

# Environment Assessment and Measures

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Initial Environmental Examination: Divune Hydropower Plant  
Document Stage: Draft  
Project Number: 41504  
August 2010

## Papua New Guinea: Town Electrification Project

Prepared by PNG Power Ltd for Asian Development Bank

The initial environmental examination is a document of the borrower. The views expressed herein do not necessarily represent those of ADB's Board of Directors, Management, or staff, and may be preliminary in nature.

## ABBREVIATIONS

ADB	–	Asian Development Bank
AP	–	Affected person/s
B&C	–	Bid and Contract Document
CEP	–	Contractor's Environmental Plan (prepared by contractor)
DE	–	Design Engineer
DEC	–	Department of Environment and Conservation
DPE	–	Department of Petroleum and Energy
EA	–	Executing Agency
EARF	–	Environmental and Review Framework
EIA	–	Environmental Impact Assessment
EMP	–	Environmental Management Plan
EO	–	Environmental Specialist
GoPNG	–	Government of Papua New Guinea
GRP	–	Glass reinforced plastic
HPP	–	Hydropower project
IA	–	Implementing Agency
IEE	–	Initial Environmental Examination
JPRF	–	Japan Poverty Reduction Fund
kW	–	kilowatt
LLG	–	Local Government
MFF	–	multi tranche financing facility
MSDS	–	Material safety Data Sheet
MW	–	megawatt
NTU	–	Nephelometric Turbidity Unit
PCB	–	Polychlorinated biphenyl – a persistent organic pollutant used as an insulating material in transformers (Now banned.)
PE	–	Project Supervising Engineer (attached to PMU, responsible for construction supervision)
PM	–	Project Manager
PMU	–	Project Management Unit
PPL	–	PNG Power Ltd
PPTA	–	Project Preparation Technical Assistance
RP	–	Resettlement Plan
RoW	–	right of way
SDS	–	Social Development Specialist
SE	–	Site Engineer (Contractor's representative)
TEP	–	Town Electrification Project

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A. ENVIRONMENTAL MONITORING PLAN: HPP sub-project

## I. EXECUTIVE SUMMARY

1. An IEE study of the Divune hydropower project (HPP) was carried out which was based on secondary data and field work in flora, fauna, land use and sociology. Public consultation was also undertaken. The sub-project will develop a small 3MW hydropower run-of-river project on the Luwini Creek at an altitude of 460m on the lower northern slopes of the Owen Stanley Range in Oro Province. A low 3m high weir will be built across the Luwini Creek to create a small headpond which will divert 3.7m<sup>3</sup>/s of the mean flow of 9.1m<sup>3</sup>/s via an intake to a buried low pressure supply pipe which terminates at a forebay where the flow will be directed to a penstock to the powerhouse. After turbining, the flow will be returned to the Luwini Creek. The partially affected section of Luwini Creek between the intake and the powerhouse is 2.6km. Electricity will be reticulated by a 22 kV transmission line to Popondetta and Kokoda which are 65 km and 25 km west and east of the HPP respectively.
2. The IEE report has reviewed the environmental impacts associated with the sub-project and has developed a comprehensive Environmental management Plan (EMP) to address these activities. Overall there are few impacts associated with the development of the power station.
3. The Luwini Creek will be blocked by the weir. Only four small fish species were noted which commonly occur throughout PNG. None of the fish have any dedicated migratory requirements. Fish are occasionally caught on an opportunistic basis but do not represent a major dietary component. While an area of high biodiversity occurs in the upper Owen Stanley Ranges above the sub-project area, the sub-project is located outside this area. The area around the sub-project is now highly disturbed by gardens and oil palm plantations. The contractor is required to minimise clearing so as to limit the impact on vegetation. No significant vegetation, primary forest or conservation areas will be affected by the development.
4. The Luwini Creek consists of two sections, a very steep upper area that is contained within the Owen Stanley Ranges and a lower section which flows out over the alluvial fan shaped depositional area where the creek emerges from the Owen Stanley Ranges. Flow is reasonably constant but is subject to seasonal variations and flash floods which may occur from the steep upper catchment area. The Luwini Creek is one of several tributaries of the Ovi Creek which then drains to the north coast via the Kumusi River over 120 km distant. The population of the surrounding areas is located in scattered settlements and about 1,500 persons are living in the immediate area in five villages. The communities lifestyle is based on subsistence farming which is supplemented by cash crops such as oil palm. There is one primary school and an aid post in the area. None of the villages are electrified. People collect water from neighbouring creeks. Two graves and a cultural site were identified. If the graves are to be disturbed the views of the relatives will need to be determined. The other cultural site appears to be outside the sub-project area and will not be affected.
5. Pre-construction requirements mainly concern the preparation of the EMP as a contractual document. Issues such as stormwater management can be addressed by environmentally sound design. During this time compensation will be paid for the loss of any privately owned assets. While land issues had stopped the construction of the subproject back in the late 1980's there now seems to be a genuine attempt to resolve these issues and to move forward with the sub-project.
6. Construction activities will be localised and intense for the 2-3 years construction period but will be of a relatively small size. The main issue will be work in and alongside the stream channel to construct the weir foundations and prepare the intake, clearing of scattered regrowth

and cash crop trees and trenching over 2.6 km to bury the low pressure supply pipeline and construction of a 3 km long 6m wide access road to the weir and powerhouse. Vegetation will be disposed of by allowing the local communities to retrieve this as fuelwood. All other construction impacts are of a routine nature and are addressed by the EMP. During construction the contractor will be initially responsible for monitoring and supervising compliance with the EMP. The Project Engineer (PE) will be assisted by the Environmental Officer (EO) to supervise the contractor while the EO will monitor the work and report any defects to the PE as required. The local community will be encouraged to seek work on the sub-project and will be advised of opportunities by a series of planned awareness meetings which will commence during pre-construction.

7. During operation the possible loss of fish species by the weir blocking the watercourse was examined. The fish species that are found in the area are well distributed and common. While the weir will separate the fish populations none of these are migratory fish and it is unlikely that the weir will have any significant impact on fish populations. During construction possible water quality impacts caused by construction activities in and alongside the stream bed will be offset by the provision of a reticulated water supply to the two main villages.

8. The project will be managed by the PNG Power Ltd (PPL) as the implementing agency. PPL will form a Project Management Unit (PMU) which will be headed by a Project Manager (PM) and include both engineering and social and environmental staff. Three staff - an Environmental Officer (EO), a Land Acquisition Officer (LAO) and a Community Development Officer (CDO) will be appointed to the PMU. The EO will be supported by an internationally recruited Environmental Specialist (ES) to provide support in strengthening the linkage of the EMP with the contractual documents as well as supporting the environmental program during pre-construction and construction. The cost of establishing the PMU, i.e. recruiting EO position and an international specialist together with their support costs for the first three years of the tranche is \$220,000. This cost will be spread over all of the three sub-projects under the first tranche. Recommendations are made within the EMP for including work requirements in the Statement of Duties for the PM and PE to harmonise their duties with the application of the environmental safeguards.

9. The IEE concludes that the project has few adverse impacts and all can be satisfactorily managed and that an EIA is not required. The HPP will need to be approved by the DEC who will issue an Environmental Permit for the sub-project to proceed.

## II. INTRODUCTION

10. The Government of Papua New Guinea (GoPNG) has requested the Asian Development Bank (ADB) to provide a multi-tranche financing facility (MFF) to develop hydropower resources to reduce reliance on diesel generation in five small townships throughout the country as part of the Town Electrification Project (TEP). This is one of the sub-projects identified for implementation under the Project Preparation Technical Assistance (PPTA) No. 7113-PNG. The Executing Agency (EA) for the PPTA is the Energy Division of the Department of Petroleum and Energy (DPE) while the Implementing Agency (IA) will be PNG Power Ltd, a government owned corporation that is responsible for the generation and distribution of electricity throughout PNG.

11. This Initial Environmental Examination presents the environmental assessment of the Divune hydropower project (HPP) which is located in Oro Province. The IEE has been carried out in compliance with the *Asian Development Bank Safeguard Policy Statement, June 2009*.

12. The main purpose of the IEE is to environmentally assess the location, construction and operation of the Divune HPP which is shown in Fig. 1. The IEE has been submitted to the ADB by PNG Power Ltd. A separate report to meet GoPNG environmental requirements in accordance with the Environment Act 2000 and associated regulatory tools will be submitted to the Department of Environment and Conservation (DEC) for evaluation and issuance of relevant environmental permits.

#### **A. Overview**

13. Approximately 90% of the population of PNG live in highly dispersed and culturally diverse rural settlements that are isolated from each other by rugged topography. While PNG has adequate hydropower resources the development and distribution of power from these resources is difficult due to the scattered population, low population densities, the rugged topography and low ability to pay. Electricity grids that do exist are isolated and clustered around the main population centres. Small provincial and district centres have traditionally relied on diesel generation. However, with increasing fuel prices and high maintenance costs many of these systems are now in need of replacement. PPL is now considering replacing or reducing reliance on these systems with hydropower generation.

#### **B. Objectives and Scope of the IEE**

14. The objectives of the IEE are to:

- Assess the existing environmental conditions in the project area including the identification of environmentally sensitive areas;
- Assess the proposed location, design, construction and operation activities to identify and evaluate their potential impacts, and determine their significance; and
- Propose appropriate mitigation and monitoring measures that can be incorporated into an Environmental Management Plan that will avoid or minimize adverse impacts so that residual impacts are reduced to acceptable levels.

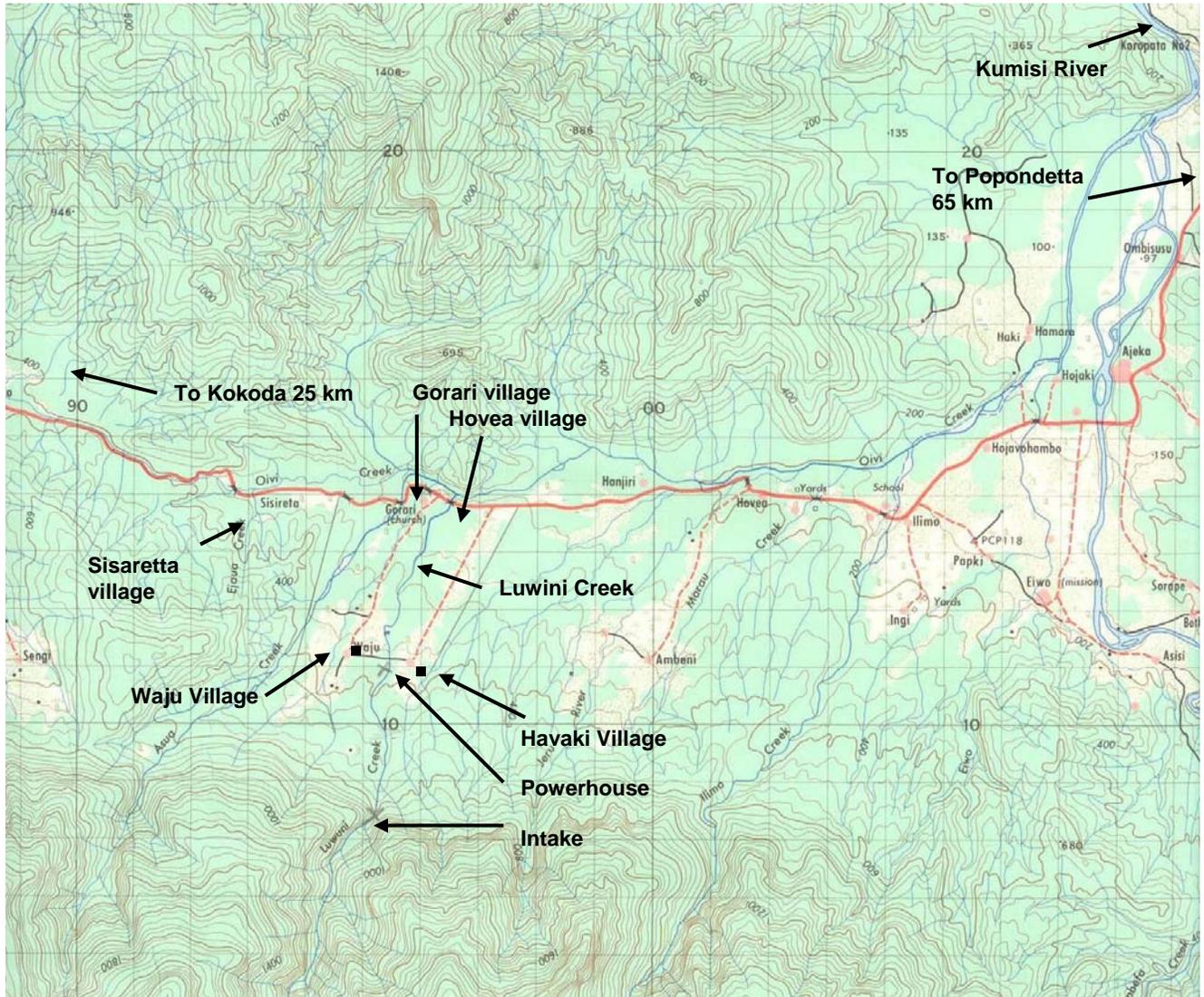
15. The IEE is based on secondary sources of information which is supplemented as required by field studies to improve the data. Field studies were undertaken in aquatic systems, terrestrial ecology and land use. Data was also carried into the study from the sociological study that was undertaken at the same time. Extensive public consultation was undertaken as part of the IEE process to determine community attitudes to the possible development.

