagers to sell outside village or districts. There is no forest conversion for new coffee plantation. Coffee can be harvested for minimum of 15 years. After that, local villagers replant new coffee plant or utilize other prospective crops such as cocoa, or timber/wood plant such as rubber, meranti and albasia where such woods are utilized for building houses. Evidence suggests that cultivated crops occur within the Project Area and AoI. There is potential for impacts to cultivated crops from air emissions.	Yes

Ecosystem Service Type	Description, Examples	Current Known Ecosystem Services	Screened in?
Food: herbs and plants	Herbs and plants collected for food by local people	Herbs and plant are planted in the local villagers' house yard and in between other crops such as ginger, turmeric, galangal, lemongrass, etc. Herbs are used for cooking ingredient. Local villagers have less interest in making traditional herbs drink (example ginger drink) in their daily consumption, however, if they need to keep body health stamina, local villagers made herbs drink from ginger and lemongrass. Evidence suggests that herbs and plants are planted in villagers' farm or house yard.	No
Livestock farming	Sedentary and nomadic livestock farming	There are no livestock farming because livestock farming is not primary livelihood of local villagers. However, there is one villager (Bapak Masrul Rohim) in Rantau Dedap who owns livestock of 64 "garut" goats. Cows and chicken are kept by local villagers in very small amount such as one or two cows and five to 15 chicken. In addition, cows, and chicken are sold during religious festive such as Eid Fitr or Eid Mubarak to those local villagers who need them. "Garut" goats are sold to neighbors or outside village during religious festive such as Eid Mubarak. Evidence suggests that local people do not undertake livestock farming within the Project Area and AoI.	No
Biomass fuel	Wood, dung and plant matter collected for charcoal, fuel	Local villagers do not utilize biomass fuel for their daily cooking fuel from their livestock. Cows and chicken are in very small quantity. Cow and chicken dung are utilized for crops fertilizer. Evidence suggests that there is no collection of wood, dung and plant matter for the production of charcoal and fuel.	No
Timber and wood products	Wood collected for local use or for sale as timber, wood pulp and paper	Local villagers collect timber and wood from their own crops field/ plantation where they plant albasia, cemara (casuarina equisetifolia) and meranti (shorea sp.) trees for building houses. If they do not have it, they bought it from neighbors whose timber plantation. Local government official (forestry) forbids access to forest for anyone for cutting wood through local government regulation (by regency head). There is a heavy penalty imposed to those who violate the law/regulation. Wood/timber needs are reduced due to local villagers prefer to build houses using concrete wall as local villagers have better access (transportation) to go to house building store in nearby city. Evidence suggests that wood is harvested from villagers' own plantation or farm.	No
Non- Timber Forest Products (NTFP)	Non-timber products collected from the forest. For example, cane, palm, straw, cotton, hemp, twine and rope, natural rubber	Local villagers do not collect or gather non-timber forest product such as wild honey. Wild honey is gathered or collected from bees that made their nests in trees like coffee, cemara in plantation/crops field. The honey is sold to local villagers who need it. The price of honey is valued Rp. 150,000 per bottle (1 liter). In addition to that, a few local villagers make "small rice basket" made from Enau plant (arenga pinnata) in small quantity. Small rice basket is sold around Rp. 8,000 per piece. Evidence suggests that NTFP is harvested from villagers' own trees planted in their farm/plantation.	No

Ecosystem Service Type	Description, Examples	Current Known Ecosystem Services	Screened in?
Regulating services			
Freshwater Biochemical, natural medicines, pharmaceuticals	Freshwater for bathing, drinking, irrigation, laundry, household and industrial use	Freshwater is utilized by local villagers for various purposes such as development of micro-hydro power and hygiene activities. Through development of micro-hydro power, local villagers use it for their electricity as the PLN network is not available. There is no water quality and quantity issue since local villagers utilize water from trusted source such as spring water distributed through PAMSIMAS. River water which is distributed to villagers' houses using water piping or water hose. The river water is only utilized for hygiene activities not for cooking or drinking. Addition to that, local villagers have their own shallow well which can be easily obtained with a depth of 7 meters. Evidence suggests that freshwater is used by local people from within the Project Area and AoI. The project may restrict or impact this activity.	Yes
	Natural medicines, biocides, food additives, pharmaceuticals and other biological material for commercial or domestic use. For example, pelts, carved or decorative animal products, live animal trade	Local villagers do not collect or gather any natural medicines from the forest. Local villagers go to doctor or drugstore or village health center if they are sick. Medicinal plants grow wildly in crops field/plantation. Evidence suggests that there is no use of natural medicines biocides, food additives, pharmaceuticals and other biological material for commercial or domestic use.	No
	Genes and genetic information used for animal breeding, plant improvement, and biotechnology	There is no genes and genetic information used for animal breeding, plant improvement, and biotechnology. Evidence suggests that there is no current use of genes and genetic information used for animal breeding, plant improvement, and biotechnology.	No
Ecosystem functions	The influence ecosystems have on air quality by extracting chemicals from the atmosphere (i.e., serving as a "sink") or emitting chemicals to the atmosphere (i.e., serving as a "source")	Evidence suggests that the Project area of AoI has no major influence on air quality in the vicinity due to the project has not been initiated yet.	No
	Carbon sequestration (impacts on global climate change) regulation of temperature, shade air quality by vegetated areas	Evidence suggests that the Project area of AoI has no major influence on Carbon sequestration in the vicinity due to the project has not been initiated yet.	No
	Influence ecosystems have on the timing and magnitude of water runoff, flooding, and aquifer recharge	Evidence suggests that the Project area of AoI has no major influence on water runoff, flooding, and aquifer recharge in the vicinity due to the project has not been initiated yet.	No
	Role played by vegetation and bacteria in the filtration and decomposition of organic wastes and pollutants and the assimilation and detoxification of compounds.	Evidence suggests that the Project area of AoI has no major influence on filtration and decomposition of organic wastes and pollutants in the vicinity due to the project has not been initiated yet.	No

Ecosystem Service Type	Description, Examples	Current Known Ecosystem Services	Screened in?
	Role of natural habitats (e.g. wetlands, beaches, reefs) in protecting crops, buildings, recreation areas from waves, wind and flooding from coastal storms.	Evidence suggests that the Project area of AoI has no major influence on protecting crops, buildings, recreation areas from waves, wind and flooding from coastal storms in the vicinity due to the project has not been initiated yet.	No
	Regulation of fire frequency and intensity (e.g. dense forest can provide firebreaks)	Evidence suggests that the Project area of AoI has no major influence on regulation of fire frequency and intensity in the vicinity due to the project has not been initiated yet.	No
	Predators from forests, grassland areas, etc. may control pests attacking crops or livestock	Evidence suggests that the Project area of AoI has no major influence on Predators from forests, grassland areas, etc. may control pests attacking crops or livestock in the vicinity due to the project has not been initiated yet.	No
	Influence ecosystems have on the incidence and abundance of human pathogens	Evidence suggests that the Project area of AoI has no major influence on incidence and abundance of human pathogens in the vicinity due to the project has not been initiated yet.	No
	Role of vegetation in regulating erosion on slopes and riparian areas	Evidence suggests that the Project area of AoI for the geothermal site has regulating erosion on slopes and riparian areas in the vicinity, due to the project has not been initiated yet.	No
	Birds, insects and some small mammals pollinate certain flora species, including some agricultural crops	Evidence suggests that the Project area of AoI has no major influence on birds, insects and some small mammals pollinate certain flora species, including some agricultural crops in the vicinity due to the project has not been initiated yet.	No
Cultural Services			
Spiritual, religious or cultural value	Natural spaces or species with spiritual, cultural or religious importance	There are no natural spaces or species with spiritual, cultural or religious importance. Local villagers are embracing the religion of Islam. Therefore, they do not utilize any natural spaces or species with spiritual and religious values. However, there are two sacred sites (Puyang Lake and Belerang Hill) where both are considered haunted places. Puyang Lake is located nearby well pad B, C, E and I and according to Supreme Energy representative, location is far from basecamp about 10 km. For Belerang Hill, it is located faraway about 30 km and it is located in other district. Evidence suggests that the Project area of AoI is not considered as important natural spaces or species with spiritual, cultural or religious importance.	No
	Cultural value placed on traditional practices such as hunting, fishing, crafts and use of natural resources.	Evidence suggests that the Project area of AoI is not considered important areas for cultural value on traditional practices.	No
	Use of natural spaces and resources for tourism and recreation (e.g. swimming, boating, hunting, bird-watching, fishing)	There is a waterfall in the forest namely "Sebidang Rindu" which is located 2 km from project area with 60 metres high. Evidence suggests that the Project area of AoI is considered important natural spaces and resources for tourism and recreation.	Yes

Ecosystem Service Type	Description, Examples	Current Known Ecosystem Services	Screened in?
	Cultural value placed on the aesthetic value provided by landscapes, natural landmarks	Evidence suggests that the Project area of AoI is not considered as important aesthetic value provided by landscapes, natural landmarks.	No
	Information derived from ecosystems used for intellectual development, culture, art, design, and innovation.	Evidence suggests that the Project area of AoI is not considered important for information derived from ecosystems used for intellectual development, culture, art, design, and innovation.	No
	Ornamental resources	A few local villagers use ornamental resources from coconut trees (leaves) which can be found in their crops field/plantation. The coconut leaves are used for decoration such as for wedding event. Evidence suggests that the Project area of AoI is not considered important ornamental resources.	No
Supporting Services			
Non-use value of biodiversity (e.g. existence, bequest value)	Species and areas valued globally as of high conservation value	There is no non-use value of biodiversity in the villages. However, Evidence suggests that the Project areas of AoIs may contain species that are considered as being a high conservation value.	Yes
	Formation of biological material by plants through photosynthesis and nutrient assimilation.	Evidence suggests that the Project area of AoI is not considered important regarding biological material by plants through photosynthesis and nutrient assimilation.	No
	Flow of nutrients (e.g., nitrogen, sulfur, phosphorus, carbon) through ecosystems.	Evidence suggests that the Project area of AoI is not considered important for the flow of nutrients.	No
	Flow of water through ecosystems in its solid, liquid, or gaseous forms.	Evidence suggests that the Project area of AoI is not considered important for the flow of water through ecosystems.	No
	Natural soil-forming processes throughout vegetated areas.	Evidence suggests that the Project area of AoI is not considered important for natural soil forming processes.	No
	Natural spaces that maintain species populations and protect the capacity of ecological communities to recover from disturbances.	Evidence suggests that the Project area of AoI is not consider important to maintain species populations and the capacity to assist ecological communities recover from disturbances.	No

3. *ECOSYSTEM SERVICE DATA COLLECTION AND PRIORITIZATION*

Community interviews were conducted on ecosystem services assessment at the SERD site in October 2017. The summary of the results are outlined below.

3.1 *COMMUNITY SURVEYS*

ERM undertook the following consultation as part of ecosystem services assessment:

- Consultation meetings with internal SERD representatives (environment, social and management).
- Consultation with 15 local village representatives living in close proximity to Supreme Energy site location in Rantau Dedap from selected communities (3 villages); and
- Household survey questionnaires were used to gather data from the communities around SERD site locations to solicit their opinions on both the positive and negative aspects of the Project development. The data is relevant to understanding current socio-economic conditions in the Area of Influence of the Project, historical impacts associated with SERD project activities as well as potential issues associated with the on-going activities of the Project.

The topics addressed in the household surveys included:

- Basic household information (Individual);
- Group discussions focussed on the livelihoods of coffee small business women group; and
- Socio-economic system survey as a quantitative assessment of the level of reliance on natural resources by affected communities and the linkage between the subsistence economy and the livelihoods of affected communities.

Prior to conducting household surveys, an introductory meeting was convened in the host community to introduce the purpose of the consultation.

3.2 *DATA COLLECTION*

Data was collected through community meetings, household surveys and face to face discussions with stakeholders. Community meetings were arranged by Supreme Energy representatives in collaboration with the village leaders and other village representatives. The meetings provided an opportunity to gather feedback on SERD activities.

A total of fifteen (15) village representatives had discussions on their socio-economic conditions across three (3) villages with particular focus on the livelihoods of women and farmers. The details the surveys conducted are in ***Table 3-1***.

Table 3-1 The details of the surveys conducted in project area.

Date	Name of Villagers	Occupation	Villages/ Villages
06-10-17	Jutawan; H. Tawil; H. Ismail; Coffee small business woman group	Village head; community leaders	Tunggul Bute
	Markun	Head of village	Rantau Dedap
07-10-17	Edi Prayitno	Religious leader	Talang Pisang
	Kaluri	Farmer/ traditional healer	Talang Pisang

In addition to conducting face-to-face interview with local villagers, ERM also conducted field observations. The field observations include the presence of Pamsimas (Indonesian Government program in clean water access and sanitation for local communities), rivers and site visits to Supreme Energy project activities.

The questionnaire used to collect data on ecosystem services is shown in ***Table 3-2***. Data was collected on screened in ecosystem services relevant to the community. Information was collated on:

- Type of ecosystem services used by the local community;
- Sources (locations), amounts utilised and availability of alternatives;
- Condition and trends in resource availability;
- Cultural and supporting ecosystem services;
- Screened ecosystem services for erosion, and;
- Non-use value of biodiversity

Table 3-2 Ecosystem Services Questionnaire

ES Screened in	Questions
Food: wild-caught-fish and shellfish and aquaculture	• Do fishermen go fishing for fish/shellfish? How often do fishermen go fishing? Record locations of where the fishing takes place on a map.
Food: wild meat	• Do local hunters go hunting? How often do they go? What species do they target? Identify hunting areas on a map; • Do local hunters travel to other forests to undertake hunting? What species do they target? Record the species hunted and location; • Record the type and trend (increasing or decreasing)
Food: cultivated crops	• What crops are cultivated? What type of agriculture is utilized (shifting or permanent plots)? What seasonal crops are planted? Are the crops are sold locally or outside the village? Identify location of cropping areas on a map; • Do other plot owners travel to other areas to undertake cropping? Record the area of plots, species planted and location. Mark the location on a map; • Discuss any trends in quality or quantity. Record the type and trend (increasing or decreasing).
Food: herbs, mushrooms and plants	• What herbs and plants are collected from the forest? Are the herbs and plants used for consumption or sold at the market? How often are the collected? • Discuss the alternative herbs and plants are available? Where are these bought? • Have there been any changes in yield? Record the type and trend (increasing or decreasing)
Livestock farming	• What livestock are tended? Are the livestock used for consumption or sold at the market? • What alternative livestock are available? Where are these bought? • Discuss the type of livestock tended and whether there is a trend in quality or quantity. Record the type and trend (increasing or decreasing)
Timber and wood products	• What species of timber and wood collected? When is the timber collected? Is the timber and wood used in the village or sold outside the village? Identify location of collection areas on a map; • Do timber gatherers travel to other forests to undertake wood and timber collection? What is the frequency and amount of collection from alternative locations? Mark the location on a map; • What are the trends in timber volume and quality? Record the type and trend (increasing or decreasing).
Non- Timber Forest Products (NTFP)	• What species of NTFP are collected? • Discuss what other NTFP are used by households. Record the type and amounts. • Record the type and trend (increasing or decreasing) of NTFP collected.
Freshwater	• What is the uses for freshwater in the village? Where is the water collected from? Record the location of water sources; • Are there alternatives to water supply available to villagers? Where are these alternative supplies?; • Has water quality and quantity been impacted? If so what by?
Biochemical, natural medicines, pharmaceuticals	• What medicines are collected from the forest? What is the amount, uses and location of the main collection points? • Are alternatives to local medicines available? If so, what are they and where are they collected? • Are natural medicines becoming more or less available? Is the availability of medicines increasing or decreasing?

ES Screened in	Questions
Ornamental resources	• What ornamental resources are collected from the forest? What is the amount, uses and location of the main collection points? • Are alternatives to ornamental resources available? If so, what are they and where are they collected? • What is the current condition of ornamental resources in the yield (increasing or decreasing)?
Spiritual, religious or cultural value	• Are there important forest and river resources for spiritual and religious values located in the area? Record values and places; • Are there other areas used for spiritual or religious values outside of the project area that locals could use as an alternative? • Have spiritual and religious values been impacted previously? Record values and places.
Traditional practices	• Are there important forest and river resources used for traditional practices located in the area? Record values and places; • Are there other areas used for traditional practices outside the project are that locals could use as an alternative? • Have areas used for traditional practices been impacted previously? Record values and places.
Recreation and tourism	• Are there important forest and river resources used for recreation and tourism located in the area? Record values and places; • Are there other areas used for recreation and tourism values outside the project area that locals could use as an alternative? • Have recreation and tourism values been impacted previously? Record values and places.
Aesthetic value	• Are there important aesthetic values associated with the forest and river located in the area? Record values and places; • Are there other areas appreciated for aesthetic value outside of the project area that locals could use as alternative? • Have aesthetic values been impacted previously? Record values and places.
Educational and inspirational values	• Are there important educational values located in the area? Record values and places; • Are there other areas used for education values outside of the project area that locals could use as alternative? • Have educational values been impacted previously? Record values and places.
Non-use value of biodiversity (e.g. existence, bequest value)	• Are there important landscape values located in the area? Record values and places; • Are there other areas that have an importance outside of the project area that locals could use as an alternative? • Have landscape values been impacted previously? Record values and places.

3.3 *RESULTS*

The results of the survey for screened ecosystem services are outlined below.

3.3.1 *Provisioning Services*

Food: wild-caught fish and shellfish and aquaculture

The results of the survey in relation to provisioning services for food wild-caught fish and shellfish and aquaculture are outlined in ***Table 3-3*** below.