#### **C. Report Structure**

16. The report structure follows the format outlined in Annex to Appendix 1 of the *Asian Development Bank Safeguard Policy Statement, June 2009*. The IEE consists of eleven sections: (A) Executive Summary, B Introduction; C Policy, Legal and Administrative Framework; D Description of the sub-project; E Description of the Environment; F Anticipated Environmental Impacts and Mitigation Measures; G Analysis of Alternatives; H Information Disclosure, Consultation, and Participation; I Grievance Redress Mechanism; J Environmental Management Plan; K Conclusions and Recommendations.

The Environmental Management Plan (EMP) is presented in Annex 1, and the monitoring plan in Annex 2.

Figure 1: Location of Luwini Creek HPP



### III. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

#### A. ADB Policies

17. The IEE has been carried out to ensure that potential adverse environmental impacts are addressed according to the *Asian Development Bank Safeguard Policy Statement, June 2009*.

18. The ADB's *Safeguard Policy Statement, June 2009* has been used to classify the sub-project as a **Category "B"** project which requires an IEE.

#### B. PNG Requirements

19. Environmental impact assessment and management in PNG is provided for under the **Environment Act of 2000** and its accompanying regulatory instruments including the

Environment (Prescribed Activities) Regulation, 2002, and the Guideline for Conduct of Environmental Impact Assessment and Preparation of an Environmental Impact Statement, 2004. The Act and regulations are administered by the Department of Environment and Conservation (DEC).

20. The Environment Act caters for the sustainable management of the biological and physical components of the land, air and water resources of the country. Other related legislation administered by DEC includes; the Fauna (Protection and Control) Act (1966) the Conservation Areas Act (1978), the International (Fauna and Flora) Trade Act (1978), the Crocodile Trade (Protection) Act (1978) and the National Parks Act (1984).

21. **The Environment (Prescribed Activities) Regulation 2002** categorizes projects as "Prescribed Activities" in two schedules according to the anticipated potential environmental impact. Schedule 1 consists of Level 2 activities that are subdivided into two categories (Category A and B). Category B has 13 sub-categories with sub-category 10 addressing Energy Production. Item 10.1 in this sub-category includes *Operation of hydroelectric plants with a capacity of more than 2 MW*. Projects that have more adverse environmental impact are designated in Schedule 2 as Level 3 Activities and only apply to major hydropower schemes with reservoirs inundating an area greater than 5km<sup>2</sup>. All hydropower projects that meet any of these requirements are required to prepare a Notification of Preparatory Works which is submitted to the Department of Environment and Conservation (DEC) who review the Notification and then advise the level of investigation required. A Notification has been prepared for this sub-project and the DEC have advised PPL that the hydropower development has been assessed as a level 2B activity requiring PPL to submit an Environmental Application which is in a similar format to the IEE. Following approval DEC issue an Environmental Permit (EP). A project cannot proceed until the EP has been granted.

22. Current pollution standards that will be applicable to this project relate to drinking water quality and aquatic life protection. The drinking water quality standards for raw (untreated) water are contained in the Public Health Drinking Water Quality Standards of 1984 while the standards for aquatic life protection are listed in the Environment (Water Quality Criteria) Regulation 2002 and are shown in Table 1 of Act. Sec. 133(2); Reg. Sec. 2. Ranges of criteria are given for several parameters including turbidity which shows that turbidity should not exceed 25 NTU.<sup>1</sup>

23. The **Department of Environment and Conservation** is responsible for the administration and enforcement of the Environment Act 2000 and its regulations. As the governments environmental management agency, the mission statement of DEC is: *To ensure PNG's natural resources are managed to sustain environmental quality, human well-being and support improved standards of living*<sup>2</sup>. The department consists of three divisions: Environment Protection which is responsible for environmental approvals, Sustainable Environment Management and Policy Coordination and Evaluation. The current organisation structure consists of about 200 positions and about 170 are currently occupied.

24. The DEC have also issued several guidelines including:

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<sup>1</sup> This standard is close to clean water. Many of the water courses in PNG are naturally quite turbid. It is suggested that this be clarified with DEC on the basis that the actual pre-project turbidity in the water course be used as the standard for assessing turbidity during construction.

<sup>2</sup> DEC Corporate Plan 2009 - 2012.

- Guideline for submission of an application for an environmental permit to discharge waste. *GL-Env/03/2004*. These include:
  - Noise discharges. *IB-ENV/03/2004*
  - Air discharges. *IB-ENV/02/2004*
  - Water and Land Discharges. *IB-ENV/04/2004*

25. DEC operates at the national level from its office based in Port Moresby. It does not have offices and personnel in the provinces. As part of the national government's decentralisation policy, DEC has to work in close consultation with the various provincial governments through the respective provincial administrations to ensure implementation of environmental legislation at the provincial level. Certain environmental management and monitoring functions are delegated to provincial administrations if and when they have the resources and capacity to conduct these activities.

### **C. Other PNG Legislation**

26. The following legislation will also apply to the HPP:
- (i) The Forestry Act, 1991. The main objective of the Forestry Act is to manage, develop and protect the Nation's forest resources and environment in such a way as to conserve and renew them as an asset for succeeding generations.
  - (ii) The Employment Act, 1978. An act relating to the employment of nationals and non-citizens. The act covers recruitment, conditions of employment as well as health and safety aspects.
  - (iii) The National Cultural Property (Preservation) Act 1965. An Act relating to the preservation and protection of objects of cultural or historical importance to PNG
  - (iv) Road development, felling of trees, waste disposal, etc should abide by the *PNG Logging Code of Practice* and the *Department of Works and Supply Roads and Bridges Design Specification*.

### **D. International Agreements**

27. Papua New Guinea is a signatory to the following international agreements with environment-conservation implications:
- International Plant Protection Convention, Rome 1951.
  - International Convention for the Prevention of Pollution of the Sea by Oil, London 1954.
  - Plant Protection Agreement for the South East Asia and Pacific Region, Rome 1956.
  - International Convention on Civil Liability for Oil Pollution Damage, Brussels 1969.
  - International Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter, London, Mexico City, Moscow 1972.
  - International Convention on International Trade in Endangered Species of Wild Fauna and Flora, Washington 1973 (CITES Treaty).
  - International Convention on the Conservation of Nature in the South Pacific, Apia 1976.
  - International Convention on the Prohibition of Military or any other Hostile Use of Environmental Modification Techniques, New York 1976.
  - United Nations Convention on the Law of the Sea, Montego Bay 1982. International Convention for the

- Protection of the Natural Resources and Environment of the South Pacific, 1986 (SPREP Convention).
- International Convention on Biological Diversity, Rio de Janeiro 1992.

#### IV. DESCRIPTION OF THE SUB-PROJECT

##### A. Background

28. Electricity demand is growing rapidly in PNG and is forecast to increase from 801 GWh in 2009 to 1,140 GWh by 2018 which is equivalent to an average growth rate of 4.13% per annum<sup>3</sup>. In Oro Province, Popondetta is the main load centre and supply is restricted to the town. Significant commercial activity is now developing along the Kokoda - Popondetta road where there is a large nucleus oil palm plantation and timber operations. These areas are not serviced by an electricity supply and with the development of the Divune HPP a 22 kV transmission line connection to Popondetta will provide a source of electricity for this area. There are currently 960 customers connected to the system which is generated from diesel plants with an installed capacity of 3.2MW<sup>4</sup> of which the maximum demand is now 1.5MW. From 2009 - 2018 demand is expected to increase from 5.6 GWh to 6.4 GWh. (PPL, 2009). Development of the Divune HPP will provide an additional 3 MW which assist in meeting growth and allow some of the diesel generators to be stood down. Kokoda located to the west of the project can also be connected to the Divune HPP by a 25km long transmission line.

##### B. Technical Description

29. The Divune HPP will be a 3 MW run-of-river HPP that will be located on the Luwini Creek about 60km from Popondetta and 25 km south of Kokoda Station. The principle landowners of the sub-project are located at Waju village. The hydropower potential of the Luwini Creek has been recognised since the mid 1960's and has been extensively studied with the latest study being the study carried out by MacDonald Wagner in 1989. This study also included an environmental assessment of the site that concluded that there were no outstanding issues regarding the development of the site for hydropower.

30. The Divune HPP will involve the development of approximately 2 km of the Luwini Creek immediately downstream of the Owen Stanley escarpment. The powerhouse is located approximately 1 km from the villages of Waju and Havaki.

- (i) Construction of a low 3m high concrete gravity diversion weir and intake on the Luwini River. The intake will divert 3.7 m<sup>3</sup>/s of flow from the creek to a pipeline. A small headpond will be created behind the weir within the channel. The weir will be designed to pass bedload.
- (ii) Construction of an underground low pressure pipeline 2.6 km long on the left bank of the Luwini River from the intake to the forebay area where the water will be held before being directed to the powerhouse via a penstock.
- (iii) A powerhouse will be constructed on the left bank of the Luwini River which will contain two 1.5 MW turbines with generators and a small outdoor substation.
- (iv) Erection of a 22kV transmission line from the powerhouse to Popondetta over a road distance of about 65 km and a second transmission line to Kokoda over about 25 km. The transmission lines will follow the Waju access road to the

<sup>3</sup> Details in this section are quoted from *National and Provincial Ten Year Power Development Plan 2009-2018*, PNG Power Ltd, 2009.

<sup>4</sup> Several of these gensets are no longer functioning while the remainder are old and some will be retired.

- Popondetta - Kokoda road. The transmission line will be erected on poles within the road easement.
- (v) Re-construction of a 3.5 km long track to Waju village to provide access to the HPP northwards from the Popondetta - Kokoda road.
  - (vi) Constructing a 2.6 km long access road to the intake and powerhouse which will be located on top of the buried pipeline.
  - (vii) Construction of 2 houses for operators.
  - (viii) Security fencing around the switchyard, powerhouse and operator houses.
  - (ix) Acquisition of 50 ha of traditionally owned land will be required for siting the sub-project facilities.

31. Two transmission lines are planned to be built. The first will connect to Popondetta via a 65 km long line while the second will be a 25km long line to Kokoda. Both will be 22kV and will be strung on wooden poles located alongside the road inside the road easement. The transmission line will be capable of transporting electric power in both directions so that if the hydropower powerhouse is shut down power may be fed in from the diesel sets at Popondetta which will continue as required to meet growth that cannot be accommodated by hydropower.

32. The sub-project will have several benefits including:
- The annual generation of 18.4 GWh of energy.
  - Provision of a reliable and sustainable power supply to Popondetta and Kokoda and the surrounding region which will cater for future increases in demand.
  - It will facilitate rural electrification in the area.
  - The sub-project will provide an alternative to the existing diesel generation facilities at Popondetta which are now old and rely on expensive diesel fuel. The sub-project will also reduce thermal emissions from these plants.
  - By increasing availability to a reliable and economic supply of electricity the sub-project will provide opportunities for increased agricultural and industrial activity in the surrounding areas.
  - There will be some employment opportunities created during construction.
  - Water supplies to downstream villages can be incorporated in the design of the sub-project.
  - Improved road access for villages in the area of the sub-project from the upgraded road access to the site.

## **V. DESCRIPTION OF THE ENVIRONMENT**

33. The project area includes; (i) the technical components that have already been described as well as the access road and transmission lines. Construction facilities include the contractor's facilities (administration offices, workshop, storage areas for materials and fuel and vehicle parking areas). During construction, quarries, concrete batching and spoil disposal areas will also be sited in the vicinity of the sub-project.