Table 3-3 Results of survey in relation to Food: wild-caught fish and shellfish and aquaculture

Name of Village	Food: wild-caught fish and shellfish and aquaculture					
	Wild-caught fish and shellfish and aquaculture from the river/lake (every catch)		Other sources of protein consumed (per month/household) from the market (bought)		Resource condition and trends	
	Type	Amount	Type	Amount (kg)	Size	Trend
Tunggul Bute, Rantau Dedap and Talang Pisang	Local fishes: mujair, nila and gold fish from Endikat River and Deduruk small lake	5 to 10 fishes every catch	Chicken	10 kg	Normal	Decrease

Food: wild-meat

The results of the survey in relation to provisioning services for food wild-meat are outlined in ***Table 3-4*** below.

Table 3-4 Results of survey in relation to Food: wild-meat

Name of Village	Food: wild-meat					
	Wild-meat		Other sources of protein consumed (per month/household) from the market		Resource condition and trends	
	Type	Amount	Type	Amount (kg)	Size	Trend
Rantau Dedap	Deer	1 with weight of 40 to 65 kg	Chicken Fish Beef	10 kg 5 to 10 kg 15-20 kg (only during Islamic festive e.g. Eid Mubarak-once a year)	Normal	Decrease

Food – Cultivated Crops

The results of the survey in relation to provisioning services for Food – Cultivated Crops are outlined in ***Table 3-5*** below.

Table 3-5 Results of survey in relation to Food – Cultivated Crops

Name of Village	Food: Cultivated Crops					
	Crops cultivated in the farm/plantation		Crops used by Household		Resource Condition and Trends	
	Name	Plot area each household	Type	Amount	Trend	
					Quality	Quantity
Tunggul Bute, Rantau Dedap, and Talang Pisang	Coffee	0.5 to 1 hectare	Coffee; Chili and Spring Union	1 to 2 tons per hectare (coffee); 10 to 20 kg per hectare (chili and spring union)	Same	For coffee is fluctuating due to unpredictable weather (dry or wet) where in the wet (decrease) and in the dry (increase); for chili and spring union are increasing.

Food: Herbs and plants

The results of the survey in relation to provisioning services for Food: Herbs and plants are outlined in ***Table 3-6*** below.

Table 3-6 Results of survey in relation to Food: Herbs and plants

Name of Village/ Village	Food: Herbs, and plants						
	Herbs and plants are collected from the farm/plantation and bought in the market		Other collected herbs and plants		Resource Condition and Trends		
	Name	Place	Frequency	Type	Amount	Trend	
						Quality	Quantity
Tunggul Bute, Rantau Dedap, and Talang Pisang	Ginger, turmeric, galangal, lemongrass (for cooking ingredients) and	Farm/ plantation and bought in the market	Daily	Rumput selusuh urat (for relieve wounds)	If needed	Good	Stable

Name of Village/ Village	Food: Herbs, and plants						
	Herbs and plants are collected from the farm/plantation and bought in the market		Other collected herbs and plants		Resource Condition and Trends		
	Name	Place	Frequency	Type	Amount	Trend	
						Quality	Quantity
	herbs drink						

Food: Livestock farming

The results of the survey in relation to provisioning services for Food: Livestock farming are outlined in ***Table 3-7*** below.

Table 3-7 Results of survey in relation to Food: Livestock Farming

Name of Village/ Village	Livestock Farming						
	Livestock			Other Livestock		Resource Condition and Trends	
	Name	Grazing area	Type	Amount	Type	Trend	
						Quality	Quantity
Tunggul Bute, Rantau Dedap, and Talang Pisang	Garut goat	Rantau Dedap	Cow (small amount)	1 to 5	Garut goat	Same	Increase
			Chicken (small amount)	5 to 10	Chicken	Same	Stable

Timber and wood products

The results of the survey in relation to provisioning services for timber and wood products are outlined in ***Table 3-8*** below.

Table 3-8 Results of survey in relation to Timber and Wood Products

Name of Village/ Village	Timber and wood products						
	Wood and Timber collected from the forest			Other source of wood		Resource Condition and Trends	
	Type	Amount	Location	Type	Amount	Type	Trend
							Quantity
Tunggul Bute, Rantau Dedap, and Talang Pisang	Albasia, cemara	9 to 10 trees	In the farm/	Cinnamon, Coffee and Durian logs	5 to 6 (for cooking)	Albasia, cemara (casuarina	Decrease

Name of Village/ Village	Timber and wood products						
	Wood and Timber collected from the forest			Other source of wood		Resource Condition and Trends	
	Type	Amount	Location	Type	Amount	Type	Trend Quantity
	(casuarina equisetifolia) and meranti (Shorea sp.)		plantation			equisetifolia) and meranti (shorea sp.)	

Non-Timber Forest Product (NTFP)

The results of the survey in relation to provisioning services for Non-Timber Forest Product (NTFP) are outlined in ***Table 3-9*** below.

Table 3-9 Results of survey in relation to Non-Timber Forest Product (NTFP)

Name of Village/ Village	Non-Timber Forest Product (NTFP)					
	NTFP collected from the forest			Resource Condition and Trends		
	Type	Amount	Location	Type	Trend Quality	Trend Quantity
Tunggul Bute, Rantau Dedap, and Talang Pisang	Wild honey	1 liter	In the farm/ plantation	Wild honey	Good	Decrease

Freshwater

The results of the survey in relation to freshwater are outlined in ***Table 3-10*** below. The freshwater from river is utilized for irrigation system (paddy field) and development of micro-hydro to fulfill electricity needs due to PLN (state-owned enterprise providing electricity services for households) is not available. The irrigation system applies during dry and wet seasons. However, during the wet season, the water quantity is increasing and during the dry season, the water quantity is decreasing.

Table 3-10 Results of survey in relation to Freshwater

Name of Village/ Village	Freshwater						
	Location			Alternative location	Resource Condition and Trends		
	Type	Type	Location	When	How		Why
					Quality	Quantity	
Tunggul Bute, Rantau Dedap, and Talang Pisang	River (Endikat)	Spring water	Around villages	Pamsimas program (spring water) has been running quite long time ago.	Clear (dry season) and turbidity (wet season)	Fluctuating - decrease in dry season and increase in wet season	None

Biomass Fuel

The results of the survey in relation to biomass fuel are outlined in ***Table 3-11*** below.

Table 3-11 Results of survey in relation to Biomass Fuel

Name of Village/ Village	Biomass Fuel						
	Purpose	Alternative location			Resource Condition and Trends		
	Type	Source Type	Location	Amount	How		Other alternative location
					Quality	Quantity	
Tunggul Bute, Rantau Dedap, and Talang Pisang	Fertilizer	Cow and chicken dung	In the farm/ plantation	10 to 15 sacks per month	Good	Stable	Buy in the fertilizer store in the city (Kota Agung)

Cultural Services

Spiritual, Religious or Cultural value

The results of the survey in relation to spiritual, religious or cultural value are outlined in ***Table 3-12*** below.

Table 3-12 Results of survey in relation to spiritual, religious or cultural value

Name of Village/ Village	Spiritual, religious or cultural value						
	Purpose	Presence			Resource Condition and Trends		
	Type	Name of Places/ product	Location	Other Information	How		Other alternative location
					Quality	Quantity	
Tunggul Bute, Rantau Dedap, and Talang Pisang	Sacred sites	Puyang Lake and Belerang Hill	Nearby well pad B, C, E and I (Puyang Lake) 30 km away and it is located in other district (Belerang Hill)	Local villagers consider these two haunted places	Unknown	Unknown	Unknown

Ornamental Resources

The results of the survey in relation to ornamental resources are outlined in ***Table 3-13*** below.

Table 3-13 Results of survey in relation to ornamental resources

Name of Village/ Village	Ornamental Resources						
	Purpose	Presence			Resource Condition and Trends		
	Type	Name of product	Location	Other Information	How		Other Information
					Quality	Quantity	
Tunggul Bute, Rantau Dedap, and Talang Pisang	The art decoration such as for wedding event	Coconut leaves	In the farm/ Plantation	None	Good	Stable	None

Recreation and Tourism

The results of the survey in relation to recreation and tourism are outlined in ***Table 3-14*** below.

Table 3-14 Results of survey in relation to recreation and tourism

Name of Village/ Village	Spiritual, religious or cultural value						
	Purpose	Presence			Resource Condition and Trends		
	Type	Name of Places/ product	Location	Other Information	How		Other Information
					Quality	Quantity	
Tunggul Bute	Recreation and tourism	Sebidang Rindu waterfall	2 km from project area	The waterfall has 60 meters high	Good	Stable	To access to waterfall is very difficult and only can be accessed by walk or on foot

Regulating

Role of vegetation in regulating erosion on slopes and riparian areas

Vegetation plays an important role in maintaining soil cohesion along riparian areas and on steep slopes. It was observed at the Supreme Energy site location in Rantau Dedap has managed the erosion management on slopes and riparian areas.

Biological value: Species and areas valued globally as of high conservation value

Rantau Dedap project area is candidate critical habitat areas for global high conservation species (See SERD Critical Habitat Assessment).

4. ECOSYSTEM SERVICES PRIORITISATION

4.1 APPROACH

The WRI guidelines and IFC PS6 requires that priority ecosystem services are identified, and impacts to those services are assessed (IFC 2012). The prioritization process is aimed at identifying those services for which Project impacts would be most likely to result in adverse impacts on project affected communities and other beneficiaries. Using the information collected through the baseline data collection and stakeholder engagement processes, Ecosystem Services were prioritized according to a priority matrix ranking two criteria:

- Importance of the ecosystem service to the beneficiary which considers the intensity of use, degree of dependence and the importance expressed by the project affected communities; and
- Irreplaceability of the ecosystem service, which refers to the availability of alternatives, the accessibility, cost and appetite for those alternatives as discussed with the beneficiary.

4.2 RESULTS

After compiling baseline information on the importance and irreplaceability of each service, these ratings were combined to assign a priority rating to the service grading from *Low* to *Major* as shown in the ecosystem service prioritization matrix in ***Table 4-1***.

Ecosystem services identified as *High* priority or *Major* priority were considered Priority Ecosystem Services. The weight given to each of these components varied slightly depending upon the service, but stakeholder values were given precedence over other criteria where the rating was not clear.

In addition to the above, according to the IFC definition of priority ecosystem services, all services for which project dependencies are identified are considered priority services. The importance and irreplaceability of services relied upon by the Project was assessed through the same prioritization process outlined above, with the Project filling the role of the beneficiary.

In addition to the prioritization exercise, the baseline data collection process provided the opportunity to collect information on the status, trends and sustainability of resource use as they pertain to the habitats and species that support Ecosystem Services. This information was gathered through secondary sources and field studies by the environment team and where appropriate through engagement with local stakeholders. This information is important for the assessment of impacts on Ecosystem Services and therefore on local people as the final receptors of these changes.

Table 4-2 outlines the beneficiaries, potential sources of impact and project dependence for each service, and whether the service was scoped into or out of the Ecosystem Services assessment.

This *section* provides an assessment of the potential Project impact to ecosystem services using the criteria provided.

Table 4-1 Ecosystem Service Prioritization Matrix

Importance to Beneficiaries		**Irreplaceability**		
		High	**Moderate**	**Low**
Low	The service is used and valued by parts of the community, but it is not important in maintaining quality of life or livelihoods of Project Affected Communities.	**Low Priority**	**Low Priority**	**Moderate Priority**
Medium	The service is readily used by some members of the Project Affected Communities for income or subsistence, but they are not dependent upon the service for their livelihoods, and not everyone utilises the service.	**Low Priority**	**Moderate Priority**	**High Priority**
High	The service is highly important in maintaining the livelihoods of the Project Affected Communities, and is used by most of the community regularly.	**Moderate Priority**	**High Priority**	**Major Priority**
Essential	The service is essential to maintain the health of the Project Affected Communities, and the service is used by all members of the community.	**High Priority**	**Major Priority**	**Major Priority**
Irreplaceability definition				
High	Many spatial alternatives exist that are readily available to the Project Affected Communities, and there are no major impediments to their usage.			
Moderate	Spatial alternatives exist but are either less accessible than the affected service, or there are other barriers to their use such as distance, cost and skills required to access the service.			
Low	There are few to no spatial alternatives available to the Project Affected Communities.			

Table 4-2 Results of Prioritization

Ecosystem Services	Trends and Sustainability	Beneficiaries	Importance to Beneficiaries	Irreplaceability	Potential Alternatives	Priority?
Provisioning Services						
Food: wild-caught fishes, shellfish, and aquaculture	The populations of wild-caught fishes appears to be in decline	All villages and villages within AoI of Rantau Dedap project area	Low	High	Communities in Rantau Dedap project has ready access to alternative protein sources such as chicken	Low
Food: wild meat	The populations of wild animal (deer) caught for meat appears to be in decline.	All villages and villages within AoI of Rantau Dedap project area	Medium	High	Communities in Rantau Dedap Village have ready access to alternative protein sources such as beef, fish, and chicken.	Low
Food: cultivated crops	The amount of main crops planted (coffee) and harvested within the Project AoI (Rantau Dedap) appears to be in fluctuating (decrease in wet season and increase in dry season)	All villages within AoI of Rantau Dedap project site location	High	Moderate	Besides crops from the community coffee plantation, the local people can plant other alternative plants such as vegetables	Low
Food: herbs and plants	The amount of herbs and plants available to the community from their farm/ plantation or house yard areas within the AoIs appears to be in stable.	All villages within AoI of Rantau Dedap project area	Medium	High	Replacements for herbs and plants collected are readily available within nearby markets or planted in local people farm/plantation or house yard	Low
Food: livestock farming	The amount of livestock farming available to the community from the local villager who lives in Rantau Dedap, Bapak Masrul Rohim who owns approximately 64 "garut" goats and they are increasing. The goats are sold during Islamic festive e.g. Eid Mubarak. While other villagers do raise cows and chicken in small amount.	All villages within AoI of Rantau Dedap project area	Medium	High	There alternatives for local villagers who own small amount of cows and chicken which they are for own consumption or to be sold to the market or their neighbours when needed.	Low
Biomass Fuel	Local villagers do not utilize biomass fuel for their daily cooking fuel from their livestock. Cow and chicken dung are utilized for crops fertilizer.	All villages within AoI of Rantau Dedap project area	Medium	High	Local villagers obtain organic fertilizer from seller who live outside villages (fertilizer store)	Low
Timber and wood products	The amount of timber available to local people has been decreasing. There is a restriction from local government official (forestry) by establishing the local regulation/law to prohibit people entering forest. To overcome such issue, the timber and wood are planted in local villagers' farm or plantation.	All villages within AoI of Rantau Dedap project area	Medium	High	Potential alternatives exist for use by the villages such as bricks and cement which they can get from house building store in the city (outside Rantau Dedap) as road condition to and from the store is currently is in good condition. If the local people still need timber and wood for building houses, they buy it from house building store outside Rantau Dedap.	Low
Non- Timber Forest Products (NTFP)	Wild honey availability has been decreasing at AoI of Rantau Dedap	All villages within AoI of Rantau Dedap project area	Low	Moderate	Potential alternatives for use by villagers such as buying the honey from local market or supermarket.	Low
Freshwater	Currently, local communities utilize Deduruk small Lake and Endikat River for micro-hydro development and hygiene activities. If Rantau Dedap project utilizes local river or lake, it may likely impact to the river quantity and quality.	All villages within AoI of Rantau Dedap project area	High	Moderate	Spring water (Pamsimas program) and deep well are available for hygiene, cooking and drinking; however river water is still used for micro-hydro development.	High
Regulating Services						
Erosion regulation	The forest in Rantau Dedap project may provide stability to the slopes to reduce the chance of land slips and erosion	Supreme Energy has taken erosion management to prevent impacts of the affected villages downstream.	High	Moderate	Careful management of soil surfaces and river will be required to limit damage caused by erosion and mass movement (equipment mobilization).	High
Recreation and tourism	Sebidang Rindu waterfall. It is a nature creation and the water is not decreased even in the dry season.	Villagers who live in Tunggul Bute located within AoI of project area in Rantau Dedap (2 km)	Medium	Low	Local villagers very rarely visit the waterfall due to the location distance and access to the location is difficult.	Low
Cultural Services						
Spiritual, Religious or Cultural value	The availability of sacred sites (Puyang Lake and Belerang Hill) and they are considered as haunted places as well. Puyang Lake is located nearby well pad B, C, E, and I. While Belerang Hill is located in other district. Those places are nature and local villagers keep those two places sustainable.	All villages within AoI of project area in Rantau Dedap	Low	High	Local villagers embrace Islam and such sacred sites have never been visited by local villagers. In addition, Puyang Lake is located in Supreme Energy well pad, and there is likely a restriction to enter by the project in the future.	Low
Ornamental resources	The coconut leaves are available in the villagers' farm/plantation as the coconut trees grow wildly.	All villages within AoI of Rantau Dedap project area	Low	High	Currently, local villagers very rarely use the coconut leaves for certain event, e.g. wedding party. Due to the influence of lifestyle modernization, local villagers decorate the certain event using trinkets made from colourful paper that is sold in the accessories shop for wedding party.	Low

4.3 PRIORITY ECOSYSTEM SERVICES

The following priority ecosystem services shown in ***Table 4-3*** have been identified and will be assessed against the impact assessment procedures.

Table 4-3 Priority ecosystem services

Priority Ecosystem Service	Description
Freshwater	Evidence suggests that freshwater is used by local people from within the Project Area and AoI for irrigation system and micro-hydro development. The project may restrict or impact this activity. Impacts from the project activities may likely impact downstream due to utilization of river water, especially during the dry season due to decrease of water flows.
Erosion regulation	Evidence suggests that Rantau Dedap Project area of AoI has regulating erosion on slopes and riparian areas in the vicinity. The careful efforts in erosion control can provide stability to the slopes to reduce the chance of land slips and erosion. The land clearing and other related project activities might potentially change the river sedimentation and occurrence of erosion.

5. MITIGATION TO REDUCE IMPACTS ON THE PRIORITY ECOSYSTEM SERVICES

5.1 APPROACH

In a mitigation context, rigorous functional ecosystem services (ES) impact assessments focus not only on how supply is disrupted but also on how the delivery of services will be impacted over the lifetime of the project, and how much those changes are likely to matter to people (value). At the mitigation stage, ERM identifies options through the mitigation hierarchy to enhance or at least maintain: (1) the well-being affected beneficiaries derive from ecosystem services and (2) the performance the project derives from ecosystem services at acceptable levels.

Based on the WRI Guidelines, service mitigation measures inform project design and operations and are incorporated into the environmental and social management plans. Once ecosystem service-specific mitigation measures are identified, ensure there are no conflicts between these mitigation measures and the ones identified independently by the environmental and social practitioners.

5.2 PROPOSED MITIGATIONS

For freshwater, water-related ES that depend on catchment-scale hydrologic functions must be mitigated within the same catchment (serviceshed) to provide the same benefits to the same people. Serviceshed is determined by the area that supports biophysical service production, and allows beneficiaries both physical and institutional access to the service. If there is no biophysical supply of a service (e.g. no water purification taking place, no fish that can be caught, no forest views to enjoy), then there is no benefit. If formal (laws, regulations) or informal (social norms, cultural practices) institutions restrict beneficiaries' ability to access the biophysical supply, then there is no benefit. Institutions that limit or promote access can be very diverse, and can include protected areas, irrigation rights, land tenure, traditional rights, hunting or fishing seasonal closures, and many others.

On erosion regulation, geothermal development may be accomplished with minimal mass soil movement problems, if development sites and roads are located and constructed with full consideration of the problems involved.

The following ***Table 5-1*** indicates the mitigation actions proposed for the SERD project to reduce impacts on the priority ecosystem services:

Table 5-1 Mitigations Proposed for the SERD project to reduce impacts on the priority ES

Priority Ecosystem Services	Affected Stakeholder	Predicted Impacts on Ecosystem Service Benefit	Mitigation Measures (minimization)
Freshwater	Local villagers	Reduced water quantity and quality due to water utilization* by the SERD project where local villagers use the freshwater for hygiene activities and development of micro-hydro power.	- Freshwater use impacts can be reduced by utilizing dry cooling or by using non-freshwater sources as a cooling medium[11]. A non-freshwater sources such as utilization of groundwater; - Freshwater use impacts can be reduced by utilizing groundwater source for washing and bathroom facilities
Erosion Regulation	Local villagers	Sediment carried in waters drained from roads and also soil sedimentation** includes damage to provisioning value streams or rivers.	- Road and trail construction will not block drainage systems or water courses. Culverts or other suitable crossings will be installed in drainages, and roads will be drained or water barred as necessary to prevent erosion; - All roads planned for permanent or long-term use will be adequately gravelled or paved; - Roads, well pads, building and associated structured will be located and designed to require minimum earth movement for their construction; - All disturbed areas will be seeded, mulched, and fertilized for adequate protection from rain and run-off. Where feasible, native vegetation will be included in the prescription to restore the natural setting and to take advantage of normal ecological relationships; - Adequate erosion control and drainage measures will be required on disturbed sites to minimize soil movement and sedimentation of water courses.

*water utilization by the SERD project in smaller quantities, water may be needed on a temporary basis for well field development for things such as dust suppression, drilling fluid, and reservoir stimulation. Small amounts of water may also be needed for washing and bathroom facilities for the power plant. In some cases, most geothermal plants can use either geothermal fluid or freshwater for cooling.

**soil erosion impacts can be expected from clearing and earth movement activities associated with construction of building, well sites, pipelines, transmission lines, and roads.

[11] https://www.nrel.gov/docs/fy11osti/50900.pdf

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Fish and Macroinvertebrates Rapid Assessment in the SERD (South Sumatra) and the SEML (West Sumatra)

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EXECUTIVE SUMMARY

The surveys in PT Supreme Energy Rantau Dedap (SERD) and PT Supreme Energy Muara Labuh (SEML) area have been done from 2th December until 4th December 2017 and 6th - 8th December 2017. The survey collected two types of fresh water fauna biodiversity, Fish and Macroinverterbrates. Total 15 sites were surveyed in both of Supreme Energy area, consist of eight sites in SERD and seven site in SEML. There are 10 Species of Fishes, include in five Family documented. In Muara Labuh, there are four species of Cyprinidae, one species of Poeciliidae, and two species of Sisoridae. In Rantau Dedap, there are two species of Balitoridae, two species of Cyprinidae and one species of Cichlidae. Species founded in both area were *Barbodes* cf *banksi* and *Tor douronensis*. The common species in Rantau Dedap was *Glyptothorax platypogon.* The other species with small number were *Tor tambroides, Xiphophorus hellerii* and *Glyptothorax platypogonides.* In Muara Labuh, the dominan species were *Homalopterula* cf. *gymnogaster* _1 and *H.* cf. *gymnogaster* _2 which is an endemic Sumatra. In addition, there was *Oreochromis niloticus* collected.
The macroinvertebrates result shows that the stream ecosystem in the SERD region is relatively undisturbed, the quality of clean water indicated by the number of genera of each river is high relatively ranges from 23-34 genera with the number of individuals range from 91 to 295 individuals, the genera diversity index ranges from 1.92 -2.94 is moderate and the water quality is classified as clean. The presence of genera in each river varies. Genera found in all streams are the *Centroptilum, Neoperla, Hydropsyche,* and *Pseudocloeon. Anthocha, Baetis, Phagocata* are not found in one river. The predominant macroinvertebrate genera are: *Centroptilum, Pseudocloeon*, *Nemouraelmis, Stenelmis, Simulium, Anthocha, Neophylax, Hydropsyche* and *Psychomya*. The stream ecosystem in the SEML region also relatively undisturbed, the quality of clean water indicated by the number of genera of each river is high relatively ranges from 19-27 genera with the number of individuals range from 95 to 206 individuals, the genera diversity index ranges from 2,00 -2, 59 is moderate and the water quality is classified as clean. The presence of genera in each river varies. Genera found in all streams are the *Centroptilum, Nemura, Hydropsyche,* but *Simulium* are not found in one river. The predominant macroinvertebrate genera are: *Simulium, Centroptilum, Pseudocloeon*, *Nemura, Orthocladinae, Hydropsyche, Neophylax* and *Melanoides*.
One genus of crab *Parathelphusa maculata* founded in SERD and SEML. That species recorded as Least Concern (LC) in the IUCN Red List.

Keywords: Fish, macroinvertebrate, diversity index, Supreme energy

I. INTRODUCTION

Biodiversity refers to the term for the degree of nature's variety or variation within the natural system, both in number and frequency. The manifestation of biodiversity are the biological resources (genes, species, organisms, ecosystems) and ecological processes of which they are part (Mutia, 2009). The variety of species are measured in term of *Species Richness* and *Species Abundance*. *Species Richness* is the total count/number of species in a defined area. While *Species Abundance* is refers to the relative numbers among species (Rawat & Agarwal, 2015).

In the level of species, the same species often show differences in phenotypic characters and may also include genetic characteristics if living under different ecological conditions

(Moyle & Cech, 2000). Keeley, Parkinson & Taylor (2005) suggest that the differences in characters that appear in response to habitat conditions will increase the variation and differentiation that can lead to speciation, especially in conditions of disconnected of gene flow between populations. There for in the future, it also important to monitor their genetic diversity.

Human activity for the purpose of harvesting natural resources for industry production and urbanization is often destroyed the natural habitats. Clearing forest areas, mining, logging, urban sprawl, construction of highways are some examples of habitat destruction and fragmentation (Agarwal et al, 2014 and Rawat & Agarwal, 2015).

PT SERD and PT SEML are Joint Ventures of Supreme Energy, Engie and Marubeni to develop a geothermal power plant with an installed capacity of 80MW. The SERD project is located in occurs within two regencies (Muara Enim and Lahat) near Pagar Alam in South Sumatra Province. The SEML project is located in Muara Labuh in Solok Selatan Regency, West Sumatra Province. Both projects consist of wellpads and interconnecting pipelines to supply steam to a power generator. A switch yard and transmission line network is also associated with the Project. Geologically, areas are located in the Barisan Mountains Zone or exactly in the active fault zone of the Great Sumatra Fault (GSF). Geomorphology of Rantau Dedap geothermal development area is dominated by volcanic mountains. This prospect hydrological concept consists of the catchment areas in volcanic mountains that have a height of 1700 - 2600 m above sea level. Consider most locations geothermal activity by PT SERD located in protected forest areas, the conservation of water catchment areas in protected forest areas need attention. PT SEML is located along the Sumatra fault system. Two geothermal sources extend along 50 km of the Sumatra fault zone, namely North Muara Labuh and South Muara Labuh. Both geothermal sources have different geothermal and recharge sources, although hydrologically interconnected with each other.

The presence of geothermal power plant project may alters river conditions, reduces connectivity, and blocks access to upstream areas with high quality habitat, abundant prey, and fewer predators. That area is often blamed for population declines of migratory fishes. According to Chaudhuri (2005), the availability of data and specific detailed information about the biodiversity of fish in various types of aquatic ecosystems is indispensable as a basis for freshwater fisheries habitat management on an ongoing basis. In other to anticipate losing diversity of fish fauna in the area to be developed in the construction of Geothermal Power Plant in SEML and SERD zones, research is conducted through a rapid assessment activities. The aim of the research is to collect, to record and to study diversity of fish species present in the rivers in that area, as a baseline data within the project zone which can to be useful for aquatic resources management of this area in the future.

Aquatic macroinvertebrates has a role as indicators of water quality. Different types of macro invertebrates tolerate different stream conditions and levels of pollution. Depending on the types of macro invertebrates found in a stream, predictions about water quality can be made. Aquatic macro invertebrates are also an important part of aquatic and terrestrial food chains. They graze on algae and break down leaves and sticks that fall into the water. They are also an important food source for fish. Macroinvertebrates samples collection able to estimate water conditions as ecologically. Population estimation, diversity, composition

and community structure of macro invertebrates able to show the description of the environment and carrying capacity in that location. (Michael, 1984; Wallace and Webster, 1996).

II. METHODOLOGY

Sampling methodology and Study area:

II.1. Sampling methodology of Fish:

Total 15 sites were surveyed in both of Supreme Energy area, consist of eight sites in SERD and seven site in SEML by following standard procedures according to Cailliet et al. (1986) using fish net and backpack electrofishing gear (12 Volt). Sampling of every available location was done in one-two hour. The characteristics of sample obtained such as body color, color fins that may be lost or changed after death will photographed. Then, samples will preserved with formaldehyde 4-10 % in plastic box during in the field and then wrap in gauze bandage when transported and taken to the laboratory. In the laboratory, all specimen preserved later in 70% ethanol. Taxonomic studies, count and measurement are based on Hubb and Lagler (1947). Measurement were made by using Vernier caliper. Classification and identification follow those texts written by (Weber & Beaufort, (1916), Roberts (1989), Kottelat et al. (1993), Kottelat & Whitten (1996), Kottelat (2013) etc. All specimens are deposited in Andalas University Museum. Upon each sampling location, the composition of riparian vegetation, river substrate, type of water level, current (using a buoy), water clarity (using a Secchi Disk), and temperature will recorded. Local weather, date, time of day, location, stream channel conditions also recorded.

II.2. Sampling metodhology of Macroinvertebrates

The sampling of Aquatic macroinvertebrate was done in six streams around the SEML Project and seven streams around the SERD Project. The sample was collected using Surber Sampling Method (with 30 cm x 30 cm in size). The sampling area in each stream is determined along 100 m which represents the characteristics of the stream. The samples collected from productive area (area most likely inhabited by macroinvertebrates) such as riffle, pool, run, leaf pack, stream margin with vegetation within the 100 m reach of the stream. Sample with a Surber net by holding the net frame firmly against the stream bottom and disturbing the substrate with our hand or digger. Dig deeply into the substrate with digger to dislodge macro invertebrates from the streambed. The macro invertebrate collected in a bottle or plastic pack and preserved by formaldehyde 4% (Michael, 1984). Sampling begins at the downstream and proceeds to the upstream. In each stream collected tree sample with Surber net on the rocky substrat is approximately faunal diversity in the area. The Surber net place on the bottom of stream with the mouth facing upstream, 20-30 cm depth. All the stone in the square are pick up and remove into the bucket. The remaining substrate in the square is disturbed by garden trowel. Dislodge organisms are washed in to the net. The stone brushed in the bucket is fill with the sufficient water to cover stone by using stiff bristle brush to release the organisms. Macroinvertebrate were filter with 250 mikron mesh sieve. The material leaf in the filter removed to jar and water added sufficiently. Preserved with 40 % formalin aranged to the concentration of the solution in the sample bottle to 5 %. Hand collection is also done that are animal not caught with the net will be found in this way. Five stone are rather large, flat and rough surface selected. The animals attached to the stone are taken with tweezers or removed with a wire brush.The

sample collected from leaf pack and steram margin with vegetation. The debris rinsed and inspected, then filtered with the same screen. The sample place into the jar. Enviroment data recorded such as: instream features, width, depth, current velocity, substrat type, water temperature, pH, riparian vegetation, aquatic vegetation.

II.3. Data Analysis

Estimation for Fih and macroinvertebrates diversity was doing with by Shannon-Wiener Diversity index:

$$H' = -\sum_{n=1}^{s} pi \ln pi$$

Where:

H' = Shannon-Wiener diversity index
Pi = ni/N
ni = Number individual of one genus
N = Total number of all individuals in the sample

II.4. Locations Surveyed

Table.1. Position of the sampling site in SERD

No.	Site Code	Stream	Position	Altitude
1	SERD 1	Indikat	S-04^{0}12'02,6" E-103^{00}27'39,7"	1500 m asl
2	SERD 2	Cawang Kiri	S-04^{0}12'48,9" E-103^{0}24'39,7"	11746 m asl
3	SERD 3	Cawang Tengah	S-04^{0}11'45,9" E-103^{0}24'29,4"	1439 m asl
4	SERD 4	Asahan	S-04^{0}11'43,7" E-103^{0}25'537,8"	1572 m asl
5	SERD 5	Cawang Kanan Hulu	S-04^{0}13'13,1" E-103^{0}22'34,5"	2097 m asl
6	SERD 6	Cawang Kanan	S-04^{0}12'33,9" E-103^{0}23'48,1"	1699 m asl
7	SERD 7	Muara Cawang	S-04°10'34,3"S E-103°23'35,1"	1178 m asl
8	SERD 8	Indikat Hilir	S-04°10'47,3" E-103°25'36,46"	1349 m asl

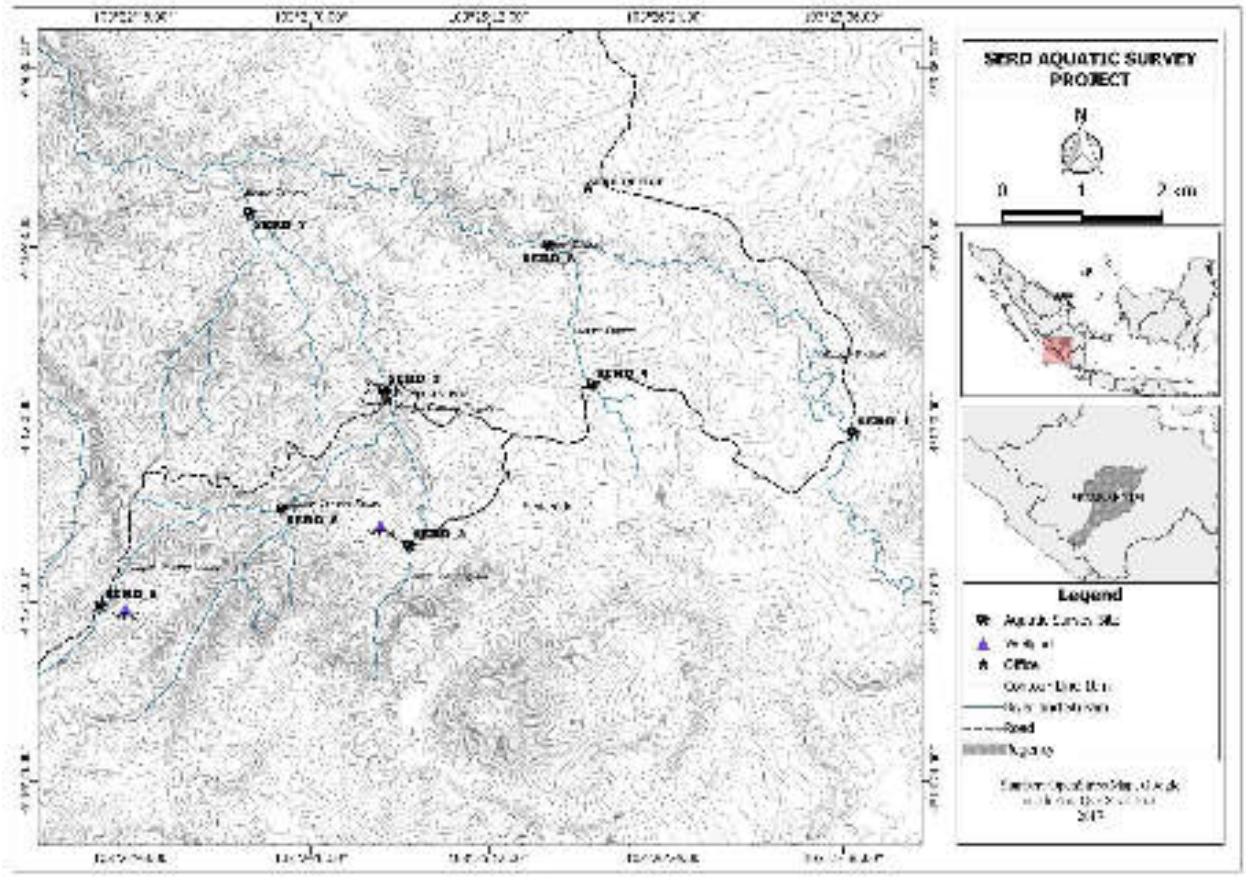

Figure 1. Location of sampling site in SERD

Table.2. Position of the sampling site in SEML

No.	Site Code	Streams	Position	Altitude
1	SEML 1	Bangko Hitam	S-01^{0}37'56,5" E-101^{00}7'40,1"	1455 m asl
2	SEML 2	Bangko Keruh	S-01^{0}36'39,4" E-101^{0}07'48,7"	1162 m asl
3	SEML 3	Muara S. Bangko Putih	S-01^{0}36'12,8" E-101^{0}07'34,0"	1055 m asl
4	SEML 4	Bangko Putih	S-01^{0}38'07,4" E-101^{0}08'07,9"	1439 m asl
5	SEML 5	Liki	S-01^{0}36'26,2" E-101^{0}09'02,4"	1003 m asl
6	SEML 6	Bangko	S-01^{0}36'31,1" E-101^{0}07'14,2"	1090 m asl