### **A. Physical Environment<sup>5</sup>**

#### **1. Topography Geology and Soils**

34. The Divune HPP site and its catchment are located in the Sohe district of Oro Province about 60 km from Popondetta and 20 km from Kokoda. The intake and powerhouse are located

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<sup>5</sup> Much of the material in this section is extracted from the *Divune Hydroelectric Project Environmental Plan, PNG Electricity Commission, March 1989*.

on an alluvial fan based structure situated on the lower foot-slopes of the Owen Stanley range. At the sub-project site the fan structure has average slope of about 7% which lessens towards the foot of the valley. Above the intake the Luwini Creek emerges from steep and rugged terrain that rises steeply to Mount Kenevi at 3440m on the Owen Stanley Range.

35. Road access to the powerhouse will be across land of low relief while access to the weir site will pass through steeper slopes which may be subject to instability.

36. The transmission line will follow the road alignment and be located within the road RoW.

37. The geology of the area has been well documented during previous studies<sup>6</sup> and at the site consists of chaotic fan deposits of sand, gravel, breccia and alluvium which were deposited during the Pleistocene era as a result of rapid erosion of uplifted areas on the Owen Stanley escarpment. Large boulders and blocks of hard schist (up to 10m) are strewn along the stream bed and banks which indicate subsequent erosion of landslide debris during the Pleistocene. The fans of alluvial, colluvial and littoral sediments indicate a period of intense erosion/deposition associated with the rapid uplift of the Owen Stanley fault. Rock outcrops occur upstream of the site and consist of low grade ultra-mafic green schists, quartzites and gneiss of Jurassic and Cretaceous origin.

38. The site is situated just below the active Owen Stanley Fault that extends for approximately 650km from the coast near Wau to Alotau in Milne Bay. The Geological Survey of PNG (1981) shows that moderate seismic activity can be expected at the site. A magnitude 6.2 earthquake occurred in 1972 from movement in the Owen Stanley Fault. However, records show that the area has not been subject to any excessive seismic disturbances.

39. Mount Lamington immediately to the east of the site erupted violently in 1951. While the site is outside the range of volcanic pyroclastic and lahar flows it could be subject to ash fallout which may affect the site and transmission lines.

40. The soils are young and have experienced limited weathering and profile development and are derived from mixtures of alluvium and ash fall deposits. The surface horizon consists of silt which is free draining and overlies gravel beds that may be between 0.7m to 1.5m deep. Fragments of volcanic glass are evident suggesting that silt is derived from weathered ash deposits. This material has a high moisture content and is difficult to compact. The soils have good inherent fertility and are slightly acid to neutral. The area is still adjusting to the geological uplift and natural erosion is high which is evidenced by the amount of boulders and gravels constituting the bed load and other debris within the creek. Due to the retention of forest and vegetation, man induced erosion is slight and is limited to scattered gardens that have been developed around the villages on the lower fan structure.

## 2. Climate

41. Luwini Creek and the sub-project site is located in an area of high annual rainfall of about 3,600 mm which is reasonably spread throughout the year. Rainfall is higher during October to April which coincides with the north west monsoon season and is lower from May to September. The elevation of the area makes this location subject to intense tropical storms. On average all months have a moisture surplus. Climate data is shown in Table 1.

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<sup>6</sup> Geological Survey of PNG, 1981.

**Table 1: Climate Data**

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Rainfall (mm)	336	333	365	328	259	187	180	224	273	321	407	362	3,596
Max temperature (oC)	32	31	32	32	32	31	31	32	31	32	31	32	31
Min temperature (oC)	22	22	22	22	22	22	22	22	22	22	22	22	22

Source: CSIRO, 1975.

Rainfall for Kokoda 39 years; temperature for Popondetta 39 years.

42. Cyclones are rare in this area with the last one, cyclone Guba occurred in 2007 which dumped large amounts of rain in the area and caused significant flood damage to crops, roads and washed away several bridges on the Popondetta - Kokoda road.

43. No air quality measurements are available for the area and apart from localised areas of smoke from village cooking fires air quality will be good.

44. PNG is exposed to climate variation<sup>7</sup> and has regularly experienced extreme weather conditions including; cyclones, landslides, flooding and droughts related to *El Nino* conditions. Evidence shows that since 1977 mean temperature has increased by almost 0.5°C which is also consistent with a similar temperature rise in mean water temperatures. Rainfall shows great variability but there appears to be an increasing trend to drier conditions with decadal rainfall decreasing from 3,000 mm to 2,500 mm.. Climate models show that by 2050 temperature may increase by 1.2-1.3°C; rainfall may increase by 2.2% to 8.8%, droughts and floods will be more intense and sea level may increase by between 20-40cm. For this sub-project the main change will be extended periods of drought which will affect hydrology whereby low flows will become smaller and high flows more extreme. Research carried out by the National Agricultural Research Institute (NARI) has predicted that a major drought will affect PNG in 2012.<sup>8</sup>

### 3. Water Resources

45. The Luwini Creek is one of many watercourses that occur in the area and has a catchment area of 98 km<sup>2</sup>. The Luwini Creek rises near Mount Kenevi at an elevation of 3,440m and then flows northwards and descends steeply at about 16% through a steep sided gorge to emerge onto the alluvial fan where the sub-project site is located. At the alluvial fan the river gradient falls away to about 5%. The catchment is mostly covered in dense rainforest but some swampy areas occur in the upper area around Mount Kenevi.

46. The creek is about 10 -15 m wide at the weir and powerhouse site and is contained within a boulder filled bed with low banks formed from mixed colluvium that are 1-3m high. Some small terraces are located alongside the creek which remains as the creek has cut down through the colluvial material. The Luwini Creek discharges to the Oivi Creek which then drains eastwards to join the Kumusi River which is characterised in its lower section by large wetland areas before it discharges to the north coast of PNG.

47. The Luwini Creek was gauged from 1985 to 1988. An analysis of the discharges are shown in Table 2. The data set is quite short and while it gives an indication of the actual results for the period it requires a longer period of record to improve the accuracy of the data set. Records ceased at the end of 1988.

<sup>7</sup> Office of Climate Change and Environmental Sustainability and World Bank, 2009. *Climate Change in Papua New Guinea: Framework for the National Climate Change Strategy and Action Plan.*

<sup>8</sup> As quoted in the *Nation* Friday 7<sup>th</sup> May 2010.

**Table 2: Mean monthly discharge measurements for Luwini Creek 1985-1988 (m<sup>3</sup>/s)**  
Area = 98km<sup>2</sup>

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average	8.97	7.66	9.58	9.68	9.36	7.96	8.18	8.79	9.40	11.99	11.19	6.56
Max	61.87	79.64	87.63	61.87	67.11	93.81	97.00	97.02	93.50	85.00	107.80	98.30
Min	4.16	2.56	2.15	1.93	2.63	2.98	2.89	2.68	2.70	3.44	4.07	3.10

Max and min are instantaneous values

Source: Hydrometric Yearbooks 1995-1988. Bureau of Water Resources.

48. Table 2 shows that the Luwini Creek has a reasonably well maintained flow but can exhibit extremely high discharges at any time of the year. The creek is sustained by well distributed rainfall and some upper swampy areas which will store and release water. Mean discharges are highest during the wet season between October and April which coincides with the rainy season. The greatest instantaneous discharge was 107 m<sup>3</sup>/s recorded in November 1985, though all months have recorded discharges greater than 60 m<sup>3</sup>/s. The lowest instantaneous discharge recorded was 1.9 m<sup>3</sup>/s in April 1988, though all months recorded flows less than 5.0 m<sup>3</sup>/s.

49. The MacDonald Wagner study (1988) concluded that the sediment load is restricted to flood flows. No sediment estimates were made but due to the uplift that has occurred within the catchment, natural erosion rates will be high which has resulted in the fan deposition being laid down where the creek emerges from the down-cutting gorge. There is a plentiful supply of bedload in the creek bed as demonstrated by the boulder strewn channel and during floods large amounts of boulders, gravels and sand will be moved along the channel. A de-sanding facility is incorporated in the design to remove large suspended particles.

50. The Luwini Creek is little used by the surrounding villagers who prefer to collect water from smaller tributaries closer to their villages. The creek does not flood any villages.

51. No water quality measurements are available for the Luwini Creek but as it emerges from a basically undisturbed upper catchment, water quality is expected to be very good.

## **B. Biological Environment**

52. Papua New Guinea is an island with high species biodiversity and belongs to the Indonesia-Malaysia region though it also shares similarities to northern Australia. It includes 39 Centres of Plant Diversity and Endemism as defined by the WWF and IUCN and includes 12 of the globally important Endemic Bird Areas recognised by Birdlife International<sup>9</sup>.

53. Plant diversity is particularly concentrated with an estimated 15,000 to 21,000 higher plants and at least 2,000 pteridophytes and more than 3,000 species of orchids. Plant endemism is high at 10,500 to 16,000 species.

54. PNG's mammal diversity includes 242 species of which 57 species are endemic but does not include primates, squirrels, cats, viverrids or ungulates. Introduced species include deer, pigs, dogs and cats. Placental mammals include rodents and bats of which there are 92 species and 32 are endemic. Marsupial diversity is second only to Australia. Bird diversity is particularly high with 762 species of which 85 species are endemic. Reptiles include 305 species with at least 93 snakes, 190 lizards, 14 turtles and two crocodiles. Amphibians include

<sup>9</sup> This section is extracted from "Megadiversity", Mittermeier et al, 1998.

200 species of which 134 are endemic. PNG has 329 freshwater fish species (excluding the Bismarck Archipelago) of which 149 are endemic.

## 1. Flora

55. Forest covers 61% of PNG and 69% of Oro Province. The vegetation of the project area has been documented by Taylor in Haantjens (1964), and later by Paijmans and Saunders in Blake et al (1973). In the last decade, the forest has suffered from both natural and human-induced activities. The 1997 drought caused a large bush fire that spread across the Owen Stanley Range burning large areas of rainforest. In addition, vegetation clearance for shifting cultivation and cash cropping has altered the vegetation in the locality. The location for the proposed dam and intake area, the power house and switchyard and the access road will be within secondary re-growth, garden and oil palm plantations and abandoned garden sites. There is no primary forest in the area demarcated for the hydro power project.

56. Secondary regrowth of *Macaranga* and *Ficus* are common in old garden areas and disturbed sites. Okari trees (*Terminalia sp.*) are found in a few locations and have been cultivated for their edible nuts. Near the river beds, *Syzygium*, *Terminalia*, *Pometia*, *Ficus*, *Pandanus* and tree ferns *Cyathea spp.* are common. Along parts of the river bank and old garden sites *Piper aduncun* is found in abundance. Gardens with cassava, bananas, sweet potato (kaukau) are cultivated about 10 m from the creek while about 40 m from the creek, oil palm plantations have been developed. In recently abandoned garden sites, grasses and creepers and vines dominates.

57. Riparian vegetation is badly degraded and contains no trees of ecological or economic importance. The edge vegetation includes mostly grasses, primarily *Typha angustata*, *Saccharium spontanarum*, *saccharum munja*, *Tammarix aphylla*, etc.

58. The intake and pipeline areas consists of secondary regrowth while the powerhouse site is mainly covered by scattered breadfruit trees, *Ficus* and several young timber trees. Other species include ferns while epiphytes are common in the trees.

## 2. Freshwater Aquatic system

59. Papua New Guinea has approximately 330 species of freshwater fish, including a few introduced species. Many of the native species share similarities with Australian fish fauna reflecting the close proximity and past links between these land masses. About 10% of the freshwater fish species found in PNG also occur in Australia. Approximately two thirds of the PNG native fish species spend their entire lives in freshwater and one third are thought to have an estuarine or seawater stage in their lifecycle. (Allen, 1991)

60. The aquatic habitats of the Luwini Creek consist of riffle and run sections falling at a steep gradient over a boulder bed. Fish species found in the Luwini prefer riffle habitats and rest near boulders, logs and other woody debris. Riparian vegetation is located alongside the creek which provides a degree of shade. Aquatic larvae of a range of insects and worm like groups dominate the streambed ecosystems.

61. Allen (1991) described the fish fauna of Eastern Papua which includes the Oro Province as being relatively impoverished. The limited fish fauna may be in part due to the relative isolation caused by the Owen Stanley Range. Four species of freshwater fish were recorded in the Luwini Creek. These are shown in Table 3.