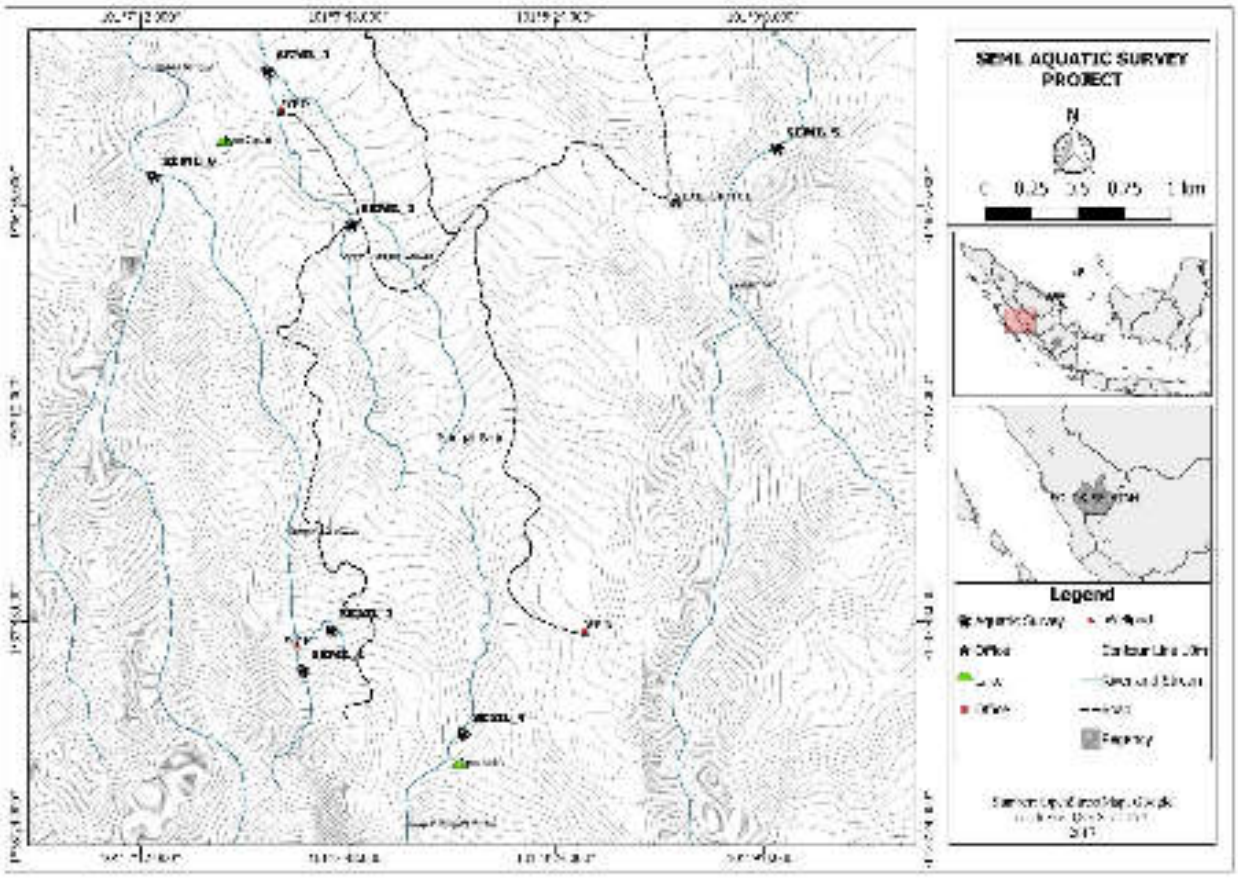

Figure 2. Location of sampling site in SEML

III. RESULT and DISCUSSION

III. 1. *An Overview* of *All Surveyed Locations*

The survey were conducted in two sites of Supreme Enegy, Supreme Energy Rantau Dedap (SERD) and Supreme Energy Muaro Labuah (SEML). The survey collected two types of fresh water fauna, Fish and Macroinverterbrata. Total 15 sites were surveyed in both of Supreme Energy area, consist of 8 sites in SERD and 7 site in SEML. The surveyed focused to the stream and river system around the Supreme Energy Company. The sampling started on 2th December until 4th December 2017 and 6th -8th December

Survey Site Description

III.1.1 SERD (Supreme Energy Rantau Dedap)

a. SERD 1

Sungai Endikat was the first surveyed site (2nd December 2017;10:45 WIB). The river has cascade type, this survey was conducted in geographical position -04°12'02,6" S and 103°27'39,7" E with elevation 1500 meter asl, width of the river 10-18 meter, a depth about 0,5-2 meter, water temperature measured was 18 °C, air temperature 24 °C, humidity 79%, velocity of river flow 0,93 m/s, pH 7, water transparency classified as turbid and cloudy weather when the survey did.This survey site lied between edge of secondary forest and

plantation. The vegetation dominated by shrubs, trees and ferns. On the right site of the river was the highly plantation activity like coffees, bananas and gourds.

b. SERD 2

Sungai Cawang Kiri was the third surveyed site (2nd December 2017; 16.20 WIB). The sites classified as stream, there were no fish has been cactched on this stream, the surveyed site closely by shortcut and road and the stream has lots of rapids. The geographical position are 04°12'48,9" S and 103°24'39,7" E, it's altitude is 1746 meter asl. The water was clear, have rocks, sand and stones substrate, 0,311 flow velocity m/s, humidity 85%, the width of the river 2-5 m, a depth about 50-100 cm, stream water ph 7. Water temperature measured was 18,5 ^{o}C. It was cloudy at the time. The vegetation around river are shrubs trees, ferns etc. This stream far from human activity.

c. SERD 3

Sungai Cawang Tengah was the fourth site that surveyed (3rd December 2017; 08.50 WIB)
The river has cascade type, has shortcut with the height 3 meters, so many rapids on this stream. This survey was conducted in geographical position 04°11'45,9" S and 103°24'29,4"E with elevation 1500 meter asl, width of the river was 3-10 meters, a depth about 1-2 meter, water temperature measured was 18 ^{o}C and air temperature was 20 ^{o}C, humidity 81%, velocity of river flow 0,327 m/s, pH 7, the water was clear. Substrates composed of rocks, sand and stones. The weather cloudy when the survey did.This survey site lied between edges of secondary forest. No fish catched from this site. The vegetation dominated by shrubs, trees and ferns. Low intensive of human activites along the river, but in the some sites showed the river excavation was did.

d. SERD 4

Sungai Asahan was the second surveyed site (2nd December 2017; 14:43 WIB)
The river has cascade type, has shortcut with the lenght about 15 meters, so many rapids on this stream especially in down stream. This survey was conducted in geographical position 04°11'43,7"S and 103°25'53,8"E with elevation 1572 meter asl, width of the river 2-3 meters, a depth about 0,5-2 meter, water temperature measured was 20 ^{o}C, air temperature was 21,5 ^{o}C, humidity 75%, velocity of river flow 1,63 m/s, pH 7. The water was clear. Substrates composed of rocks, sand and stones. The weather was cloudy when the survey did.This survey site located between edges of secondary forest. The vegetation dominated by shrubs like graminae, leguminoceae, trees and ferns. Low intensive of human activites along the river.

e. SERD 5

This site known as sungai Cawang Kanan Hulu was the fifth surveyed site (2nd December 2017; 10.30 WIB). The river has cascade type, has shortcut with the lenght about 20 meters, so many rapids on this stream especially in down stream. This survey was conducted in geographical position 04°13'13,1" S and 103°22'34,5" E with elevation 2097 meter asl. This river has 2-6 meters width, a depth about 0,5-2 meter, water temperature measured was 15 ^{o}C, air temperature was 21 ^{o}C, humidity 73%, velocity of river flow 0,377 m/s, pH 6,5, the water was clear with rocks, sand and stones as the substrates. It was cloudy weather when the survey did. This survey site located between edges of secondary forest. No fish catched

from this site, the vegetation dominated by shrubs like graminae, mosses, trees and ferns. Highly human activities and disturbance especially a pool for intac and shortcut.

f. SERD 6

This site known as sungai Cawang Kanan was the sixth surveyed site (3rd December 2017; 15:00 WIB). The river has cascade type, so many rapids on this stream especially in up and down stream. This survey was conducted in geographical position 04°12'33,9"S and 103°23'48,1" E with elevation 1699 meter asl, width of the river was 3-7 meters, a depth about 0,3-1,5 meter, water temperature measured was 18 °C, air temperature was 21 °C, humidity about 78%, velocity of river flow 0,345 m/s, pH 7, the water was clear with rocks, sand and stones as the substrates. It was sunny at the time.This survey site is secondary forest. No fish catched from this site, the vegetation dominated by trees, shrubs like graminae, mosses, trees and ferns.

g. SERD 7

Sungai Muara Cawang was the seventh surveyed site (4th December 2017; 08:54 WIB)

This study site is a confluence of all of the Cawang rivers and a small stream, the river has cascade type, so many rapids on this stream especially in up and down stream. this survey was conducted in geographical position 04°10'34,3"S and 103°23'35,1" E with elevation 1178 meter asl, width of the river was 8-12 meters, a depth about 0,1-1,5 meter, water temperature measured was 21 °C, and air temperature was 22 °C, humidity 96%, velocity of river flow was 0,335 m/s, pH 7, the water was clear. Substrates composed of rocks, sand and stones. The weather was cloudy when the survey did. This survey site located between plantation and vegetation dominated by shrubs, coffee, *Micania micranta, Piper aduncum*, graminae, small trees and ferns. Local people said taht the river was flooded seven years ago, and the flooded influenced the existence of fish and macroinvertebrata.

h. SERD 8

This site known as Sungai Endikat, the last surveyed site (4th December 2017; 14:15WIB)

This study site is a confluence of the Asahan stream and Endekat river, the river has cascade type and so many rapids.This survey was conducted in geographical position 04°10'47,3" S and 103°25'36,46" E with elevation 1349 meter asl, width of the river was 7-26 meters, a depth about 1-3 meter, water temperature measured was 19 °C, air temperature was 20 °C, humidity 87%, pH 7, the water is turbid. Substrates composed of rocks, sand and stones.The weather was cloudy when the survey did.This survey site lied between plantation and vegetation dominated of shrubs, bambos, trees *Micania micranta, Piper aduncum*,graminae, small trees and ferns.

III.1.2. SEML (Supreme Energy Muaro Labuah)

a. SEML 1

Sungai Aia hitam was the sixth surveyed site in Muara Labuah. The suvey was started in 8th December 2017 at 09:07 WIB. The river has cascade type, so many rapids on this stream especially in up and down stream. This survey was conducted in geographical position 01°37'56,5"S and 101°07'40,1" E with elevation 1455 meter asl, width of the river was 1-3 meters, a depth about 0,1-1 meter, water temperature measured was 17 °C, and air temperature 18 °C, humidity 81%, velocity of river flow 0,33 m/s, pH 7, the water is clear.

Substrates composed of rocks, sand and stones. The weather was sunny when the survey did. This survey site have any intac and human disturbance, especially for well pad operation. The vegetation dominated by small trees, shrubs like graminae, and ferns, etc.

b. SEML 2

Sungai Bangko Karuah was the fourth surveyed in Muara Labuah. The suvey was started in 7th December 2017 at 14.21WIB. The site has shortcut and small waterfall. This survey was conducted in geographical position 01°36'39,4"S and 101°07'48,7" E with elevation 1162 meter asl, width of the river was 1-5 meters, a depth about 01-0,5 meter, water temperature measured was 24 °C and air temperature 25 °C, humidity 77%, velocity of river flow 0,364 m/s, pH 7, the water is not fully clear, rocks, sand, stones as the substrates, there are some pools. It was sunny when the survey did. This survey site has human disturbance, especially for plantation and agricultural activities. The vegetation dominated by small trees, shrubs like graminae, and ferns, etc.

c. SEML 3

Sungai Bangko Putiah was the fifth surveyed site in Muara Labuah. The suvey was started in 7th December 2017 at 16.4WIB.

Different with the sites before, the river is a lower course of the Bangko karuah and Aia putiah, when the the surveyed did, the water was muddy caused the activities in up river. The stream has intensively for distrurbance and fluctuatif, when the rainy season the river will be flood and when the dry, the water will be lost. The site has shortcut and bridge. This survey was conducted in geographical position 01°36'12,8 S" and 101°07'34,0" E with elevation 1055 meter asl, width of the river 5-8 meters, a depth about 0,4-1 meter, water temperature measured was 20 °C, air temperature was 19 °C, humidity 92%, velocity of river flow 0,568 m/s, pH 6,5, the water is not fully clear. Rocks, sand, stones were the substrates of the river. There were some pools. It was sunny weather when the survey did. The vegetation dominated by trees, shrubs like graminae, and ferns, etc.

d. SEML 4

Sungai Bangko Jernih was the second surveyed site in Muara Labuah. The suvey was started in 7th December 2017 at 09:24 WIB.

The river has cascade type, there are many rapids on this stream in up and down stream. This survey was conducted in geographical position 01°38'07,4"S and 101°08'07,9"E with elevation 1439 meter asl, width of the river was 10-15 meters, a depth about 0,5-2 meter, water temperature measured was 15,5°C and air temperature was 18°C, humidity 81%, velocity of river flow 0,54 m/s, pH 6, having rocks, sand and stones substrates. The weather was sunny when the survey did. This survey site lied in secondary forest, far for human disturbance, especially for plantation. The vegetation dominated by trees, graminae, mosses and ferns, etc.

e. SEML 5

Sungai Liki is the first surveyed site in Muara Labuah. The suvey was started in 6th December 2017 at 14.03 WIB.

The river has cascade type, so many rapids on this stream especially in up and down stream. Upstream has any waterfall. This survey was conducted in geographical position

01°36'26,2"S and 101°09'02,4"E with elevation 1003 meter asl, width of the river 5-20 meters, a depth about 0,5-1,5 meter, water temperature measured was 19°C, air temperature was 22°C, humidity 84%, velocity of river flow 0,678 m/s, pH 7, the river had clear water and rocks, sand and stones substrate. The weather was sunny when the survey did. This survey site has human disturbance, especially for plantation. The vegetation dominated by small trees, shrubs like graminae, and ferns, etc.

f. SEML 6

Sungai Bangko was the last surveyed site in Muara Labuah. The suvey was started in 8th December 2017 at 14:50 WIB.

The river has cascade type, so many rapids on this stream in up and down stream. This survey was conducted in geographical position 01°36'31,1"S and 101°07'14,2"E with elevation 1090 meter asl, width of the river was 6-10 meters, a depth about 0,1-1 meter, water temperature measured was 20 °C, air temperature was 23 °C, humidity 92%, velocity of river flow 0,657 m/s, pH 6,5, have rocks, sandy and stones substrate and bright cloudy weather when the survey did. The vegetation dominated by trees, coffees, bananas graminae, mosses and ferns, etc.

g. SEML 7

This site was a small stream that closely by sungai Aia hitam. The suvey was started in 8th December 2017 at 08:36 am.

The river has cascade type has small waterfall and so many rapids on this stream in up and down stream. This survey was conducted in geographical position 01°37'49,5 S" and 101°07'45,0" E with elevation 1467 meter asl, width of the river was 1-2 meters, a depth about 0,1-0,5 meter, water temperature measured was 18°C, air temperature was 22°C, humidity 87%, pH 6,5, having rocks, sand and stones substrate. It was sunny weather when the survey did. This survey site lied in secondary forest, but it was close well pad activity, and any intac or pools was build for that. The vegetation dominated by trees, coffees, graminae, ferns, etc.

III.2. Fish and Macroinvertebrate diversity

III.2.1. Fish diversity

Survey that has been done around PT Supreme Energy Rantau Dedap (SERD) and PT Supreme Energy Muara Labuh (SEML) documented 10 Species, include in five Family. There are three Family got in Muara Labuh, including Cyprinidae (four species), Poeciliidae (one species), and Sisoridae (two species). Family founded in Rantau Dedap consist of Balitoridae (two species), Cyprinidae (two species) and Cichlidae (one species). Species founded in both locations were *Barbodes* cf *banksi* and *Tor douronensis.* The common species found in Rantau Dedap was *Glyptothorax platypogon.* Furthermore, other species got in small number were *Tor tambroides, Xiphophorus hellerii* and *Glyptothorax platypogonides.* In Muara Labuh, species collected in large number were *Homalopterula* cf. *gymnogaster* _1 and *Homalopterula* cf. *gymnogaster* _2. In addition, there was *Oreochromis niloticus* collected.