**Table 3: Freshwater fish occurring in Luwini Creek**

Common name	Species
Papuan Gudgeon	<i>Mogurnda sp.</i>
Kokoda Mogurnda	<i>Mogurnda lineata</i>
Popondetta Blue-eye	<i>Pseudomugli (Popondichthys) connieae</i>
Kokoda Glass Perchlet	<i>Tetracentrum caudovittatus</i>

62. All of the fish species are commonly found in the area with the Kokoda Mogurnda caught in Luwini Creek during the field study. The occurrence of the other species was confirmed by discussions with the villagers. All fish species are small with the adults growing to <10 cm. All fish are common in rainforest streams. Gudgeons and the Kokoda Glass Perchelet have defined breeding seasons with Gudgeons spawning in late summer and autumn while the Kokoda Glass Perchelet spawns at the onset of the monsoon. Neither the Kokoda Mogurnda nor the Popondetta Blue-eye have any particular spawning requirements and may breed all year round, though this may peak at the onset of the rainy season. Based on this and their small size (unable to move long distances) there appears to be no strongly related migratory requirements in these fish species. No prawns were found in the water course and it is thought that this may be due to the extensive flooding that occurred in 2007. Eels are also found in the area.

63. Tadpoles from the families *Hylidae* and cane toad tadpoles (*Bufo marinus*) were also observed in the Omare Creek which is a located alongside the Luwini Creek. No reptiles were noted to be present in the water bodies.

### 3. Wildlife

64. Luwini Creek is located within a known area of high biodiversity within Oro Province and has a particularly high diversity of fruit bats, frugivore birds (Parrots and Pigeons) and nectivore birds (Honeyeaters), marsupials (cuscus), Birds of Paradise, Casowaries, snakes and other reptiles such as lizards. The area is also famous for the Queen Alexandra Birdwing Butterfly.

65. Birds noted in the area include the Papua Hawk Owl (*Uroglauz dimorpha*), the Barn Owl (*Tyto alba*) which nests in Oil Palms and trees. Birds of Paradise including *Paradisea apoda*, *Paradisea minor* and *Paradisea rudolphia* occur in heavily forested areas away from the site. The Willie Wagtail (*Rhipidura leucophrys*) occurs around habitation, while Parrots and Lorikeets, honeyeaters and swifts are found near the Luwini Creek. The Cassowary is hunted for food and occurs in areas away from the village.

66. Mammals include feral pigs, cuscus, tree kangaroo and bats. These are hunted and mainly occur at some distance from the villages.

### 4. Rare and Endangered Species

67. The Tree Kangaroo, Birds of Paradise and Queen Alexandra's Birdwing Butterfly are listed as protected fauna of PNG under the Fauna (Protection Control) Act 1976 and subsequent amendments. None of these fauna occur in the disturbed areas where the sub-project is located.

68. All of the four fish species are common and are widely distributed throughout PNG and Australia. None of these are listed as rare or threatened.

## 5. Conservation Areas

69. There is no Conservation Areas (CA) or Protected Areas (PAs) that are close to the sub-project site that would warrant protection or be affected by the proposed development. The only PAs in the Province is the Hombaretta Wildlife Management Area (WMA). The WMA has a total land area of 149 ha, comprising 52 ha of rainforest areas. However, extensive logging has resulted in 52 ha of logged over forest resulting in 100% forest cover change (Shearman et al, 2008).

70. The Conservation Needs Assessment (CNA) undertaken by DEC in 1992 identified the upper Luwini Catchment as having high priority areas of conservation. The sub-project is located below and outside the area and does not contain any conservation priority areas.

## 6. Invasive Alien Species

71. Biological impacts from introduced species and invasive species can cause a great deal of damage to naturally adapted systems. Invasive or introduced species are species that are non-indigenous and can colonise and out compete local species. Most of these species are a major threat to freshwater ecosystems of Papua New Guinea. Aquatic plants such as *Salvinia* (*Salvinia molesta*) and Water Hyacinth (*Eichhornia crassipes*) have been reported to cause major problems in Sepik river and other major rivers. Introduced species such as Tilapia and Mosquito fish are two examples that threaten natural freshwater fauna in the country. The aquatic plant was not observed in the project site but precautionary measures need to be taken to control the plant species if there is evidence of it occurring. Mosquito fish was not found in Luwini Creek. This particular fish inhabits slow flowing streams and fast flowing creeks like Luwini Creek will restrict its colonization. *Tilapia* is another introduced species but it was not found in the area.

## C. Socio-economic Conditions

72. The population of PNG in the 2004 census was determined as being 5.7 million and is dispersed widely across the country. Since the 1970s the population has been growing at an average rate of 2.3 %/yr but in reality this may be higher. Accordingly the population has a broad based age-sex structure with about 40% of the population less than 15 years of age. This implies a very high level of youth dependency as well as a high child-woman ratio and a low median age of <20 years. With population doubling every 30 years pressure on available services and natural resources has increased dramatically during the last decade, which will require PNG to invest large resources in social infrastructure.

73. PNG is a culturally diverse country with over 875 different languages of which 87% of the population are still living in rural environments. While this has provided the country with distinctive cultures the isolation of these groups has also created a high dependence on natural resources. Development has not been uniform across the country and the resulting migration to urban areas has created landless people who live in squatter settlements in and around urban areas with accompanying high crime rates.

74. PNG's social environment is based on three key elements; (i) the traditional land tenure system whereby 97% of land is locked away in customary tenure; (ii) the "wantok" system whereby family and clan members support each other, and (iii) service delivery by churches and

community groups which now provide around 50% of all health and education services in the rural sector.<sup>10</sup>

75. It is considered that despite some gains in the economy the number of people living in poverty has changed little during the last two decades with 30% of the population continuing to live below the 1996 criteria of K400/yr. Average life expectancy is 54 years. The national literacy rate is 62% which has slightly improved.<sup>11</sup>

76. Villages are based on family or clan group. Within the immediate proximity of the sub-project site there are two villages, Waju on the left bank and Havaki on the right bank of the Luwini Creek. Both are the closest villages to the powerhouse. The sociology survey shows that Waju has 120 households with a population of 720 people while Havaki which is opposite Waju has 21 households with 126 people.

77. Below the proposed site are three other villages all of which are spread out. On the right bank and alongside the Kokoda road is Hovea, while on the left bank are Gorarai and Sisaretta. There are no villages upstream of the powerhouse. The location of these villages is shown on Figure 1 while Table 4 presents the population and number of households for each village.

**Table 4: Population and number of households for Waju and surrounding villages**

Village	Households (no)	Population (no)	Remarks
Waju	120	720	Main village on left bank
Havaki	21	126	Opposite Waju on right bank
Hovea	26	156	Below Havaki on right bank
Gorari	42	252	Below Waju on left bank alongside Kokoda road
Sisireta	40	240	On Kokoda road past Gorari
<b>TOTAL</b>	<b>249</b>	<b>1,494</b>	

Source: GHD Sociology Study, 2010.

78. Table 4 shows that there are 846 people in 141 households living close to the powerhouse and another 648 persons in 108 households live below the HPP site. While most houses are constructed from traditional materials some have corrugated iron roofs.

79. Social infrastructure consists of a first aid post at Waju and a primary school at Gorari. There are also two elementary schools and seven churches in the immediate area. Drinking water is fetched from smaller streams and creeks. The Luwini is mostly used for washing but people will collect drinking water from it when the water is clean. All villages have road access which was built to access oil palm plantings. None of the villages are connected to rural electricity and eleven households use portable generators for special occasions. The aid post uses solar panels for lighting.

#### **D. Land Use**

80. The people of Waju are mostly subsistence farmers. Staples include taro, banana, cassava, sweet potato, sugar cane and corn which is supplemented by fresh vegetables such as; aibika, soko and edible ferns, which grow abundantly in abandoned gardens and also in the

<sup>10</sup> United Nations and GoPNG, 2004. *Millennium Development Goals. Progress Report for Papua New Guinea 2004.*

<sup>11</sup> UN and GoPNG 2004, *op.cit.*

wild. Gardens are cultivated within boundaries that are marked by various landmarks such as large boulders, creeks, okari trees, etc.

81. No fertilizers, pesticides or insecticides are used. Produce was sold in the Kokoda and Popondetta markets before several bridges collapsed and the roadway between Kokoda and Embara River was damaged by Cyclone Guba. Following this event there has been a decline in economic activities.

82. Small-holder cash cropping is used to generate household income and includes; rubber, coffee (Arabica and Robusta), vanilla, rubber, oil palm copra and betel nut. However, accessibility to Popondetta to sell these crops is difficult due to constraints in access, transportation, marketing and processing facilities. Some small-holder blocks of rubber and coffee have been replanted with cocoa, oil palm and vanilla, though marketing is difficult due to lack of buyers and many crops are now unattended. Sago (*Metroxylum spp.*) is a new food crop introduced into the area. Cultivation is limited to only a few individuals and is not widespread. Due to lack of swamplands in the area, sago suckers are grown near small streams.

83. Pigs and poultry are the only livestock kept by communities within the project area, whereby up to 6 pigs may be kept per household. Women feed and care for the pigs which are opportunistically fed on food scraps and garden produce. During special occasions such as traditional singsing, bride price payments, welcoming outsiders, etc, pigs are slaughtered to mark the occasion. Pigs can be sold at prices ranging from K200.00 to K1000.00 depending on size. Waju village has 14 individually owned fish ponds which are located close to the Luwini Creek and being downstream of the Power Station site will not be affected. These were built about 2 to 3 years ago and are stocked with common carp and trout which are used to supplement the diet of the village house holds.

#### **E. Tourism and Cultural Sites**

84. One family established a guest house for visitors to the area. Initially it was used to accommodate visitors, especially people who originally evaluated the hydro project. However, when the project was halted due to land disputes the guest house was forced to close. A new guest house has been established at Waju to accommodate tourists coming to Kokoda.

85. There are no sacred or historical sites of significance to the landowners within the project area, except for two burial sites that are more than 50 years old. It is important that the views of the relatives or family members regarding the two burial sites are obtained before construction commences. Landowners upstream of the weir site where the Luwini Creek leaves the gorge support the project but would not want to see that particular section of the Luwini River disturbed by the project as they have reserved this area as a potential tourist attraction.

### **VI. ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES**

86. Run-of-river hydropower projects of this size have limited adverse impacts, normally the main concern with dams is the blocking of the creek which affects fish movement. The aquatic study showed that all of the fish are very small and are commonly found in these habitats. None of the fish had any specific migration needs. While habitats may be affected in the section where the flow will be reduced this is not expected to cause significant changes in fish diversity and populations. Construction will create a range of expected minor impacts which can be easily handled by conditions imposed in the Environmental Management Plan (EMP). No resettlement

will be required nor will any primary forest be cleared. During operation 3.7m<sup>3</sup>/s of flow will be diverted from the creek which will reduce the mean flow in the 1.3 km long section by 42%.

87. The project will have limited environmental impacts on the natural environment since it will be constructed within already disturbed areas. Construction is expected to take about 24 months and a range of minor impacts will be created in terms of noise, dust, employment opportunities and waste disposal. Construction will create some short term employment opportunities that wherever possible should benefit the local communities. Construction impacts are of a general nature and as these are applicable to most projects these will be discussed in the EMP section.

88. The sub-project will use a renewable resource to generate electricity and should have a long lifetime as the weir will be able to pass bedload and accordingly has very high sustainability.

89. The impacts are presented in terms of their impacts on the physical, biological and socio-economic environments. For each of these categories the impacts are discussed in terms of their decreasing order of magnitude. Only the main impacts are discussed in this section while a complete list of impacts and risks together with mitigation measures, areas of responsibility, costs and monitoring requirements are presented later in the EMP section.

## A. Impacts on the Biological Environment

### 1. Blocking of fish movement – operation

90. The weir will create a barrier in the stream which will stop fish movement up-stream but will allow downstream movement. The aquatic study shows that there are only four minor fish species found in the Luwini Creek, none of which have any dedicated migration requirements. The weir will separate fish populations to those above and those below the weir. Fish will not be able to move upstream past the weir while those upstream will be able to move downstream. There is unlikely to be any effect on fish population dynamics as the weir is situated at the extreme end of the Kumusi River catchment of about 3,500 km<sup>2</sup>. The Luwini Creek is also one of several upper tributaries of the Ovi Creek which in turn drains to the Kumusi River, about 120km from the north coast. The 98km<sup>2</sup> catchment above the weir represents <3% of the total catchment and due to steepness, the very swift current, the effects of flash floods and lack of feeding areas represents a hostile aquatic environment. Thus the blocking of the creek will have little overall impact on the fish population.