Actually, according to the villagers there are several Fish in Liki River like *Hampala macrolepidota*, *Barbodes*, *Tor*, *Glyptothorax*, *Homalopterula*, *Channa* and *Hemibgrus*. Unfortunately, in our rapid assessment we couldn't find all of them.

In this report, we named *Barbodes* cf. *banksi* because of the previous study (Roesma, 2017 in press) reported that there are variation in Sumatra *Barbodes banksi*, both at morphological and molecular levels with the sequence divergence up to 8.3% for CO1 gene. We need to analize the *Barbodes* samples from SERD and SEML morphologically and molecularly. We also write in this report that there was a *Tor* sp in SERD 8 (Endikat Hilir River), we need to check it further for those seven small samples.

Table 3. Fish Species Collected at PT. Supreme Energy Rantau Dedap (SERD)

No.	Scientific name	Vernacular name	status	Locality
A.	**Family : Cyprinidae**			
1	*Barbodes* cf *banksi* (Herre, 1940)	Spotted barb	NE	SERD-1, SERD-7, SERD-8
2	*Tor douronensis* (Valenciennes, 1842)	Semah mahseer	NE	SERD-1, SERD-7
3	*Tor tambroides* (Bleeker, 1854)	Thai mahseer	DD	SERD-8
4	*Tor* sp	-	Ni	SERD-8
B.	**Family: Poeciliidae**			
1	*Xiphophorus hellerii* Heckel, 1848	Green swordtail	NE	SERD-1
C.	**Family: Sisoridae**			
1	*Glyptothorax platypogon* (Valenciennes, 1840)	Brauner Gebrigwels	NE	SERD-1, SERD-4, SERD-8
2	*Glyptothorax platypogonides* (Bleeker, 1855)	Spotted barb	NE	SERD-1, SERD-4

Note: SERD-1= Sungai Endikat, SERD-4=Sungai Asahan, SERD-7=Sungai Cawang, SERD-8=Sungai Endikat Hilir. DD= Data Deficient, NE= Not Evaluated in IUCN Red List, Ni=could not compare to IUCN because inadequate data.

Table 4. Fish Species Collected at Supreme Energi Muara Labuh (SEML)

No.	Scientific name	Common name	Status	Location
A.	**Family: Balitoridae**			
1	*Homalopterula* cf. *gymnogaster* _1	-	Ni	SEML-1, SEML-2, SEML-5, SEML-6, SEML-7
2	*Homalopterula* cf. *gymnogaster* _2	-	Ni	SEML-1, SEML-2, SEML-3, SEML-5, SEML-6, SEML-7
B.	**Family: Cyprinidae**			
1	*Barbodes* cf *banksi* (Herre, 1940)	Spotted barb	NE	SEML: 2,3,5,6
2	*Tor douronensis* (Valenciennes, 1842)	Semah mahseer	NE	SEML: 5
C.	**Family: Cichlidae**			
1	*Oreochromis niloticus* (Linnaeus, 1758)	Nile tilapia	NE	SEML: 7

Note: SEML-1=Sungai Aia Hitam, SEML-2=Sungai Bangko Karuah., SEML-3=Sungai Bangko Putiah, SEML-5=Sungai Liki, SEML-6=Sungai Bangko, SEML-7=Sunagi Anak Aia Hitam. NE= Not Evaluated in IUCN Red List, Ni=could not compare to IUCN because inadequate data.

Table 5. Number of Individu per species collected at PT. Supreme Energy Rantau Dedap (SERD)

Spesies	SERD -							
	1	2	3	4	5	6	7	8
Barbodes banksi (Herre, 1940)	9						6	1
Glyptothorax platypogon (Valenciennes, 1840)	3			7				4
Glyptothorax platypogonides (Bleeker, 1855)	1			1				
Tor douronensis (Valenciennes, 1842)	5						2	
Tor tambroides (Bleeker, 1854)								1
Tor sp								7
Xiphophorus hellerii Heckel, 1848	1							
Total individu	19	0	0	8	0	0	8	13

Table 6. Number of Individu per species collected at PT. Supreme Energy Muara Labuh (SEML)

Spesies	SERD -						
	1	2	3	4	5	6	7
Barbodes cf *banksi* (Herre, 1940)		22	3		12	15	
Homaloptera cf. *gynogaster_1*	3	2			18	23	5
Homaloptera cf. *gynogaster_2*	13	10	5		8	22	11
Oreochromis niloticus (Linnaeus, 1758)							1
Tor douronensis (Valenciennes, 1842)					1		
Total Individu	16	34	8	0	39	60	17

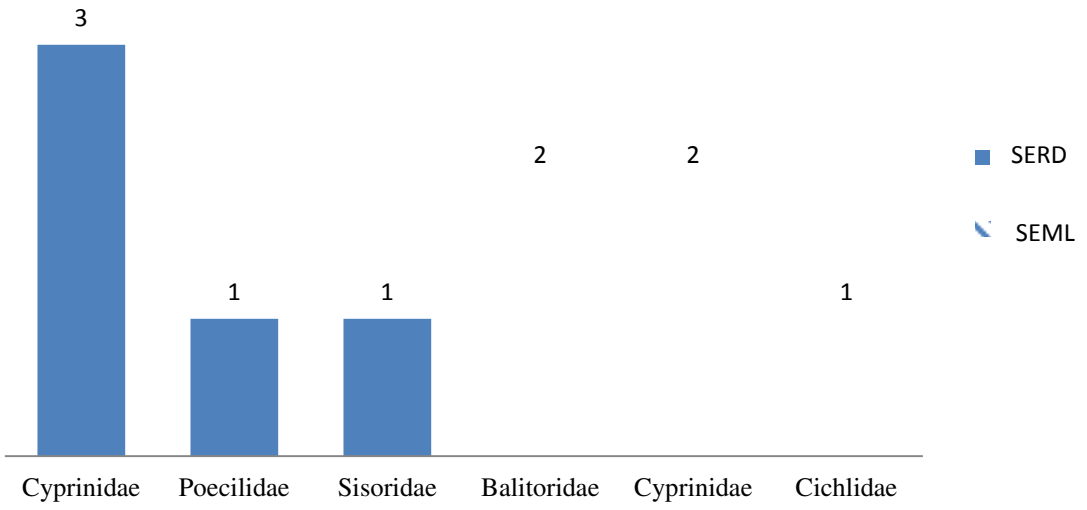

Figure 3. Number of Species per Family in both location.

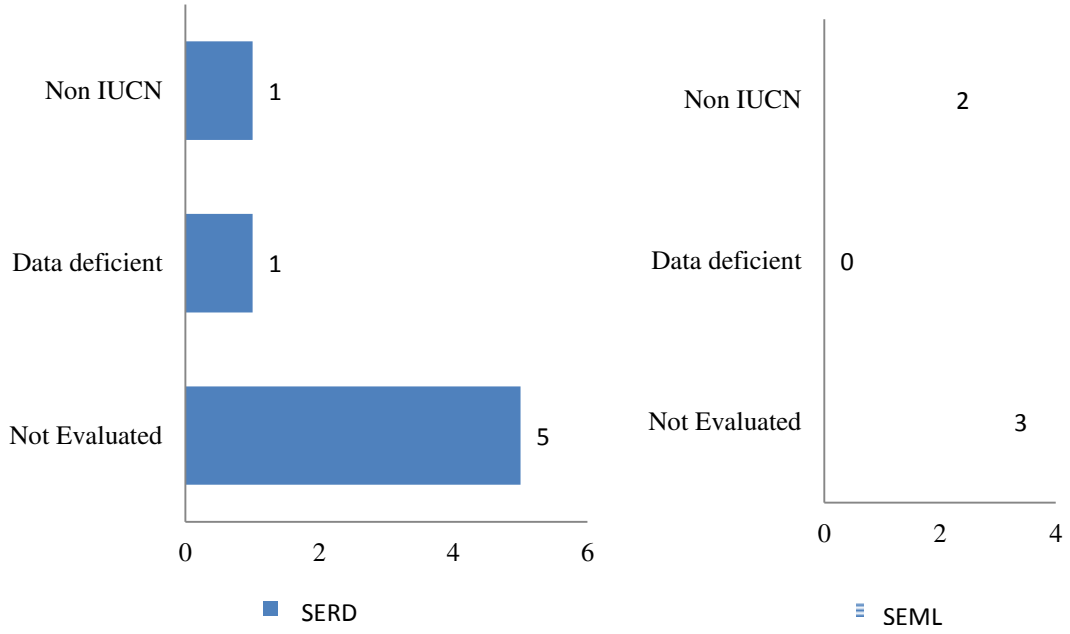

Figure 4. Number of species collected in Rantau Dedap and Muara Labuh according to IUCN conservation status.

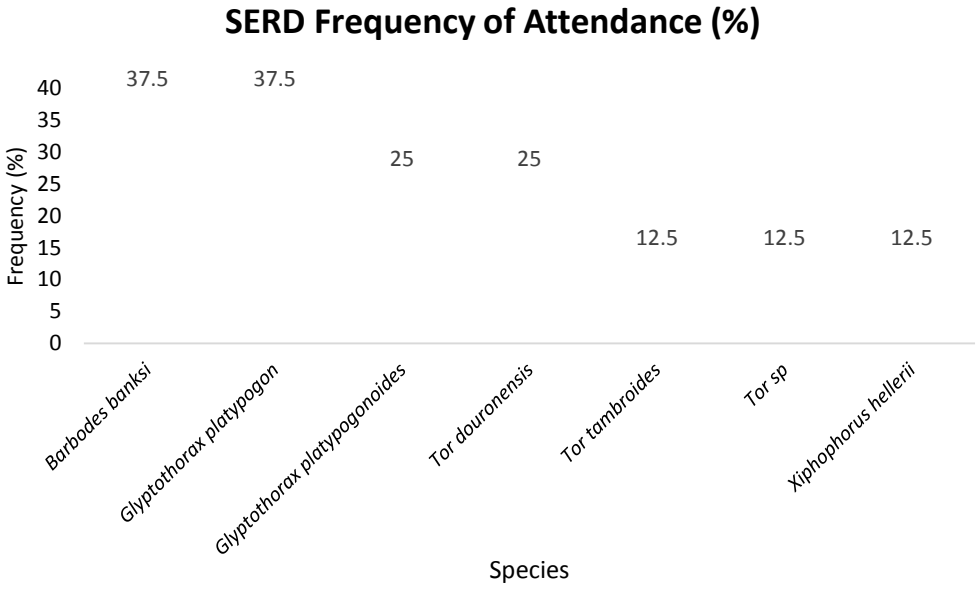

Figure 5. Frequency of attendance of fishes in SERD

The Figure 5 shows that the highest of Fish frequency in SERD (Supreme Energy Rantau Dedap) were *Barbodes* cf. *banksi* and *Glyptothorax platypogon* (F: 37,5). Followed by *Glyptothorax platypogonides* and *Tor douronensis* (F:25). *Tor tambroides, Tor* sp., *Xophophorus hellerii* were the lowest frequency (F: 12,5). While Figure 6 shows the diversity index. The Shannon-Weiner Index showed the highest of the diversity is SERD-1(H':1,19) , followed by SERD-8 (H':1,09), SERD-7 (H':0,56), and SERD-4 (H':0,3). SERD-4 and SERD-7 classfied as low diversity. In otherwise, SERD-2, SERD-3, SERD-5, SERD-6 set as uncategorized index becaused there is no one fish catched from the site.

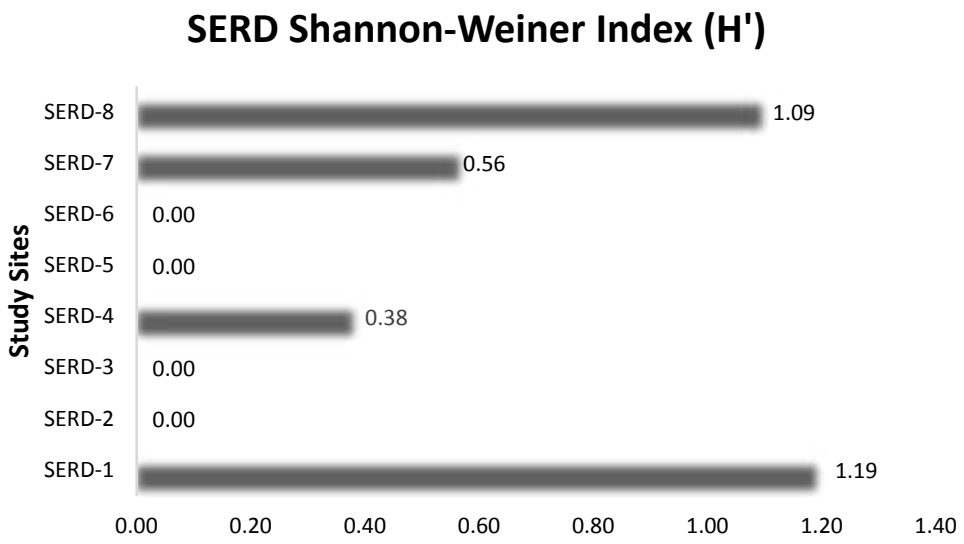

Figure 6. Shannon-Wiener species diversity in the SERD

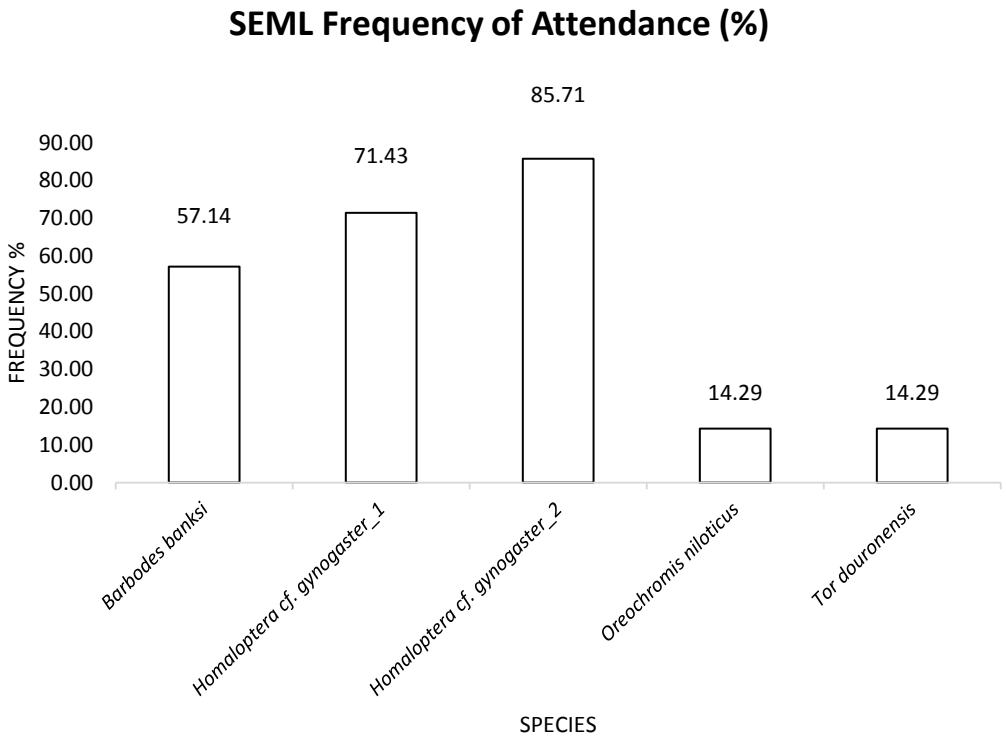

Figure 7. Frequency of attendance of fishes in SERD

Figure 7 shows the frequency attendance of fishes in SEML (Supreme Energy Muaro Labuah). The highest value was *Homaloptera* cf. *gymnogaster_2* (F: 85,71), followed by *Homaloptera* cf. *gymnogaster_1* (F:71,43), *Barbodes* cf. *banksi* (57,14), *Oreochromis niloticus* (F:14,29), and *Tor douronensis* (F:14,29).

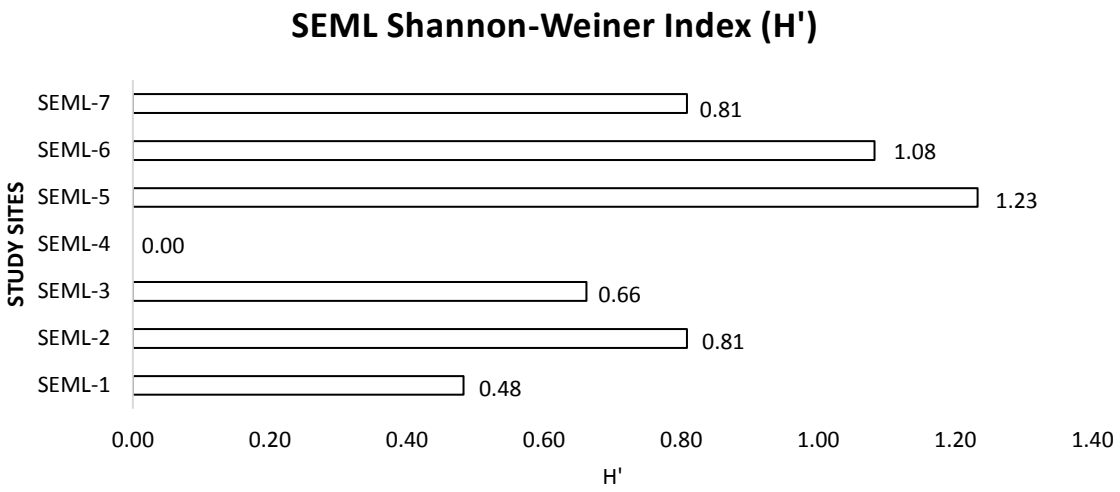

Figure 8. Shannon-Wiener species diversity in the SEML

The higher diversity index was in SEML-5 (H': 1,23), followed by SEML-6 (H':1,08) and categorized as fair diversity. SEML-7 and SEML-2 (0,81), SEML-3 (H':0,66) and , SEML-1 (H':0,48) were categorized as low diversity. There in no categorized of SEML-4 caused none of fish catched from the site (Figure 7).