### 2. Loss of aquatic habitat and fish production in section between weir and powerhouse – operation

91. The weir will divert the 90% occurring flow of 3.7m<sup>3</sup>/s from the Luwini Creek to the powerhouse which will affect a 2.6 km long section of the Luwini Creek from the weir to the powerhouse. The effect of removing the powerhouse design flow of 3.7m<sup>3</sup>/s flow is shown in Table 5.

**Table 5: Flows above and below weir (m<sup>3</sup>/s)**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Average	8.97	7.66	9.58	9.68	9.36	7.96	8.18	8.79	9.40	11.99	11.19	6.56	9.11
Diverted	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	2.9
Residual	5.27	3.96	5.88	5.98	5.66	4.26	4.48	5.09	5.70	8.29	7.49	2.86	6.21
Remaining	59%	52%	61%	62%	60%	54%	55%	58%	61%	69%	67%	44%	58%

92. Table 5 shows that the mean monthly flows remaining in the 2.6km long partially dewatered section will range from 2.9 m<sup>3</sup>/s to 8.3m<sup>3</sup>/s which is 44% - 69% of the remaining monthly mean flows. On a yearly basis the diversion represents 58% of the original mean annual flow. Minimum instantaneous flows shown in Table 2 shows that for nine months from February to November it is possible for instantaneous flows to fall below the 3.7m<sup>3</sup>/s - it does not mean that it will always happen during these months as the instantaneous flows are the minimum extreme value that has occurred during the time of the recording. Thus there will be periods when there will be no flow over the weir and when this does occur this will be for short periods. Overall any effect on the partially dewatered section appears to be minimal and of short duration.

93. As flows fall away or either cease the aquatic system will become progressively stressed from reduced habitat. The aquatic study showed that all of the fish are very small and are commonly found in these watercourses. None of the fish had any specific migration needs. While habitats may be affected in the section where the flow will be reduced this is not expected to cause significant changes in fish diversity and populations as these fish are shown to rapidly recover from changes in the aquatic system.

94. Spillway discharge will also be determined by the turbine requirements which for two turbines each will have a requirement of 1.8 m<sup>3</sup>/s. As flow falls below 3.7 m<sup>3</sup>/s then it will not be possible to run both turbines in which case one turbine will be shut down and the diverted flow reduces to 1.8 m<sup>3</sup>/s which will allow the weir to again spill. At night as power demand falls away the power station requirements will be reduced which may also allow one turbine to be shut down which will again allow water to spill over the weir. However, if any flow is to be returned to the partially dewatered section this will only occur if the flow to the turbines is controlled at the intake and not at the forebay above the powerhouse. This will be a residual impact and will be difficult to mitigate. That the pipeline intake be fitted with a control gate to regulate flow to the powerhouse and that a spillway be fitted to the intake and before the control gate to allow surplus water to be returned back to the river immediately below the weir.

### **3. Work in and alongside the river channel - construction**

95. During construction the weir is likely to build in two sections each extending halfway across the channel. The area being worked on will be protected by a temporary coffer dam which will remain in place to allow the weir foundations to be excavated and the weir constructed. During this time the channel will be disturbed and turbidity may be increased.

96. This is unlikely to be an issue as turbidity is dependent on an abundant supply of fine particles (clays) which in this situation will not be present as the high stream velocities will have carried any fine particles past the fan. Any disturbed particles will settle quickly below the site and there is unlikely to be any deleterious downstream impact on water quality.

### **4. Clearing of Vegetation**

97. Clearing requirements are shown in Table 6. Table 6 shows that the total vegetation clearance requirements for the Divune HPP is 77.5 ha made up of 5.5 ha for the sub-project facilities and 72.0 ha for the transmission line. The HPP will be sited within disturbed vegetation consisting of young regrowth, old and existing gardens and plantations. A small area of secondary growth (old gardens) fringes the creek where the intake and powerhouse will be located. Clearance for all of the site facilities and access road may involve about 5.5 ha all of

which is non significant vegetation. In total the two transmission lines which total 90 km will require 72.0 ha of secondary growth vegetation, plantations and light open shrub regrowth along the road between Popondetta and Kokoda. The transmission line will be carried alongside the road within the road easement.

**Table 6: Vegetation Clearance Requirements**

Vegetation Clearance requirements	Divune		
	Length (m)	Width (m)	Area (ha)
Weir + Intake	50	30	0.2
Pipeline + intake access	2600	8	2.1
Powerhouse	100	50	0.5
Access road	3500	8	2.8
<b>TOTAL HPP facilities</b>			<b>5.5</b>
Transmission line 1	65000	8	52.0
Transmission line 2	25000	8	20.0
<b>TOTAL Transmission Line</b>			<b>72.0</b>
<b>TOTAL HPP+TRANS LINE</b>			<b>77.5</b>

Note: All vegetation are secondary growth. The main facilities covered by old gardens, and the transmission lines located within the road right-of-way covered with scrubs and secondary growth vegetation,

## **B. Impacts on the Socio-economic Environment**

### **1. Acquisition of land**

98. The sub-project will need to acquire about 22 ha of customary land for siting infrastructure (weir: 1 ha, forebay: 1 ha, pipeline 8 ha, powerhouse: 6 ha, access road: 6 ha). Acquisition of customary land in PNG is a complex process requiring considerable negotiation with landowners. Land acquisition and compensation will be addressed by the Resettlement Action Plan. All land acquisition and compensation payments must be settled and completed before construction commences. The GoPNG has already commenced dialogue with the customary landholders to acquire the land.

### **2. Loss of fish production caused by the weir**

99. The survey showed that the Luwini Creek only had four fish species which were small and rather difficult to catch. The surrounding communities catch whatever fish they can on an opportunistic basis. There is no season where there is any increase in fish numbers in which case it is considered that there is no migration requirements for any of these fish species when they may need to return upriver for breeding or feeding. As the upriver section is excessively steep - about 16% - this would provide both a challenge to fish to move into these areas and furthermore there are no suitable feeding sites such as flooded wetlands in this section that would induce them into this section. Overall it is concluded that it is extremely unlikely that the weir will have any adverse impact on fish production as it lies immediately below an area that will be inhospitable for fish and is devoid of feeding and breeding sites.

### **3. River safety – operation**

100. A small headpond will be created which will be attractive for swimming. Flow within the headpond will be directed to the intake while surplus flow will be discharged over the spillway. While the spillway will be an obvious visual danger the submerged intake can drag surface

objects down which can be held against the grill. This danger is not particularly obvious to children and while the intake has a grill it is recommended that hand holds be placed above and alongside the grill for people to pull themselves out and away from the intake area. Awareness of the dangers need to be created by community awareness meetings as well as placing warning signage around the area.

## **VII. ANALYSIS OF ALTERNATIVES**

### **1. Alternatives to Location**

101. As hydropower sites are very site specific and must optimise head within the topographic constraints there are few alternatives to location. Luwini Creek is one of several creeks in the locality that descend the Owen Stanley Range. All of the creeks have similar characteristics i.e. steep gradients that are built up on colluvial fans. The Luwini site has been extensively evaluated since the 1980's and meets acceptable technical requirements without compromising acceptable social and environmental requirements. i.e. there is no resettlement required nor is there any loss of any significant ecology. There is no apparent economic, environmental or social advantage in any of the other sites.

### **2. Alternatives to Technology**

102. The hydropower site will allow a renewable resource to be used to generate clean energy. The technical alternative would have been to build an equivalent sized diesel power plant which would have produced about 14,717 t of CO<sub>2</sub> annually<sup>12</sup>. By using hydropower this is an avoided emission.

### **3. Alternatives to Design**

103. Design alternatives include the use of a GRP pipe rather than an open canal for moving the water from the intake to the forebay area where it is temporarily stored before being directed to the penstock. The use of a GRP pipe will be cheaper and will allow the pipe to be placed underground thereby taking up less ground space as instead of the canal being located alongside the intake access road the pipe can now be placed under the road minimising land take for the road.

104. A further design alternative is to control the flow to the powerhouse at the intake rather than at the end of the supply pipeline at the forebay which is immediately above the penstock. The installation of a remotely operated gate at the intake would provide a coarse flow control at this location which would allow for surplus flow to be returned to the water course immediately below the weir rather than just above the powerhouse. This would assist in maintaining aquatic health in the dewatered section. Control may be achieved via a SCADA system.

### **4. Alternatives to Operation**

105. Run-of-river hydropower plants operate according to the flow and when the spillway is operating they generate continuously for both base and peak load requirements. When the spillway is not operating the powerhouse may then operate on one of the two generators which reduces the requirement to 1.5m<sup>3</sup>/s. In the Luwini Creek situation the hydrology records show (Table 2) that instantaneous flow has dropped below 2.9 m<sup>3</sup>/s on occasions within the months of

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<sup>12</sup> Figure taken from UNFCCC/CCNUCC I.D./Version 15 Table I.D.1 for engines >200kW on mini grid with 24 hr service.

February to September but never below 1.5m<sup>3</sup>/s in which case the powerhouse will reduce from two to one generator. Reservoir projects however, have sufficient storage to meet both situations but a reservoir type development is not viable in this situation. There are no identifiable operation alternatives.

#### **5. The “no project” alternative**

106. Popondetta and the surrounding areas depend on diesel generation from old and poorly maintained engines that are now costing a lot to run in terms of fuel and repairs. Power is currently sold below the cost of production and in this situation it is not possible to extend the network to rural areas. Without the sub-project the existing situation will continue to deteriorate which will not promote rural electrification.

#### **6. Reasons for selection of the proposed sub-project**

107. The sub-project will provide a cheaper source of power than that generated by the diesel power stations. This will allow PPL to cover costs of production which will facilitate the extension of rural electrification. Additionally the sub-project by providing a reliable 24 hour service to Kokoda and Popondetta will provide a vehicle for the development of additional business opportunities especially alongside the transmission line route which currently are not electrified. The sub-project will also provide a sustainable source of electrical energy that will be produced as clean energy and avoid the annual release of 14,717 tonnes of CO<sub>2</sub> emissions. Construction of the sub-project is relatively benign as no resettlement is required and there is little adverse environmental or social impact.

### **VIII. INFORMATION DISCLOSURE, CONSULTATION AND PARTICIPATION**

108. The sub-project details have been posted on PNG Power’s website [www.pngpower.com.pg](http://www.pngpower.com.pg) . Following approval of the IEE by the ADB this will also be posted on the website.

109. Consultation includes meetings with government organisations and landowners.

110. Two formal meetings were held with government organisations on 8th March and 26th March, 2010 at the Provincial HQ in Popondetta. Both meetings were chaired by the Provincial Administrator and included representatives from the Divune Landowners Group, the Provincial Administration, the District Administration of Sohe District (where the sub-project is located), PNG Power and the District Public Works Coordinator.

111. The purpose of the meetings were to follow up on communications that had already been made to the provincial government concerning the sub-project and to present environmental findings. At these meetings the provincial government explained that it had long term plans for developing the hydropower resources of the province which would allow the relocation of the provincial centre to the coast at Oro Bay. At both meetings the provincial and district representatives together with the landowners representatives supported the development of the sub-project as they see the sub-project as the only opportunity for the province to venture into other development projects that have been hindered due to lack of a reliable source of electricity. It was considered that it had taken too long for the sub-project to be implemented and was prepared to work closely with the developer, project donors, consultants, etc to ensure that any land issues dealing with the project are settled prior to construction.

112. Meetings were also held at Waju Village on both dates and again on the 8<sup>th</sup> and 9<sup>th</sup> of April when the sociology study was being undertaken. At these meetings the sub-project details were explained to the people and the people were asked for their comments. Up to 100 people attended the meetings of which 20% were women. The majority of the people were farmers from the surrounding area, together with some government employees. During the meetings the village elders expressed a positive interest in the sub-project and stated that they will continue to support the investigations to see the project realized. People expressed concerns about possible safety issues with regard to electricity in general and the intake area at the headpond should people want to swim in that area. The meeting was advised that it would be unwise to swim in the headpond and that PPL will arrange a series of awareness meetings with the communities before the project becomes operational. Notices will also be put up advising people not to swim in the headpond area. Several people mentioned land issues and what people would get in return for transferring land to the HPP. The importance of settling land ownership issues was expressed as a prior condition to the development. Benefits that the participants identified would be better lighting and at a cheaper price, the villagers would now feel as though they were connected to the outside world via TV and the internet, and there would be no further need to travel to Popondetta to buy kerosene. Apart from the land ownership issues there were no other significant adverse comments made regarding the sub-project and there was consensus among the participants that providing land ownership is resolved to the communities satisfaction the sub-project should proceed.