III.2.2. Fish Descriptions

III.2.2.1 Family: Balitoridae

4.2.1.1 *Homalopterula gymnogaster* (Bleeker, 1853)

Classification

Kingdom : Animalia
Phylum : Chordata
Class : Actinopterygii
Order : Cypriniformes
Family : Balitoridae
Genus : Homaloptera
Species : *Homalopterula gymnogaster* (Bleeker, 1853)
Common names : Julung
Local name : Lepu

(a) (b)

Figure: (a) *Homalopterula* cf. *gymnogaster*_1, (b) (a) *Homalopterula* cf. *gymnogaster*_2

Description:
H. gymnogaster has dorsal origin behind pelvic origin, 60-73 scales along lateral line, anal origin much closer to caudal base than to pelvic base, 5-6 pectoral spines and 8-9 pectoral soft rays. There are not scales in front of pelvics. The total length of this species is 75 mm (Kottelat et al., 1993).

Habitat and Ecology:
H. gymnogaster include in highland species inhabiting riffles and 'quiet waters', which we assume to mean lakes. Most importantly the water must be clean and well-oxygenated. Base substrate can either be of gravel, sand or a mixture of both to which should be added a layer of water-worn rocks and pebbles of varying sizes (Rolland and Page, 2015).

Distribution : **Sumatra (Endemic)**
IUCN Red List Status : Not Evaluated

4.2.2 Family: Cyprinidae
4.2.2.1 *Barbodes* cf. *banksi* (Herre, 1940)
Classification
Kingdom : Animalia
Phylum : Chordata
Class : Actinopterygii
Order : Cypriniformes
Family : Cyprinidae
Genus : Barbodes
Species : *Barbodes* cf.*banksi* (Herre, 1940)
Common name : Spotted barb
Local name : Pegek (Rantau Dedap), Pareh (Muara Labuh)

Figure. *Barbodes* cf. *banksi* (Herre, 1940)

Description:
Barbodes banksi is different with Puntius binotatus in having a dark wedge-shaped marking (vs. a round spot) on the sides of the body immediately below the dorsal fin. As there seems

to to be a considerable amount of variation in the markings between populations, it also mean that banksi and binotatus represent 2 extreme color forms of a single species (Kottelat and Lim, 1995). This species has 90-110 mm in maximum standard length (seriouslyfish, 2017).

Habitat and Ecology:
Found in a variety of small streams in lowland and foothills, usually with clear water (Kottelat and Widjanarti, 2005).

Distribution : Malaysia, Singapore and Indonesia
IUCN Red List Status : Not Evaluated

4.2.2.2 *Tor douronensis* (Valenciennes, 1842)
Classification
Kingdom : Animalia
Phylum : Chordata
Class : Actinopterygii
Order : Cypriniformes
Family : Cyprinidae
Genus : Tor
2 Species : *Tor douronensis* (Valenciennes, 1842)
Common name : Semah mahseer
Local name : Cengkak (Rantau Dedap), Ikan Putih (Muara Labuh)

Figure: *Tor douronensis* (Valenciennes, 1842)

Description:
T. douronensisi has median lobe on lower lip not reaching corner of mouth and its stiff part of last simple dorsal ray as long as head without snout. Total length reaches 350 mm (Kottelat et al., 1993). It has dorsal fin with 3 spines and 9 ray; 3 spines and 5 rays of anal fin; pectoral fin consist of 1 spine and 16 rays; ventran fin with 2 spines and 8 rays; linea lateralis with 21-

24 scales. Rostral barbels about 1 ½ times, maxillary barbels about twice in eye. Pectoral slightly shorter than height of dorsal. Caudal deeply forked, its lobe pointed, about equal to head. Least height of caudal peduncle 1 ½ or more in its length, surrounded by 12 scales. Silvery, back darkish. Base of scales of back and sides darkish (Haryono, 2006).

Habitat and ecology:
This species lives on a stream of tropical forest in moderate to heavy flow and in clear waters. Found in medium to large-sized river during the dry season and migrate downstream in the rainy season. Living on the waters with basic substrates in the form of gravel and rocks (Kottelat, 2012).

Distribution : Thailand, Vietnam and Indonesia
IUCN Red List Status : Not Evaluated

4.2.2.3 *Tor tambroides* (Bleeker, 1854)
Classification
Kingdom : Animalia
Phylum : Chordata
Class : Actinopterygii
Order : Cypriniformes
Family : Cyprinidae
Genus : Tor
3 Species : *Tor tambroides* (Bleeker, 1854)
Common name : Thai mahseer
Local name : Cengkak (Rantau Dedap), Garing (Muara Labuh)

Figure: *Tor tambroides* (Bleeker, 1854)

Descripsion:
T. tambroides has dorsal fin with 3 spines and 9-10 rays; pectoral fin with 1 spine and 15-16 rays; ventral fin with 2 spines and 8 rays; anal fin wiht 3 spines and 5 rays; linea lateralis

with 23-24 scales. Lips broad, swollen, thick, continuous, the upper one generally with an anterior lobe, the lower one with a long free median lobe, which reaches to aline connecting the corners of the mouth. Maxillary barbels somewhat longer than the rostral ones, slightly or much longer than eye. Anal truncate, depressed not reaching caudal, its height somewhat less than that of the dorsal. Ventral as long as height of anal, not reaching anus, separated by 2 scales from lateral line. Pectoral slightly shorter than height of dorsal. Caudal deeply forked, its lobe pointed, the lower one the longer, equal to or longer than head (Haryono, 2006).

Habitat and ecology:
The species lives in large streams and rivers with moderate to swift flow. Adults live in deep pools and juveniles are most commonly observed in or near rapids (Kottelat, 2012). Found in rivers during dry season, moves downstream in rainy season, and spawns in mouths of small streams (Baran *et al.* 2005).

Distribution: Brunei Darussalam; China (Yunnan); Indonesia (Jawa, Kalimantan, Sumatera); Laos; Malaysia (Peninsular Malaysia, Sabah, Sarawak); Thailand.

IUCN Red List Status : **Data deficient**

4.2.3 Family: Cichlidae

4.2.3.1 *Oreochromis niloticus* (Linnaeus, 1758)

Classification
Kingdom : Animalia
Phylum : Chordata
Class : Actinopterygii
Order : Perciniformes
Family : Cichlidae
Genus : Oreochromis
4 Species : *Oreochromis nioloticus* (Linnaeus, 1758)
Common name : Nile tilapia
Local name : Nila

Figure: *Oreochromis niloticus* (Linnaeus, 1758)

Description:
O. niloticus has 15-18 dorsal spines, 11-13 dorsal soft rays, 3 anal spines, 9-11 anal soft rays and 30-32 vetebrae. Maximum standard length is 60 cm, but usually smaller (around 35 cm). Male fish develop pointed dorsal and anal fins while the females are rounded. Jaws of mature male not greadtly enlarged (29-37% of head length).The presence of regular vertical stripes throughout depth of caudal fin can be the most distinguishing characteristic (Fishbase, 2017).

Habitat and ecology:
It is an adaptable species that is found in a wide range of habitats, including rivers, streams, ponds, lakes and coastal plains. It occurs in both fresh and brackish waters and usually inhabits shallow areas. Some vegetable matter should be included in its diet. This species will eat most food offered.

Distribution :
O. niloticus has a very wide natural range and is native to (in alphabetical order) Burkina Faso, Cameroon, Chad, Egypt, Ethiopia, Gambia, Ghana, Guinea, Israel, Ivory Coast, Liberia, Mali, Niger, NIgeria, Senegal, Sierra Leone, Sudan, Togo and Uganda. It has also been introduced as a food fish in over 70 other countries and escaped or released populations now exist in many of these (seriouslyfish, 2017). Several countries report adverse ecological impact after introduction.

IUCN Red List Status : Not Evaluated
Threath to humans : potential pest

4.2.4 Family: Poeciliidae
4.2.4.1 *Xiphophorus hellerii* Heckel, 1848
Classification
Kingdom : Animalia
Phylum : Chordata
Class : Actinopterygii
Order : Cyprinodontiformes
Family : Poeciliidae
Genus : Xiphophorus
5 Species : *Xiphophorus hellerii* Heckel, 1848
Common names : Green swordtail
Local name : Ikan pedang

Figure: *Xiphophorus hellerii* Heckel, 1848

Description:

Caudal of male has a long and sharp-tipped process at its lower corner. It has various colour forms (Kottelat, 2012). This species is distinguished by having a medium to large swordtail with a long straight caudal appendage, 11-14 Anal spines, 2 additional reddish stripes may be present above midlateral line and one beneath terminal segment of gonopodial ray 3 produced into a crescent-shaped hook and blade pointed distally (Kallman et al., 2004)

Habitat and Ecology:

Natural populations are found in various types of habitat from sea level to around 1500 m altitude, including fast-flowing, rocky hasstreams, to springs, ditches, ponds, and rivers containing clear to turbid water. In most cases the water is less than 1.5 m deep and there is no aquatic vegetation.

Distribution :
The natural geographic range *X. helleri* is North and Central America: Rio Nantla, Veracruz in Mexico to northwestern Honduras. Several countries report adverse ecological impact after introduction. Introduced accidentaly from aquaria.
IUCN Red List Status : Not evaluated
Threat to humans : potential pest

4.2.5 Family: Sisoridae
4.2.5.1 *Glyptothorax platypogon* (Valenciennes, 1840)
Classification
Kingdom : Animalia
Phylum : Chordata
Class : Actinopterygii
Order : Siluriformes
Family : Sisoridae

Genus : Glyptothorax
Species : *Glyptothorax platypogon* (Valenciennes, 1840)
Common name : Brauner Gebirgswels
Local name : Lepu

Figure: *Glyptothorax platypogon* (Valenciennes, 1840)

Description:

G. platypogon has body depth 5,0-5,6 times in standart length and caudal peduncle nearly as long as deep. Its body marmorated with a faint stripe along back and body covered by coarse granulation. This species can grow to 100 mm total length (Kottelat et al., 1993). Its body is flat and adapted to the fast current of mountain streams. It has three pairs barbels, thick-based barbels at angle of mouth. Adhesive organ comprised of longitudinal plaits of skin on thorax between pectorals. It has forked caudal. Small eyes are located at the top, dorsal fin is hard and tapered.

Habitat and Ecology :Live in freshwater, include in benthopelagic fish, pH range: 6,0-7,0.

Distribution : Sumatra, Borneo, Java

IUCN Red List Status : Not Evaluated

***4.2.5.2 Glyptothorax platypognoides* (Bleeker, 1855)**

Classification
Kingdom : Animalia
Phylum : Chordata
Class : Actinopterygii
Order : Siluriformes
Family : Sisoridae
Genus : Glyptothorax

Spesies : *Glyptothorax platypogonides* (Bleeker, 1855)

Common name :

Local name : Lepu

Figure: *Glyptothorax platypogonides* (Bleeker, 1855)

Description:

G. platypogonides has body depth 5.0-5.5 times in standard length and caudal peduncle about twice as long as deep. Its body is blueish-black in life, with a conspicuous light stripe along the back. The body's covered by very fine granulation. Its total length around 120 mm (Kottelat et al., 1993).

Habitat : Live in freshwater, include in benthopelagic fish.

Distribution : West Sumatra, West Borneo

IUCN Red List Status: Not Evaluated

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III.3. Macroinvertebrate Diversity

Based on the macroinvertebrate survey that has been conducted on six streams around the geothermal Power Plant - PT. Supreme Energy Muara Labuh shows that macroinvertebrate composition varies in each stream (Table 7).

1. Bangko Hitam stream (SEML 1) which has a width of 2- 5 m, 20-100 cm deep, with rock bottom substrate, gravel and sand, current velocity is moderate (40 cm/s). In this stream found 22 genera and 95 individuals macroinvertebrata classified as 3 classes divided into 8 orders. The predominant genera in this stream are *Simulium* (Diptera; Simulidae), *Pseudocloeon* and *Centroptilum* (Ephemeroptera; Baetidae. There found two individuals of crab *Parathelphusa maculata* (C.Macostraca; O.Decapoda; F.Gecarcinucidae). A genus is said to be a predominant if it has an individual number of ≥10% in its community (Kendeigh, 1980) .The genera diversity index (H') is 2.5

2. Bangko Keruh Stream (SEML 2) which has wide stream 2-5 m, depth 50 cm, bottombase substrate consist of rock covered with algae, gravel, and sand. There was a muddy puddle under the bridge. Its currentvelocity is moderate (37 cm/s). In this stream was found 157 individuals, 27 genera macroinvertebrata classified into 5 classes and 11 orders. There found distinctive genera in calm waters and muddy substrate ie worm (Oligochaeta) 3 genera, 1 genus leech (Hirudinea), slug (Gastropoda) 4 genera. The predominant genera are Orthocladinae (Diptera: Chironomidae), *Nemoura* (Plecoptera; Nemouridae) and *Melanoides* (Gastropoda; Mesogastropoda) . Genera diversity index is 2.51

3. Muara Bangko Putih (SEML 3), has stream wide 5-8 m, depth 40-100 cm, bottom substrate consist of rock, pebbles, sand, fast current velocity (54 cm/s). In this stream found 123

individuals and 23 genera of macroinvertebrates classified into 2 classes and 8 orders. Its members are mostly of the insects with the predominant genera are *Simulium*, Orthocladinae 1 and *Hydropsyche* (Trichoptera, Hydropsychidae). Genera diversity index is 2.48

4. Bangko Putih Stream (SEML 4), has a stream width of 10-15 m, depth 50-200 cm, bottom substrate consist of stone, pebbles, sand, fast current velocity (52 cm/s). In this stream found 206 individuals and 19 genera of macroinvertebrates belonging to 1 class (Insecta) and 8 orders. The predominant genera are Orthocladinae 1, *Nemoura* (Plecoptera, Nemouridae) and *Simulium*. The genera diversity index is 2.00.

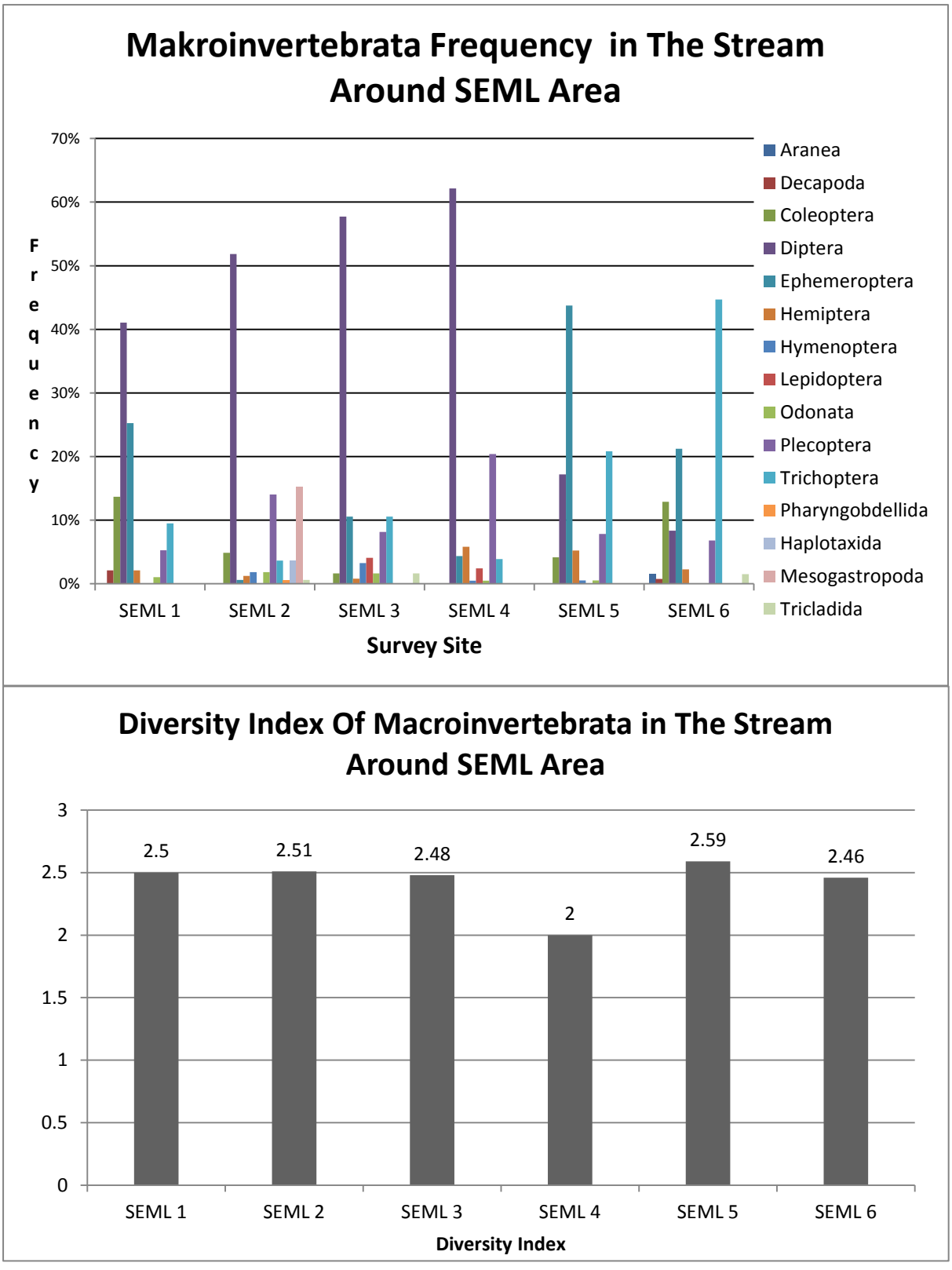
5. Liki Stream (SEML 5), has a stream width of 5-30 m, a depth of 30-200 cm, bottom substrate are stone gravel and sand, fast current velocity (95 cm/s). In this stream found only Insect 192 individuals and 27 genera classified 8 orders. The predominant genera are *Centroptilum* (Ephemeroptera; Baetidae), *Pseudocloeon* (Ephemeroptera, Baetidae), *Neophylax* (Trichoptera; Limnephilidae). Many found Neophylax and case on the stone surface. The genera diversity index is 2.59.

Tabel 7. Macroinvertebrata commuities in the stram around SEML area

No.	Taxa	SEML 1		SEML 2		SEML 3		SEML 4		SEML 5		SEML 6	
		S. Bangko Hitam		S. Bangko Keruh		Muara Bangko Putih		Bangko Putih		S.Liki		Sungai Bangko	
		Ind.	%	Ind.	%	Ind.	%	Ind.	%	Ind.	%	Ind.	%
	C. ARACHNIDA												
	O. Aranea												
1	*Archuphantes*											1	0.76
2	Aranea 1											1	0.76
	C. MALACOSTRACA												
	O. Decapoda												
3	*Parathelphusa maculata*	2	2.11									1	0.76
	C. INSECTA												
	O. Coleoptera												
4	*Donacia*											1	0.76
5	*Elmomorphus*					1	0.81			3	1.56	9	6.82
6	*Dineutus*											2	1.52
7	*Hydrocasis*			7	4.27					3	1.56		
8	*Nomuraelmis*									2	1.04		
9	*Promoresia*												
10	*Stenelmis*	2	2.11										
11	*Zaitzevia*	5	5.26									5	3.79
12	*Alabameubria*	2	2.11										
13	*Psephenoides*	4	4.21	1	0.61	1	0.81						
	O. Diptera												
14	*Philorus*					1	0.81						
15	*Canace*									2	1.04		
16	*Bezzia*	1	1.05										
17	*Culicoides*					1	0.81	1	0.49				
18	*Cryptochironomus*					10	8.13	6	2.91				
19	*Microspectra*			1	0.61								
20	*Polypedilum*			3	1.83			6	2.91				
21	Orthocladinae 1	5	5.26	38	**23.17**	13	**10.57**	74	**35.92**				
22	Orthocladinae 2			28	**17.07**	7	5.69	2	0.97				
23	Tanypodinae	1	1.05			1	0.81	1	0.49				
24	*Simulium*	28	**29.47**	7	4.27	36	**29.27**	36	**17.48**	14	7.29		
25	*Anthocha*			7	4.27	1	0.81	1	0.49			8	6.06

No.	Taxa	SEML 1 S. Bangko Hitam		SEML 2 S. Bangko Keruh		SEML 3 Muara Bangko Putih		SEML 4 Bangko Putih		SEML 5 S.Liki		SEML 6 Sungai Bangko	
		Ind.	%	Ind.	%	Ind.	%	Ind.	%	Ind.	%	Ind.	%
26	*Limnophila*	2	2.11							8	4.17	3	2.27
27	*Pilaria*	2	2.11	1	0.61	1	0.81	1	0.49	4	2.08		
28	Tipulidae									5	2.60		
	O. Ephemeroptera												
29	*Baetis*	2	2.11			1	0.81	3	1.46	4	2.08	1	0.76
30	*Centroptilum*	10	**10.53**	1	0.61	5	4.07	6	2.91	30	**15.63**	14	**10.61**
31	*Pseudocloeon*	11	**11.58**			7	5.69			40	**20.83**	12	9.09
32	*Caenis*											1	0.76
33	*Ecdyonurus*									1	0.52		
34	*Ephemerella*									2	1.04		
35	*Cincticostella*									3	1.56		
36	*Torleya*	1	1.05							4	2.08		
	O. Hemiptera												
37	*Geris*			2	1.22								
38	*Hydrometra*	1	1.05										
39	*Ilyocoris*									1	0.52		
40	*Pelocoris*					1	0.81	1	0.49	5	2.60		
41	*Halobates*	1	1.05							2	1.04		
42	*Rhagovelia*							11	5.34	2	1.04	3	2.27
	O. Hymenoptera												
43	*Tetramorium*					4	3.25			1	0.52		
44	*Anaplolepis*			3	1.83			1	0.49				
	O. Lepidoptera												
45	*Elophila*					5	4.07	5	2.43				
	O. Odonata												
46	*Chlorogomphus*					1	0.81						
47	*Sympecna*			1	0.61								
48	*Crocothermes*					1	0.81						
49	*Leucorrhinia*			1	0.61								
50	*Libellula*									1	0.52		
51	*Orthetrum*							1	0.49				
52	*Ephoptalmia*	1	1.05										
53	*Macromia*			1	0.61								

No.	Taxa	SEML 1		SEML 2		SEML 3		SEML 4		SEML 5		SEML 6	
		S. Bangko Hitam		S. Bangko Keruh		Muara Bangko Putih		Bangko Putih		S.Liki		Sungai Bangko	
		Ind.	%	Ind.	%	Ind.	%	Ind.	%	Ind.	%	Ind.	%
	O. Plecoptera												
54	*Chloroperla*			1	0.61								
55	*Neoperla*	1	1.05			2	1.63	2	0.97	11	5.73	6	4.55
56	*Nemoura*	4	4.21	22	**13.41**	8	6.50	40	**19.42**	4	2.08	3	2.27
	O. Trichoptera												
57	*Hydropsyche*	8	8.42	6	3.66	13	**10.57**	8	3.88	1	0.52	31	**23.48**
58	*Ochrotrichia*	1	1.05							2	1.04	2	1.52
59	*Neophylax*									35	**18.23**	24	**18.18**
60	*Limnephilus*									2	1.04	2	1.52
61	*Philopotamus*												
62	*Psychomya*												
	C. Hirudinea												
	O. Pharyngobdellida												
63	Erphobdella			1	0.61								
	C. Oligochaeta												
	O.Haplotaxida												
64	*Branchiura*			2	1.22								
65	Tubificidae 1			2	1.22								
66	Tubificidae 2			2	1.22								
	C. GASTROPODA												
	O. Mesogastropoda												
67	*Helicorbis*			1	0.61								
68	*Physa*			4	2.44								
69	*Bellamya*			1	0.61								
70	*Melanoides*			19	**11.59**								
	C. TURBELLARIA												
	O. Tricladida												
71	*Phagocata*			1	0.61	2	1.63					2	1.52
Total of individual		95	100.00	164	100	123	100.00	206	100	192	100.00	132	100.00
Total of Genus		22		27		23		19		27		21	
Diversity index (H')		2.50		2.51		2.48		2.00		2.59		2.46	



6. Bangko stream (SEML 6) has a stream width of 6-10 m, a depth of 60 cm, the bottom substrate is dominated by stone, very fast current velocity (121 cm/s). In this stream found as many as 132 individuals and 21 genera belonging to 4 classes and 9 orders. The predominant genera are *Hydropsyche*, *Neophylax* and *Centroptilum*. There are found a kind of crab *Parathelphusa maculata*. The genera diversity index is 2.46.

The presence of macroinverebrate genera in all streams in the SEML region varies. Genera found throughout the stream are *Centroptilum, Nemoura and Hydropsyche. Simulium* is found in five streams, not found in Muara Cawang (SEML6). However, many genera are found in one stream only, such as *Donacia, Dineutus, Nemuraelmis* and *Stenelmis* only found in Bangko Hitam (SEML1), *Microspectra* only in Bangko Keruh (SEML 2), *Phylorus, Chlorogomphus, Crocothermes, Leucorrihinia* were found only in Muara Bangko Putih (SEML3), *Orthetrum* in Bangko Putih (SEML 4), *Tanypodinae, Ecdyonurus, Ephemerella, Cincticostella, Iliocoris, Libellula* found only in Liki (SEML 5), *Archupanthes*, Aranea 1 (Arachnida) and *Caenis* found only in Bangko (SEML 6).

The six streams observed are streams located in the highlands ranging from 1003 - 1162 m. The current velocity range from medium to fast with rock-dominated substrate, except in Bangko Keruh in certain places there are calm areas with muddy substrate. The six streams are dominated by Insects. In the Bangko Keruh Stream has the moderate current velocity is found 4 genera of Gastropods which is dominated by *Melanoides*. On the edge of the stream there are rice fields, it is estimated that the gastropods found in this stream come from the fields enter with the flow of water into the stream. The stream conditions suitable for gastropod life such as algae-covered the stone in the bottom provide a food source for the organism so that it can survived in the Bangko Keruh stream. Gastropods are also found in the pool that found in this streams. In this puddle also found 3 genera of worms (Oligochaeta) which is a characteristic genera in calm waters with muddy substrate. The dominance of Insects in this stream is due to its ability to maintaining the current. Insects' larva generally has attachment devices including silk and other sticky secretion, hooks, suckers and cases (Allan, 1995).

In Bangko Hitam Stream and Bangko Stream found crabs of *Parathelphusa* obtained on stream banks with relatively slow currents when collecting fish samples using electrofishing devices, only 1 individual in each stream. *Parathelphusa* belonged to the family of Pharathelphusidae but is now classified into the Gecarcinucidae family (Klause *et al*., 2008). *Parathelphusa maculate* is included in the IUCN Red List of Threatened species as Least Concern (LC). This species prefers lowland stream and tolerant of muddy water. This animals have a highttolerance of low oxygen condition. It commons under rock, logs, vegetation, debris but also dig deep burrow on the banks of the stream. The burrow is always open into the water. Normally adult females live in burrows, but their juveniles can be found in open water (Klause et al, 2008).

In Bangko Stream found 2 genera Arachnida (Acuphantes and Aranea 1) each 1 individual. Arachnida that get this habitat is not in the water, but make a nest in plants, especially at the bottom near the surface of the soil. These genera are collected at the edge of the stream where there are plants.

The presence of macroinvertebrate genera in each stream depends on the habitat's suitability and its adaptability to the environmental conditions of the stream. Hence there are genera that can be found throughout the stream and there are also genera whose presence is rarely present only in certain streams. Streams in SEML substrates are essentially dominated by

rocks and moderate to very fast current velocities. The well-adapted genera in the stream in the SEML region are *Centroptilum, Nemoura, Hydropsyche* found throughout the stream and and *Simulium* is not found in one stream. All these genera have good morphological adaptability to fast currents, because they have the means to maintain themselves with fast currents: Centroptilum, Nemoura have a dorsoventral flat body and has strong claws, Hydropsyche has netspining, and Simulium has a circlet of hooks on posterior proleg, wich this larvae attached to the substrate, allowing the animal to climb down with the silk thread and re-attached (Allan, 2001). Genera are rarely found in the number of individuals one or two individuals. The absence of a river may be due to its small population, so the chances of getting caught are also small.

The genera diversity index of macroinvertebrates in the all streams is moderate with the index (H ') range from 2 to 2.59. Based on the criteria Lee *et al*., (1978) that streams with macroinvertebrate diversity index larger than two indicate that the stream is considered clean. The presence of EPT (Ephemeroptera, Plecoptera, Trichoptera) in the six observed streams also shows indicator of clean water quality, especially Plecoptera usually live on rocky stream upstream or low stream order which is cooler and sensitive to organic pollution and low oxygen but tolerant to acidic conditions (Giller and Malmqvist (2003).

Conclusion

1. The stram ecosystem in the SEML region is relatively undisturbed, the quality of clean water indicated by the number of genera of each river is high relatively ranges from 19-27 genera with the number of individuals range from 95 to 206 individuals, the genera diversity index ranges from 2,00 -2, 59 is moderate and the water quality is classified as clean.
2 The presence of genera in each river varies. Genera found in all streams are the *Centroptilum, Nemura, Hydropsyche,* but *Simulium* are not found in one river. The predominant macroinvertebrate genera are: *Simulium, Centroptilum, Pseudocloeon*, *Nemura, Orthocladinae, Hydropsyche, Neophylax* and *Melanoides*.
3. Found one genus of crab *Parathelphusa maculata* included in the IUCN Red List of Species Threatened 2008 as Least Concern (LC).

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Appendix

The predominant macroinvertebrates genera in stream around SEML area.

Orthocladinae 1

Orthocladine 2

Melanoides

Centroptilum

Psedocleon

Hydropsyche

Simulium

Nemoura

Neophylax

This crab included in the IUCN Red List of Threatened species as Least Concern (LC)

Parathelphusa maculata

II. Stream macroinvertebrates in the SERD project area

Based on a survey of macroinvertebrates conducted on seven streams around the geothermal Power Plant - Supreme Energy Rantau Dedap (SERD) shows that macroinvertebrate composition varies in each stream (Table 8). The number of species and individuals in the SERD is higher and the individual is larger compared to SEML macroinvertebrates.

1. Indikat stream (SERD 1) which has a width of 10-18 m, 50-200 cm depth, with rock, gravel and sand bottom substrate, fast current velocity (93 cm/s). In this stream found 28 species and 91 individuals macroinvertebrates classified as 4 classes in 10 orders. Only one genus predominant in this stream is Neophylax (Trichoptera; Limnephilidae). There is one species of crab *Parathelpusa maculate* (C. Macostraca, O. Decapoda, F. Gecarcinucidae) of one individual. Index of genera diversity is 2.94.
2. Cawang Kiri Stream (SERD 2) which has a width of 2-5 m wide, 50-100 cm deep, with bottom substrate consist of rock gravel and sand, fast current velocity (85 cm/s). In this stream found 34 species and 295 individuals macroinvertebrates classified as 2 classes in 9 orders. Predominant genera in this stream are *Centroptilum* (Ephemeroptera: Baetidae), *Stenelmis* and *Nomuraelmis*, both belong to Coleoptera; Elmidae. The genera diversity index is 2.60.
3. Cawang Tengah Stream (SERD 3) which has a width of 3-10 m, 100-200 cm deep, with rock bottom substrate, gravel and sand, fast current velocity (59 cm/s). In this stream only Insecta found 23 species and 141 individuals belonging to 7 orders. Genera is predominant in this stream are *Centroptilum*, *Hydropsyche* (Trichoptera; Hydropsychidae) and *Pseudocloeon* (Ephemeroptera; Baetidae). Index of genera diversity is 2.56.
4. Asahan Stream (SERD 4) which has a width of 2-3 m, a depth of 50-100 cm, with a bottom substrate of rock, gravel and sand, the current velocity is very fast (82 cm/s). In this stream found 24 species and 137 individuals belonging to 4 classes in 10 orders. Genera predominant in this stream are *Antocha* (Diptera: Tipulidae), *Psychomya* (Trichoptera, Psycomyidae), *Hydropsyche* and *Simulium* (Diptera: Tipulidae). Index of genera diversity is 2.3.
5. Cawang Kanan Hulu Stream (SERD 5) which has a width of 2-6 m, a depth of 50-200 cm, with a bottom substrate of rock, gravel and sand, fast current velocity is 85 cm/s. In this stream found 24 species and 196 individuals belonging to 4 classes in 10 orders. Genera is predominant in this stream Orthocladinae 1 (Diptera: Chironomidae) and *Centroptilum.* The genera diversity index is 1.92.
6. Cawang Kanan Stream (SERD 6) which has a width of 3-7m, 30-150 cm deep, with rock, gravel and sand bottom substrate, fast current velocity (70 cm/s). In this stream found 25 species and 204 individuals belonging to 2 classes in 6 orders. The predominant genera in this stream are *Pseudocleon, Centroptilum* and *Neoperla* (Pecoptera, Perlidae), genera diversity index is 2.51.