## **IX. GRIEVANCE REDRESS MECHANISM**

113. During the course of the project it is possible that people may have concerns with the project's environmental performance including the implementation of the EMP.<sup>13</sup> Issues may occur during construction and again during operation. Any concerns will need to be addressed quickly and transparently, and without retribution to the AP.

114. The following process is to be used and commences with an attempt to sort out the problem directly at sub-project level. If this cannot be resolved then the grievance moves to the resolution process outlined in Section 87 of the Environment Act 2000. The process is also shown as a flow chart in Figure 2.

### **1. During construction:**

115. Most complaints arising during construction are expected to be minor complaints concerning dust or noise that should be able to be resolved quite easily and acted upon immediately at the sub-project level by the Project Engineer (PE). Where the complaint is of a more serious nature the PE will have up to two days to resolve the complaint.

- i. Affected people (AP) are in the first place to discuss their complaint directly with the Ward Councillor in their village. If the Ward Councillor supports the complaint both persons take the complaint to the on-site PE who will review the complaint within 2 days. All complaints arriving at the Site Office are to be entered in a Register that is kept at site by; date, name, contact address and reason for the complaint. A duplicate copy of the entry is given to the AP for their record at the time of registering the complaint. The Register will show who has been directed to deal with the complaint and the date when this was made together with the date when the AP was informed of the decision and how the decision was

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<sup>13</sup> This procedure is for addressing environmental issues. Any grievances dealing with land and compensation issues are to be directed to the Department of Lands who have established procedures for dealing with these issues.

conveyed to the AP. The Register is then signed off by the person who is responsible for the decision and dated. The Register is to be kept at the front desk of the Site Office and is a public document. The duplicate copy given to the AP will also show the procedure that will be followed in assessing the complaint, together with a statement affirming the rights of the AP to make a complaint. For anybody making a complaint no costs will be charged to the AP.

- ii. The (PE) will consider the complaint and within a maximum of two days will convey a decision to the AP. The AP and the Ward Councillor may if so desired discuss the complaint directly with the PE or his representative. If the complaint of the AP is dismissed the AP will be informed of their rights in taking it to the next step. A copy of the decision is to be sent to the PM at the PMU.
- iii. Should the AP not be satisfied, the AP may take the complaint to the Secretary in the Department of Environment and Conservation. (DEC) and continue the grievance in accordance with Section 87 of the Environment Act 2000. *Procedure for dealing with compensation claims for environmental impacts*. The procedure is shown in the following steps.
- iv. Affected party (AP) meets with Environment Permit Holder (PH) to formally register concern over impact and seek redress. A copy of the alleged impact is submitted to Secretary of Environment and Conservation (SDEC).
- v. PH has to determine whether the impact has occurred due to its activities.
- vi. If PH accepts responsibility for the impact, it can negotiate a mutually acceptable settlement with AP within 90 days.
- vii. If PH rejects responsibility for the impact, AP can request DEC to carry out a verification investigation.
- viii. If SDEC confirms that the impact has occurred, he/she will advise the PH and AP to negotiate a settlement within 90 days.
- ix. If a negotiated settlement is not reached under either Step 3 or 5, the PH or AP can request SDEC to formulate a determination. Once this request is made, SDEC will have 90 days to reach a determination.
- x. If either party is dissatisfied with the determination, it can appeal to the National Court.
- xi. The Secretary will have four weeks to consider the complaint. The Secretary will arrange for any complaint to be dealt with under the same procedure i.e. there will be no charge made to the AP for making a complaint.
- xii. Should the AP not be satisfied with the ruling of the Secretary of the DEC, the AP may at their discretion take the grievance to the PNG judicial system. This will be at the APs cost but if the court shows that the Secretary, or the administration have been negligent in making their determination the AP will be able to seek costs.

## **2. During Operation**

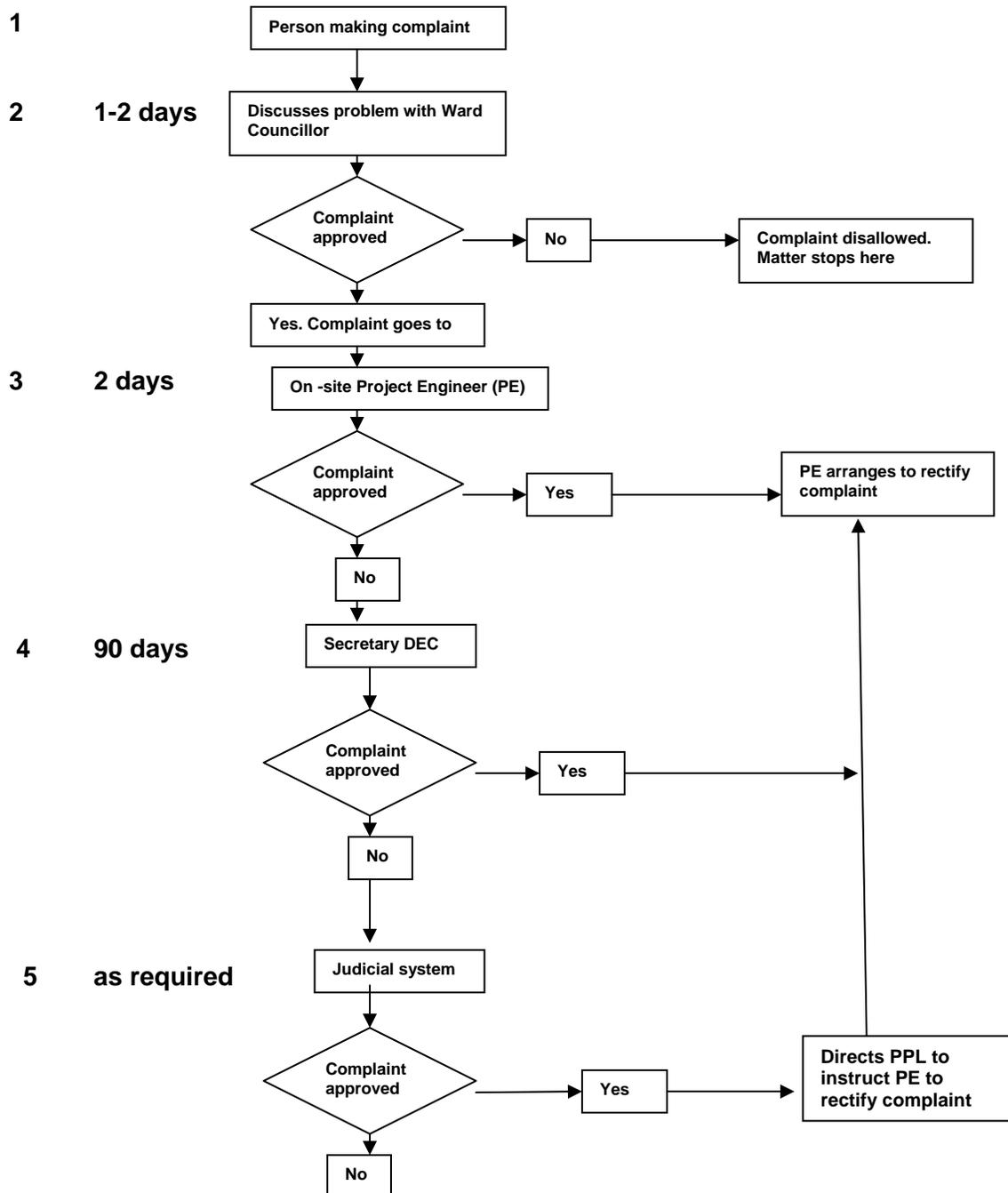
116. The same procedure is followed except that the complaint is now directed to the Power station Manager to rectify. During operation the same conditions apply; i.e. there are no fees attached to the AP for making a complaint, the complainant is free to make the complaint which will be treated in a transparent manner and the AP will not be subject to retribution for making the complaint.

### 3. Comments on the DEC grievance mechanism

117. The two main problems with the DEC procedure are: (i) establishing whether a PH is responsible for an impact (except where it is blatantly obvious) and (ii) reaching agreement on what is suitable compensation. Some compensation claims are still pending due to these uncertainties. This also underscores the need for sound baseline data against which questionable compensation claims can be evaluated.

**Figure 2: Flow Chart Outlining Grievance Review Mechanism**

**Step: Complaint to be actioned in:**



## X. ENVIRONMENTAL MANAGEMENT PLAN

118. This section identifies mitigation and management measures to avoid, reduce, mitigate or compensate for adverse environmental impacts that have already been identified in the previous sections. The environmental management plan (EMP) is a management tool and the issues are accordingly addressed with regard to the sequence of operations, i.e. those activities that apply to; pre-construction, construction and operation.

### A. Environmental Impacts and Mitigation Measures Needed during the Design/Pre-Construction Phase

119. The design and pre-construction phase will address the environmental mitigation measures that are outlined in this section. The majority of the measures are already established within Best Engineering Design Practices. The pre-construction work concludes with the integration of the EMP conditions into the Bid and Contract Documents and the evaluation and selection of the contractor. The responsibility for carrying out this work is shared by the Design Engineer and the Environmental Specialist. No additional costs have been identified for this work and all work require at this time will be covered by the budget for the pre-construction or design phase for the PMU. The following items are to be addressed during pre-construction.

- Acquisition of land and payment of compensation
- Access road - provision of stormwater drainage
- Provision for low flow release
- Provision of climate change requirements in design
- Siting of sub-project facilities - avoiding vegetation losses
- Anti-climbing barriers for wildlife on transmission poles
- Inclusion of Appendix 5 Prohibited Activities in Bid and Contract (B&C) Document
- Review EMP, extract construction section of the EMP and attach to the B&C document
- Bid evaluation and selection of contractor

120. Acquisition of land and payment of compensation: The sub-project will need to acquire about 22 ha of customary land for siting infrastructure. Acquisition of customary land in PNG is a complex process requiring considerable negotiation with landowners. Land acquisition and compensation will be addressed by the Resettlement Plan (RP). All land acquisition and compensation payments must be settled and completed before construction commences. The GoPNG has already commenced dialogue with the customary landholders to acquire the land. Land acquisition will need to be completed as soon as possible so as not to delay the implementation of the project. Implementation of the RP will be the responsibility of the Lands Department who will be directed to commence this by PNG Power.

121. The transmission line will require an easement to be created from the powerhouse out to the Popondetta - Kokoda road after which the transmission line will be carried alongside the road within an existing easement. Two issues will need to be addressed by the RAP; (i) the creation of a new easement from the powerhouse to the road and compensation for any loss of tree crops and gardens, and (ii) compensation may need to be paid for any tree crops (palm oil) that may need to be cleared from the road easement to achieve safe conductor operating requirements.

122. Determination of compensation requirements will be the responsibility of the Department of Lands which will be arranged by PNG Power.

123. Provision for low flow releases: To mitigate the dewatered effect between the intake and the powerhouse which will be most pronounced at minimal flows the DE is to review the practicality of returning the flow below the intake rather than adjusting the flow at the forebay. This will require (i) fitting the pipeline intake with a control gate to provide a coarse regulation of flow to the powerhouse and (ii) that a spillway be fitted to the intake and before the control gate to allow surplus water to be returned back to the river immediately below the weir.

124. The Design Engineer and the EO will be responsible for reviewing these requirements and addressing these in the Detailed Design.

125. Access road - provision of stormwater drainage: A 2.6 km long access road will be required to be constructed to the weir site and the powerhouse while 3.5km of access will require upgrading from the Kokoda - Popondetta road. The road will have a gravelled surface. Stormwater drainage will need to be provided wherever there is a possibility that long channelised flow will develop that will erode the drainage system. A series of side drains are to be established at 2 m vertical intervals (VI) where bare earth channels will be maintained to direct stormwater flows away from the road. If a 2m VI cannot be achieved then consideration will need to be given to vegetated channels with a VI of 4m or otherwise armoured, concrete or half round steel pipes will be required to stabilise the road stormwater drainage system. Where cross drains are required stable outlets must be provided. All pipe culverts will be required to have flared level outlets with a vertical toe wall at the end of the apron that extends about 0.35m below the apron to avoid the apron being undercut. All culverts are to discharge to safe (non-eroding) areas. The Design Engineer will be responsible for including this as a specification within the Bid and Contract Documents.