Table 8. Macroinvertebrates communities in stream around SERD area

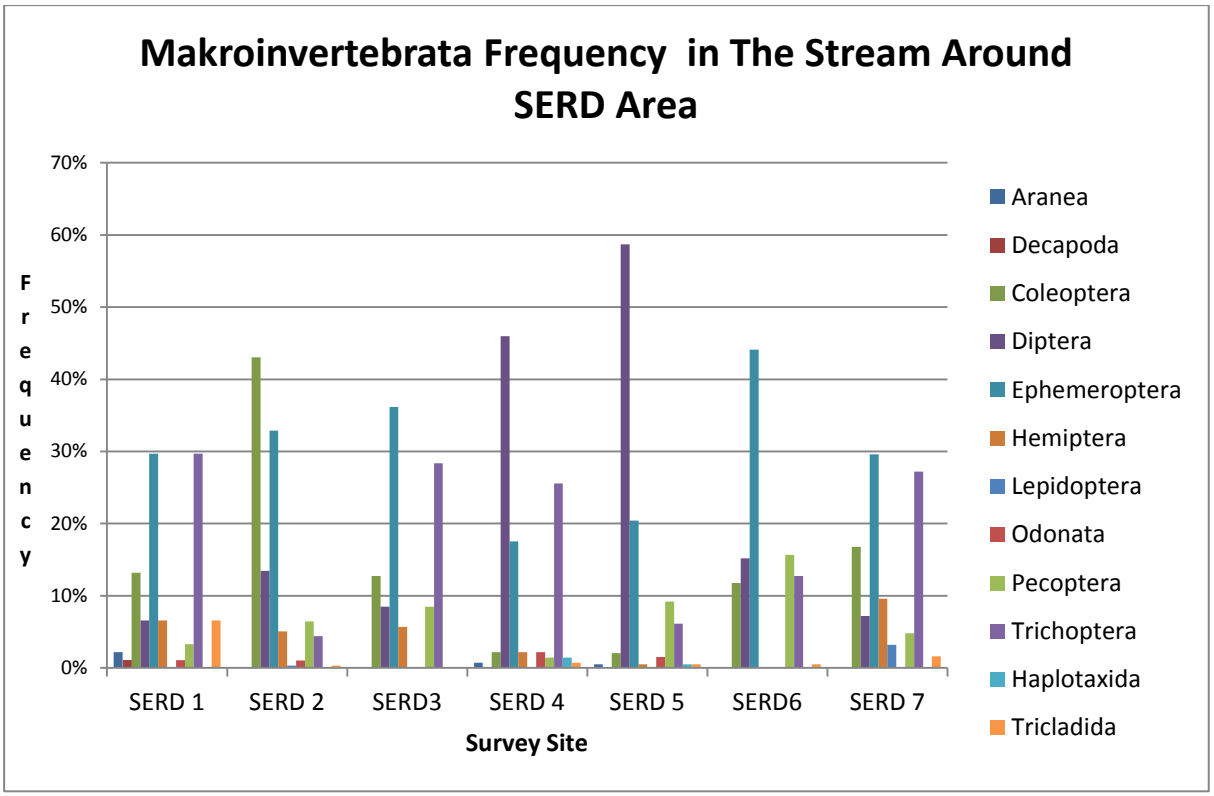
No	Taxa	SERD 1		SERD 2		SERD3		SERD 4		SERD 5		SERD6		SERD 7	
		S. Endikat		S.Cawang Kiri		S. Cawang Tengah		S. Asahan		S. Cawang Kanan Hulu		S. Cawang Kanan		Muara Cawang	
		ind	%	ind	%	ind	%	ind	%	ind	%	ind	%	ind	%
	C. ARACHNIDA														
	O.Aranea														
1	Archupanthes									1	0.51				
2	Aranea 1	2	2.20					1	0.73						
	C. MALACOSTRACA														
	O. Decapoda														
3	*Para thelphusa maculata*	1	1.10												
	C. INSECTA														
	O. Coleoptera														
4	*Donacia*									2	1.02	1	0.49		
5	*Elmomorphus*			11	3.73	5	3.55					1	0.49	7	5.60
6	*Uvarus*			5	1.69										
7	*Nomuraelmis*	1	1.10	32	**10.85**										
8	*Promoresia*	4	4.40	1	0.34	2	1.42	3	2.19			5	2.45	7	5.60
9	*Stenelmis*	1	1.10	60	**20.34**	7	4.96			2	1.02	15	7.35		
10	*Dineatus*					1	0.71					1	0.49		
11	*Gyrinus*	1	1.10			1	0.71					1	0.49	2	1.60
12	*Hydraena*			13	4.41										

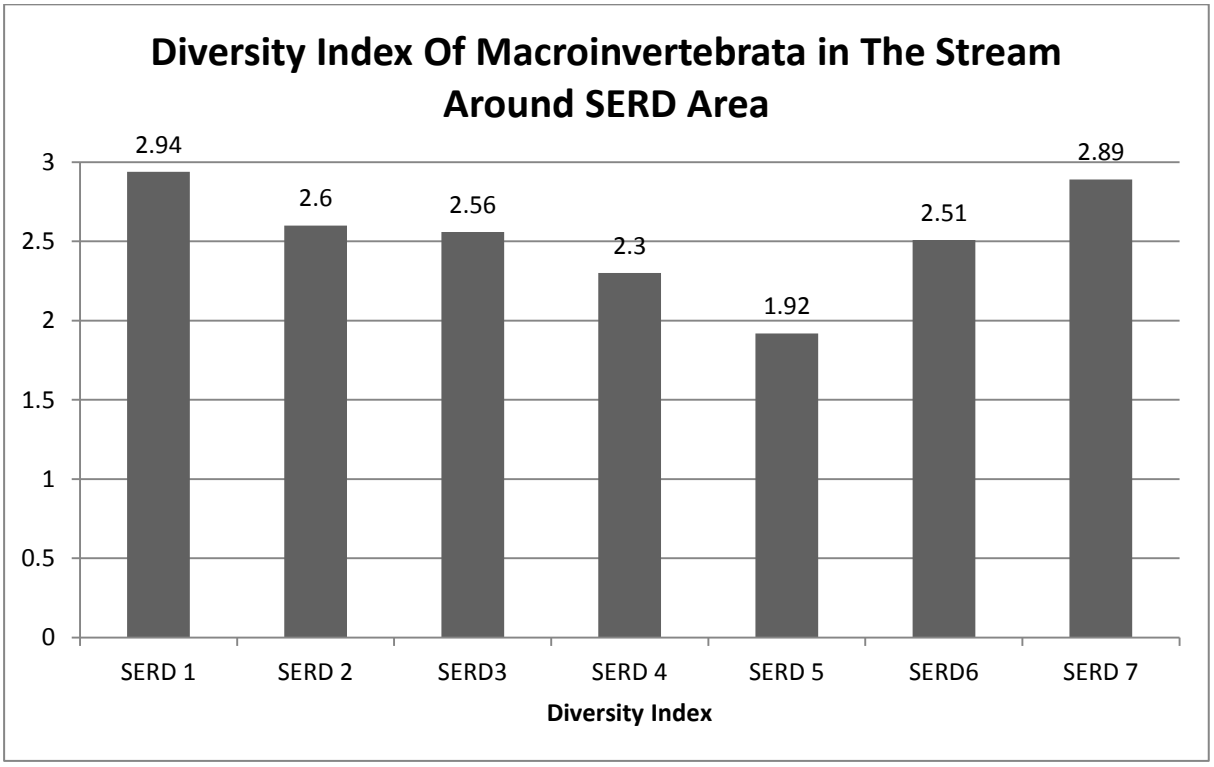
No	Taxa	SERD 1		SERD 2		SERD3		SERD 4		SERD 5		SERD6		SERD 7	
		S. Endikat		S.Cawang Kiri		S. Cawang Tengah		S. Asahan		S. Cawang Kanan Hulu		S. Cawang Kanan		Muara Cawang	
		ind	%	ind	%	ind	%	ind	%	ind	%	ind	%	ind	%
13	*Hydrocasis*			1	0.34	2	1.42								
14	*Hydriphilus*			1	0.34										
15	*Psephenoides*	5	5.49	3	1.02									5	4.00
	O. Diptera														
16	*Philorus*			1	0.34										
17	*Canace*			3	1.02										
18	*Dasyhelea*											1	0.49		
19	*Cryptochironomus*									2	1.02			2	1.60
20	*Microspectra*											1	0.49		
21	*Polypedilum*									1	0.51				
22	*Orthocladinae 1*							1	0.73	98	**50.00**	7	3.43		
23	*Orthocladinae 2*									1	0.51				
24	*Coryneura*									1	0.51				
25	*Tanypodinae*			1	0.34										
26	*Atherix*			3	1.02	5	3.55			7	3.57	1	0.49		
27	*Simulium*			2	0.68	1	0.71	14	**10.22**			7	3.43	4	3.20
28	*Anthocha*	4	4.40			5	3.55	47	**34.31**	5	2.55	11	5.39	1	0.80
29	*Limnophila*			1	0.34			1	0.73			1	0.49		
30	*Pilaria*	2	2.20	8	2.71							2	0.98	2	1.60

No	Taxa	SERD 1		SERD 2		SERD3		SERD 4		SERD 5		SERD6		SERD 7	
		S. Endikat		S.Cawang Kiri		S. Cawang Tengah		S. Asahan		S. Cawang Kanan Hulu		S. Cawang Kanan		Muara Cawang	
		ind	%	ind	%	ind	%	ind	%	ind	%	ind	%	ind	%
31	*Prionocera*					1	0.71								
	O. Ephemeroptera														
32	*Baetis*	1	1.10	2	0.68			2	1.46	1	0.51	5	2.45	11	8.80
33	*Centroptilum*	9	9.89	73	**24.75**	30	**21.28**	9	6.57	28	**14.29**	23	**11.27**	18	**14.40**
34	*Pseudocloeon*	3	3.30	9	3.05	17	**12.06**	6	4.38	9	4.59	55	**26.96**	5	4.00
35	*Caenis*			1	0.34										
36	*Ecdyonurus*	3	3.30	1	0.34					1	0.51			1	0.80
37	*Heptogenia*											5	2.45	1	0.80
38	*Rhitrogena*	3	3.30									2	0.98		
39	*Ephemerella*	2	2.20	1	0.34			4	2.92					1	0.80
40	*Cincticostella*					1	0.71								
42	*Torleya*	4	4.40	5	1.69	2	1.42			1	0.51				
43	*Choroterpes*	1	1.10	5	1.69	1	0.71	2	1.46						
44	*Paraleptophlebia*	1	1.10					1	0.73						
	O. Hemiptera														
45	*Geris*	1	1.10					1	0.73					1	0.80
46	*Mesovelia*	1	1.10											2	1.60
47	*Rhagovelia*							1	0.73	1	0.51			2	1.60
48	*Ilyocoris*	2	2.20	15	5.08	6	4.26							3	2.40

No	Taxa	SERD 1		SERD 2		SERD3		SERD 4		SERD 5		SERD6		SERD 7	
		S. Endikat		S.Cawang Kiri		S. Cawang Tengah		S. Asahan		S. Cawang Kanan Hulu		S. Cawang Kanan		Muara Cawang	
		ind	%	ind	%	ind	%	ind	%	ind	%	ind	%	ind	%
49	*Pelocoris*	2	2.20			2	1.42	1	0.73					4	3.20
	O. Lepidoptera														
50	*Elophila*			1	0.34									4	3.20
	O. Odonata														
51	*Cordulia*									3	1.53				
52	*Chlorogomphus*	1	1.10	3	1.02										
53	*Macromia*							3	2.19						
	O. Pecoptera														
54	*Chloroperla*							1	0.73						
55	*Neoperla*	3	3.30	13	4.41	3	2.13	1	0.73	15	7.65	23	**11.27**	6	4.80
56	*Nemoura*			6	2.03	9	6.38			3	1.53	9	4.41		
	O. Trichoptera														
57	*Hydropsyche*	5	5.49	2	0.68	26	**18.44**	14	**10.22**	9	4.59	18	8.82	19	**15.20**
58	*Ochrotrichia*					1	0.71							5	4.00
59	*Athripsodes*			6	2.03										
60	*Neophylax*	19	**20.88**			5	3.55	1	0.73			1	0.49		
61	*Limnephilus*			1	0.34	8	5.67			1	0.51			7	5.60
62	*Philopotamus*	3	3.30					1	0.73					3	2.40
63	*Psychomya*			4	1.36			19	**13.87**	2	1.02	7	3.43		

No	Taxa	SERD 1		SERD 2		SERD3		SERD 4		SERD 5		SERD6		SERD 7	
		S. Endikat		S.Cawang Kiri		S. Cawang Tengah		S. Asahan		S. Cawang Kanan Hulu		S. Cawang Kanan		Muara Cawang	
		ind	%	ind	%	ind	%	ind	%	ind	%	ind	%	ind	%
	C. OLIGOCHAETA														
	O. Haplotaxida														
64	Tubificidae 1							2	1.46	1	0.51				
	C. TURBELLARIA														
	O. Tricladida														
65	*Phagocata*	6	6.59	1	0.34			1	0.73	1	0.51	1	0.49	2	1.60
Total individu		**91**	**100**	**295**	**100**	**141**	**100**	**137**	**100**	**196**	**100**	**204**	**100**	**125**	**100**
Total Genus		**28**		**34**		**23**		**24**		**24**		**25**		**26**	
H′		**2,94**		**2,60**		**2,56**		**2,30**		**1,92**		**2,51**		**2,89**	





7. Muara Cawang (SERD 7) which has a width of 8-12m, depth of 80 cm, with bottom substrate consist of rock, gravel and sand. The current velocity moderate classified (50 cm / s). In this stream found 26 species and 289 individuals belonging to 2 classes in 8 orders. The predominant genera in this stream are *Hydropsyche* and *Centroptilum*. Index of genera diversity is 2.89.

The presence of genera macroinverebrate in all streams in the SERD region varies. Genera found throughout the stream are *Centroptilum, Pseudocloeon, Neoperla* and *Hydropsyche*. There are one genera that always found in all stream around SEML ie *Nemura* replaced by *Neoperla* where both genera are classified as Plecoptera. Several genera are found in six streams observed such as Centroptilum, Pseudocloeon, *Anthocha, Phagocata* not found in S. Cawang Tengah (SEML 6) and *Baetis* not found in S. Cawang Kiri (SERD 2). However, many genera are found only one stream, such as *Elophila, Archupanthes, Parathelphusa maculata*, found only in Indikat (SERD 1), Orthocladinae, *Hydraena*, *Uvarus* and *Athripsodes* found only in Cawang Kiri (SERD 3), *Macromya* found in Asahan (SERD 4), *Polypedilum* and *Coryneura* in Cawang Kanan Hulu (SERD 5) and *Dasyhelea* in Muara Cawang (SERD 6)

Discussion

The seven streams observed are streams located in the highland range from 1178 - 2097 m. The streams generally have a current velocity range from medium to very fast with rock-dominated substrates. The seven streams are dominated by Insects. On the Stream Indikat found crabs *Parathelphusa maculata* one individuals that obtained at stream banks with relatively slow current velocity when collecting fish sampling using electrofishing devices. *Parathelphusa maculata* belonged to the family of Pharathelphusidae but is now classified into the Gecarcinucidae family (Klause *et al*., 2008). This crab included in the IUCN Red List of Threatened species as Least Concern (LC). Cawang Kanan Hulu Stream (SERD 5) with the highest elevation among the other streams (2097 m) is dominated by Orthocladinae 1 (50%). This genus is found alongside the stream with a substrate covered with algae mat. The mat provides microhabitat and a food source for Orthocladinae. Members of Orthocladinae may occurred in very high densities, especially in association with filamentous algae. Orthocladinae feed on living vascular plant and macroalgae, and sher leaf litter (Giller and Malmqvist 2003). In addition to the closed subtrates algae mat also found one genus of worm (Oligochaeta) from the family tubificidae only one individual.On the Indikat and Asahan Stream found Arachnida each stream 2 and 1 individual respectively. Arachnida that get this habitat is not in the water, but make nests in plants, especially at the bottom near the surface of the soil. These genera are collected at the edge of the stream where plants are present.

The genera diversity index of macroinvertebrates in the all streams classified as moderate with an index (H ') ranging from 1.92 to 2.94. Based on the criteria Lee, *et al*. (1978) that streams with macroinvertebrate diversity index greater than two indicate that the stream is considered clean water. In general streams in the SERD area is classified as clean. The presence of EPT (Ephemeroptera, Plecoptera, Trichoptera) on the seven streams that observed also shows indicator of clean water quality, especially Plecoptera usually live in rocky upstream or low stream order where temperatures are cooler. This nymph sensitive to organic pollution and low oxygen, but tolerant of acidic conditions (Giller and Malmqvist (2003).

The presence of macroinvertebrate genera in each stream depends on the habitat's suitability and its adaptability to the environmental conditions of the stream. Hence there are genera that can be found throughout the stream and there are also genera whose presence is rarely present only in certain streams. The well-adapted genera in the Stream in the SERD region are *Centroptilum, Pseudocloeon, Hydropsyche* and *Neoperla*. There are three genera whose presence on six streams of seven streams observed ie *Anthocha* not found in Cawang Kiri (SERD 2), *Baetis* and *Phagocata* not found in Cawang Tengah (SERD 3). All of these genera

have good morphological adaptability to strong currents, because they have body shape and tools to maintain themselves with strong currents: *Centroptilum, Baeti, Pseudocloeon* and *Neoperla* have dorsoventral flat bodies, steamlining and strong claws. Hydropsyche has net spining, and Anthocha has a circlet of hooks on the abdomen proleg, wich attached to rock substrate by the larvae, (Allan, 2001). Genera are rarely found in the number of individuals one or two individuals. The absence of a river may be due to its small population, so the chances of getting caught are also small.

Conclusion

1. The stream ecosystem in the SERD region is relatively undisturbed, the quality of clean water indicated by the number of genera of each river is high relatively ranges from 23-34 genera with the number of individuals range from 91 to 295 individuals, the genera diversity index ranges from 1.92 -2.94 is moderate and the water quality is classified as clean.
2 The presence of genera in each river varies. Genera found in all streams are the *Centroptilum, Neoperla, Hydropsyche,* and *Pseudocloeon. Anthocha, Baetis, Phagocata* are not found in one river. The predominant macroinvertebrate genera are: *Centroptilum, Pseudocloeon*, *Nemouraelmis, Stenelmis, Simulium, Anthocha, Neophylax, Hydropsyche* and *Psychomya*
3. There found one genus of crab *Parathelphusa maculate* included in the IUCN Red List of Species Threatened 2008 as least concern (LC).

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Appendix

Predominan macroinvertebrates genera in stream around SERD area

		
Pseudocloeon	**Nemuraelmis**	**Steinelmis**
		
Anthocha	**Centroptilum**	**Simulium**
		
Hydrosyche	**Neophylax**	**Psychomya**

This crab included in the IUCN Red List of Threatened species as Least Concern (LC)

Parathelphusa maculata

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