126. Siting of sub-project infrastructure - avoiding vegetation losses: The main sub-project infrastructure includes the access road, the pipeline from the intake to the fore-bay area, the penstock and powerhouse. These will be sited within areas of scattered regrowth, agriculturally disturbed areas and some tree crops. The transmission line will traverse similar disturbed areas until it reaches the road where it will be carried within the road RoW which consists of similarly disturbed vegetation and some tree crops.

127. While the siting of the sub-project generation infrastructure will be somewhat constrained by technical requirements wherever possible locations should be sought that minimize clearing of vegetation. This also applies to the transmission line and the easement that is created for the transmission line should be kept to the minimum while still meeting conductor safety requirements.

128. The Design Engineer will be responsible for including this as a specification within the Bid and Contract Documents.

129. Anti-climbing barriers for wildlife on transmission poles: Cuscus - a marsupial is an avid climber and to avoid outages caused by the animal climbing and shorting the conductors, anti climbing barriers consisting of a smooth aluminium sheet about 0.5 m wide is required to encircle each pole about 3m above ground to be clear of vegetation.

130. The Design Engineer will be responsible for including this as a specification within the Bid and Contract Documents.

131. Provision of climate change requirements in design: there is evidence that climate change is occurring in PNG and modelling predicts that by 2050 there will be increased rainfall

and an increased frequency of extreme rainfall events. Stream flows will be more variable with greater extremes which will be manifest in lower minimum flows and higher maximum flows. This will have a minimal effect on the operation of the project as the required discharge for the powerhouse is selected on the 90% flow frequency which is a conservative estimate. While climate change is expected to produce a slight shift in the discharge frequencies this change will be minor and should the flows diminish there is still adequate capacity within the creek to allow the flow to be compensated from the flow diverted to the spillway. Thus there will be no effect on frequencies between 0%-90, however, for flows between 90%-100% there may be longer periods when the spillway does not flow which will have a longer drying impact on the dewatered section between the intake and the powerhouse.

132. The Design Engineer and the Environmental Officer are to evaluate the likely impact of climate change on the sub-project.

133. Inclusion of Appendix 5 - Prohibited Investment Activities List - in Bid and Contract Document: It will be necessary to include in the B&C document reference to Appendix 5 - Prohibited Investment Activities List, especially Item (ii) - production or trade in any product or activity deemed illegal under host country laws and regulations or international conventions and agreements or subject to international phaseouts or bans, such as (a) pharmaceuticals, pesticides, and herbicides (b) ozone-depleting substances, (c) polychlorinated biphenyls and other hazardous chemicals etc.....

134. The Project Manager and Environmental Officer will be responsible for including reference to Appendix 5 Activities in the B&C document in the section "Special Conditions of Contract".

135. Review EMP, extract construction section of the EMP and attach to the B&C document: Experience shows that inadequate application of the EMP by the contractor may occur due to weak linkages of the EMP with the contract document. The EMP is a part of the work program and as such it must be addressed by the contractor and carried out as required. If the EMP is not satisfactorily addressed then the environmental safeguards and project sustainability will be compromised.

136. In the B&C section "Special Conditions of Contract" list the EO will arrange the following; (i) prior to the tender being called the EO will revise and update the EMP and (ii) extract the construction section of the EMP and together with the PM will attach this to the Bid and Contract Documents in section; Part II - Requirements; Section 6 - Employer's Requirements. In the B&C section "Special Conditions of Contract" list the construction section of the EMP as forming part of the B&C document. The contractor will use this document to cost his compliance with the EMP.

137. This will be the responsibility of the EO and PM as shown above.

138. Bid evaluation and selection of contractor: The contractor will be required to provide a short statement that confirms the following three points. The statement is to be attached to the Bid in the section "Special Conditions of Contract".

- (i) that the construction section of the EMP conditions have been costed into the bid price,
- (ii) the contractor is to provide prior experience of working with an EMP,

- (iii) the contractor is required to provide the name, details of qualifications and experience of the person on the contractor's team who will be responsible for the environmental compliance requirements of the EMP.

139. During bid evaluation these strengths will be evaluated in the selection of the contractor. Should the contractor not provide these details, the bid will be judged to be non-compliant and the bid rejected.

140. The PM will be responsible for ensuring that these conditions are included as conditions in the B&C document.

141. Both the PM and Environment Specialist (EO) are to be members of the bid evaluation panel. The EO will evaluate the contractor's environmental capability to the evaluation panel.

## **B. Environmental Impacts and Mitigation Measures Needed during Construction**

142. Environmental impacts identified during construction are limited in size, are site specific and temporary. The activities would normally be recognised as Best Construction Practices. While the scale of the works for hydropower projects of this size are relatively minor the sub-project will still require the normal range of contractor's facilities such as site offices, workshops, storage areas and construction camps. The following activities have been identified during construction:

- Contractor prepares CEP
- Induction of contractor to site
- Control of invasive species
- Preparation of site and establishment of contractor's facilities, quarries, concrete batching areas etc.
- Work in and alongside the stream channel
- Excavation of pipeline, road-bed, powerhouse and other sites
- Removal and disposal of excavated waste material
- Clearing transmission line
- Storage and handling of construction materials, fuel and lubricants.
- Noise and vibration
- Dust management
- Public access to site
- Community safety from increased vehicle movements
- Use of hazardous materials and Appendix 6 Prohibited Activities
- Workplace health and safety
- Worker issues - hiring of workers
- Worker issues - use of fuelwood
- Worker issues - hunting and sale of wildlife
- Worker issues - clearing of forest for gardens
- Disposal of waste materials
- Chance discovery of archaeological and cultural sites
- Clearance and rehabilitation of construction sites and removal of contractor's facilities

143. During construction the contractor will work according to the requirements of the Contractor's Environmental Plan (CEP) which has been prepared by the contractor. Supervision and monitoring of the CEP activities will be undertaken as follows:

- (i) The contractor has the initial responsibility for supervising and monitoring of the CEP as already provided for in supervision of the works contract.
- (ii) The Project Supervising Engineer (PE) located within the Project Management Unit (PMU) will direct the contractor with regard to compliance with the CEP. The PE will be supported by the Environmental Officer (EO).
- (iii) The EO will carry out independent monitoring of the work and can issue Defect Notices to the PE who will transmit these to the contractor.
- (iv) The contractor will have his own representative on site – the Site Engineer (SE) who will be responsible for implementing the contract and complying with the CEP.

144. Contractor prepares CEP: following the award of the contract and before commencing work the contractor will be required to prepare a Contractor's Environmental Plan (CEP) that addresses the conditions of the construction EMP that has been attached to the B&C Documents. The CEP will amplify how the contractor will address the activities in the construction section of the EMP. An outline of the CEP will be provided by the EO. The contractor will submit the CEP to the EO for approval. The contractor has 10 days to prepare the CEP and the EO has 5 days to review the CEP.

145. Induction of contractor to site: Following the selection of the contractor and the approval of the CEP, the contractor together with the person on the contractor's staff who will be responsible for supervising the CEP will meet the EO on-site where the CEP conditions will be confirmed with the contractor. When the EO is confident that the contractor understands and can comply with the CEP, the EO will advise the PE that the contractor can now commence work.

146. Control of invasive species: invasive species have the ability to out compete local vegetation and the introduction of these into new areas should be avoided.

- Prior to the contractor mobilising the EO will arrange to review the site and determine whether there is or is not any infestations of invasive species in the area.
- If the area is not infested then the PE will advise the contractor that all earth must be cleaned from machinery before moving to the site.
- The contractor and the EO will be required to observe for any infestations.
- Should infestations occur on construction sites that are due or are not due to the contractor's activities the contractor will be required to control the infestation.
- Control and avoidance of the introduction of invasive species is the contractor's responsibility and this also extends to any sub-contractors that are working under his control.

147. This will be the responsibility of the contractor. The PE and the EO will responsible for the supervision and monitoring of the contractor.

148. Preparation of site and establishment of contractor's facilities: This applies to all of the contractor's facilities, storage areas, workshops, labour camps, quarries, concrete batching areas etc.

149. The sites are to be selected so that:

- they do not interfere with the welfare of surrounding communities in terms of noise dust and vibration from construction activities and their social wellbeing from their proximity to contractor's labour camps,

- size of contractor's facilities are limited to reduce unnecessary clearing of vegetation,
- sanitary waste and grey water is not to be released untreated into surface water systems.
- sites are to be properly drained. Paved areas, including vehicle parking areas, workshops and fuel storage areas are to drain to an oil and water separator.
- Fuel storage areas are not to be located within 20m of a water course.
- The contractor's facilities are to be contained within an adequate security fence.

150. The location and development of contractor's facilities are to be approved by the PE and the EO.

151. Clearing of sites and removal and disposal of vegetation: this applies to the intake area, the pipeline, powerhouse, the access road and the contractor's site facilities.

- Wherever possible limit area to be cleared and avoid excessive machine disturbance of the topsoil as this is required to be removed and stored.
- Areas of significant vegetation within the cleared area have been identified and have been shown to machinery operators.
- The area to be cleared is defined by a clearly established boundary.
- 10 m wide buffer zones are to be established around watercourses and no clearing is permitted within this area.
- Machinery operators must be shown the boundaries of areas to be cleared.
- Cleared material is to be pushed into manageable sized heaps according to disposal or re-use requirements.
- Waste vegetation should be made available to villagers as fuelwood
- If the material is an impediment to workers it may need to be burnt to clear the area. Wherever possible limit burning and if this is to be done ensure that the wood is dry so as allow a hot clean burn that produces little smoke.

152. This will be the responsibility of the contractor. The PE and the EO will responsible for the supervision and monitoring of the contractor.

153. Work in and alongside the stream channel:

- a. **Work in the stream channel**: this applies to the weir foundation and the pipeline intake. During construction the weir is likely to built in two sections each extending halfway across the channel. The area being worked on will be protected by a temporary coffer dam which will remain in place to allow the weir foundations to be excavated and the weir constructed. Turbidity is unlikely to be an issue for work in the stream channel as this is dependent on an abundant supply of fine particles (clays) which in this situation will not be present as the high stream velocities will have already carried the majority of these particles past the area. During construction any disturbed particles are likely to settle quickly below the site and there is unlikely to be any deleterious downstream impact on water quality. Aquatic life will already be adapted to a wide range of turbid conditions arising from the channel materials and are unlikely to be affected.
- b. **Work alongside the stream channel in soils**: this applies to any section of the pipeline that is located immediately alongside the watercourse where excavated material may enter the watercourse. As the pipeline will be excavated in soil materials which will contain fine particles any excavated material being entrained

by the flow will increase turbidity. The contractor is to take all reasonable precautions to avoid excavated material falling into the watercourse. When working alongside the watercourse excavated material is to be placed on the land side of the excavation. If there is insufficient room to place the material then the material is to be hauled out and returned to the site as required.

154. **Receptors:** People using the downstream area for water supplies and bathing may be affected by both increased turbidity and loss of water quality from pollutants spilled from the operation of machinery and construction activities while working on the weir foundations and alongside the watercourse. While pollutants will be contained inside the coffer dam these may enter the system when water is pumped from the coffer dam or from trenching activities.

155. Mitigation includes the following measures: Turbidity parameters established by the Environment Act 2000, state in *Table 1 Water Quality Criteria for Aquatic Life Protection* that turbidity is not to exceed 25 N.T.U. The contractor will be required to meet this requirement and turbidity is to be measured 50 m downstream of the work area. Turbidity is to be measured while the contractor is working in the stream channel. The contractor evaluates the situation should turbidity exceed these values, and stop work when necessary.

- Compliance and measurement of turbidity on site is the contractor's responsibility. This is to be measured 50m downstream of the site. Wherever possible the contractor is to avoid establishing the coffer dam and carrying out work in or immediately alongside the stream channel during high flows.
- Should turbidity exceed 25 N.T.U. the contractor to evaluate the situation, and when necessary to stop work and wait until the turbidity level has reached the acceptable level.
- Oil is to be skimmed and removed before being pumped out of the coffer dam or trench.
- No pollutants are to be released into the river channel that exceeds acceptable water quality requirements as specified *Table 1 Water Quality Criteria for Aquatic Life Protection*.

156. Excavation of construction sites: this applies to all cleared sites where excavation will be undertaken and includes the intake area, pipeline, powerhouse, access road etc. The contractor is to arrange the following.

- Limit the areas to be excavated to those that can be effectively managed and protected.
- Topsoil is removed and stored in separate heaps that are located in stable areas for later re-use for site rehabilitation.
- Excavated material is sorted and stored as either competent (able to be reused) and incompetent (to be disposed of) materials.

157. This will be the responsibility of the contractor. The PE and the EO will responsible for the supervision and monitoring of the contractor.

158. Prevention of soil erosion on construction site: this applies to all excavated sites. The contractor will be responsible for ensuring that the site is stable and that erosion is contained by appropriate soil conservation protection methods.

- Limit the extent of excavation to reduce soil erosion potential.
- Soil conservation protection methodology is to be applied to susceptible areas to avoid storm water runoff carrying eroded materials either, off-site to susceptible areas or, else onto already finished work areas.

- Where excessive areas are to be opened up, soil protection is unlikely to be effective or storm water drainage is likely to discharge sediment into neighbouring water courses sediment traps are to be used to settle eroded particles.
- Avoid excavating areas and operating machinery in wet ground conditions.
- Excavated areas are to be revegetated as soon as possible at the completion of the site work.

159. This will be the responsibility of the contractor. The PE and the EO will responsible for the supervision and monitoring of the contractor.

160. Removal and disposal of spoil: this applies to all sites where incompetent excavated materials have been produced that need to be disposed of off-site. This includes excavation waste (spoil) from; the weir, pipeline, powerhouse and access road. The contractor will be responsible for selecting sites and disposing of excavated waste at the sites. Sites for spoil dumps will not be approved where there is significant vegetation and at the completion of dumping the sites will need to be reshaped and rehabilitated back to a stable vegetated state. When the sites are opened these areas will require that vegetation be cleared and topsoil removed prior to being used. Once they are being used they must be maintained in a stable manner and soil conservation technology applied as required.

161. This will be the responsibility of the contractor. The PE and the EO will responsible for approving the site selected by the contractor and supervising and monitoring the contractor.

162. Prevention of soil erosion on finished work areas: this applies to all finished sites that have been disturbed by construction activities. The contractor will ensure at the completion of work that all excavated areas are properly stabilized. This includes the rehabilitation of all disturbed areas by the most appropriate and effective method. Re-vegetation requirements are to be discussed with the PM's representative who will advise on the re-vegetation conditions as required for the areas.

163. This will be the responsibility of the contractor. The PE and the EO will responsible for the supervision and monitoring of the contractor.

164. Clearing of transmission line easement: the transmission line will be a 22kV capacity which will be strung on wooden poles that will be erected alongside the road within the road easement. The width of the transmission line easement should be limited to that width that meets conductor safety requirements in terms of sag and side clearance limits. Waste vegetation should be made available to villagers as fuelwood or otherwise it may need to be burnt to clear the area. Wherever possible limit burning and if this is to be done ensure that the wood is dry so as allow a hot clean burn that produces little smoke.

165. This will be the responsibility of the contractor. The PE and the EO will responsible for the supervision and monitoring of the contractor.

166. Storage and handling of construction materials. Fuel and lubricants: Only small amounts of construction materials are likely to be brought to site. These will include sand, gravel and cement for concrete manufacture, reinforcing rods and steel mesh, wood and other construction materials, paint and thinners, fuel and lubricants. Areas will need to be prepared for storing these materials. Fuel and oil will need to be stored in dedicated areas at least 20 m away from a watercourse. Where >5000 litres of fuel is stored on site, the fuel must be stored in sealed tanks that are provided with a concrete base that is bunded to hold 110% of the tank capacity. All

workshops should be provided with oil and water separators. Vehicles and machinery are not to be refuelled within 20 m of the Luwini Creek. The contractor must have trained personnel who are competent in fuel handling procedures and for cleaning up accidental spills. Any major spill in the vicinity of the Luwini Creek is to be reported to the DEC. All waste oil, oil and fuel filters are to be collected and disposed of in secure landfill areas. At the closure of the site all contaminated soil is to be excavated, removed and replaced with fresh topsoil.

167. This will be the responsibility of the contractor. The PE and the EO will responsible for the supervision and monitoring of the contractor.

168. Noise and Vibration: this applies to all machinery, vehicles and construction sites where noise and vibration may affect susceptible receptors. The nearest receptors are at Waju which is about 100 m from the powerhouse site. The contractor will be responsible for ensuring that noise and vibration does not affect the surrounding communities. While it is unlikely that noise and vibration will be an issue due to the distance between the activities and the communities the contractor must be prepared to curtail work to daylight hours (0700hrs - 1900hrs) should the community find that any night time operations become a nuisance. Noise is not to exceed 45 dBA at the boundary of residential areas.

169. This will be the responsibility of the contractor. The PE and the EO will responsible for the supervision and monitoring of the contractor.

170. Dust management: this applies to all of the construction sites, haul roads, quarries and topsoil and spoil dumps. Work that is carried out during the drier time of the year and especially when wind speeds increase may create localised dusty conditions. During construction when dust may be generated the contractor is to monitor the worksite conditions and apply dust control measures which includes reducing traffic movements and spraying water on exposed areas. Use of oil for dust control is not allowed. The contractor is to maintain a dust control record that shows where and when dust control practices were carried out. This is to be made available as required when requested by the PE and/or the EO.

171. This will be the responsibility of the contractor. The PE and the EO will responsible for the supervision and monitoring of the contractor.

172. Public access to the site: this applies to the contractor's site and work areas. Access will be controlled to the contractor's facilities since this will be surrounded by a security fence. All visitors will be required to report to a check point before being allowed to enter the site. Other work areas will be demarcated by barrier tape and signs erected as required to warn people that there is no right of entry to these areas.

173. This will be the responsibility of the contractor. The PE and the EO will responsible for the supervision and monitoring of the contractor.

174. Community safety from increased vehicle movements: this applies to all vehicles and in particular haul trucks that have to pass through villages. The contractor is to ensure that all vehicles that may be required to pass through villages are operated and transport equipment and materials safely without endangering these communities. The contractor is to ensure:

- that trucks and other vehicles are maintained in a safe operating condition,
- all drivers and machinery operators act responsibly,
- all loads are to be secured and all loads with fugitive materials (e.g. excavated soil and sand) are to be covered with tarpaulins,

- the contractor is to immediately remove any drivers that ignore any of the community safety requirements.

175. This will be the responsibility of the contractor. The PE and the EO will be responsible for the supervision and monitoring of the contractor.

176. Use of hazardous materials and Prohibited Activities:

177. **Hazardous Materials:** Care will need to be taken should any hazardous (HAZCHEM) materials be required during construction. It is recommended that the contractor uses the HAZCHEM system which is based on the UN classification system. Details of the classification of dangerous materials can be found on the site <http://www.minerals.csiro.au/safety/dangood.htm>. The contractor will be required to prepare a list of all materials that are proposed to be brought to site together with their HAZCHEM rating. The EO is to verify the HAZCHEM rating and approve the use of any HAZCHEM rated chemicals. The contractor will also be required to display Material Safety Data Sheets (MSDS) in all work areas and to train workers in the safe use of these materials, including the provision of protective equipment for handling these substances.

178. **Prohibited Activities:** The contractor is to be aware of the activities shown in Appendix 5 of the of the ADB's *Safeguard Policy Statement, Prohibited Investment Activities List* that became effective in January 2010. Any listed Appendix 5 activities are prohibited. The PE and ES are to verify that the contractor is aware of the Appendix 5 requirements and that none of these activities will be sanctioned during construction.

179. This will be the responsibility of the contractor. The PE and the EO will be responsible for the supervision and monitoring of the contractor.

180. Workplace health and safety: Workplace health and safety is covered by the Employment Act (1978). The contractor may employ up to 100 people at any one time of which all will have to be housed on site. The main workplace safety issues include:

- Hazards from operating and using machinery. Direct hazards to the machine operators and to workers working in the vicinity of the machine
- Hazards from working in the pipeline trench where sides may collapse.
- Hazards to workers exposed from heavy materials being lifted by cranes.
- Refuelling hazards.
- Exposure to HAZCHEM materials.
- Traffic accident hazards

181. Before commencing work in any of these activities (and in any other areas that the contractor identifies), the contractor will be required to prepare a brief Work Statement (WS) that identifies hazards that apply at a particular site together with an outline of the approved work procedure and details of protective safety equipment to be used by any person entering the specified work area. The WS is also to include an emergency response plan to address serious accidents and nominate a person who is to be immediately contacted should an accident occur. A copy of the WS is to be posted at the site and before commencing work the contractor is required to discuss the WS requirements with the workers. The WS plan is to be submitted to the PE and ES for approval one week prior to starting work in any of these areas.

- The contractor will be required to keep the site free of drugs and alcohol.

- The contractor will be required to appoint a person on his staff who will evaluate workplace safety issues and instruct all workers on workplace hazards and health and safety issues.
- The contractor will be required to provide a safe work environment and provide safety measures and protective equipment for all workers including; hand, head, eye and ear protection and safety footwear.
- The contractor is also to provide first aid facilities on-site and employ a competent person trained in first aid.
- Noise and dust are to be controlled at the workplace.
- Supplies of potable water, toilets and washing water are to be provided for workers.
- A record of accidents and time lost from accidents will be required to be kept by the contractor which will be forwarded each month to the PM's representative for the attention of the ES.

182. The PE or EO will inspect and approve the adequacy of these arrangements.

183. Worker camp establishment/incoming workers: (i) location of camps with regard to social conflicts: A construction site such as this may employ upwards of 100 persons who will be housed and located on-site. There is a potential for conflict to develop with local communities should they be marginalised by the introduction of outside workers who then enjoy an enhanced economic status in comparison the local communities.

- Camps to be located and managed so that social harmony is maintained between workers and local communities.
- Local people should be given priority in labour recruitment.

184. This will be the responsibility of the contractor. The PE and the EO will responsible for the supervision and monitoring of the contractor.

185. Worker camp establishment/incoming workers: (ii) provision of adequate living conditions: Workers will need adequate housing, sanitation and recreational facilities.

186. The contractor will provide acceptable camp facilities with potable water, adequate food rations and recreational facilities to either meet requirements of the Employment Act (1978) or an acceptable international standard whichever is the higher.

187. This will be the responsibility of the contractor. The PE and the EO will responsible for the supervision and monitoring of the contractor.

188. Worker camp establishment/incoming workers: (iii) camp water heating and cooking: To avoid sudden and unsustainable loss of any resources to the detriment of surrounding communities, the contractor will be required to address these issues as follows.

- Locate camp outside significant forest areas.
- Limit collection and use of fuel-wood.
- Contractor provides gas and kerosene for water heating and cooking.

189. This will be the responsibility of the contractor. The PE and the EO will responsible for the supervision and monitoring of the contractor.

190. Worker camp establishment/incoming workers: (iv) hunting and sale of wildlife: To avoid sudden and unsustainable loss of any wildlife resources the contractor will be required to address these issues as follows.

- Labour employment agreement enforced by Contractor that bans hunting and trading in wildlife.
- Provision of adequate camp rations.

191. This will be the responsibility of the contractor. The PE and the EO will responsible for the supervision and monitoring of the contractor.

192. Worker camp establishment/incoming workers: (v) clearing of forest for gardens: workers may want to clear areas for gardens. This will be driven by tradition rather than necessity as the contractor will be required to provide all workers with an adequate ration. While there is adequate land in the area this is owned under traditional systems and should workers want to prepare gardens they must first seek the approval of the Ward Counsellor to avoid social conflict with the surrounding communities. The Ward Counsellor will be advised that workers will not be permitted to clear any forest for garden activities. The contractor is to provide adequate and nutritionally balanced rations for all workers under his control that also incorporates traditional food items that would normally be sourced from markets.

193. This will be the responsibility of the contractor. The PE and the EO will responsible for the supervision and monitoring of the contractor.

194. Disposal of waste materials: All construction waste materials including steel and timber off-cuts, sand and gravel, cement bags etc are to be suitably disposed of. If these cannot be recovered for scrap value these materials are to be taken to an approved landfill sites and dumped there. Operation of landfill sites will be included as an item in the Environmental Permit.

195. This will be the responsibility of the contractor. The PE and the EO will responsible for the supervision and monitoring of the contractor.

196. Chance discovery of archaeological and cultural sites: Archaeological sites are protected under the National Cultural Property (Preservation) Act (1965). There are no known archaeological or cultural sites within the boundaries of the sites. However, it is possible that "chance discoveries" may be made during development of the site. The contractor will be responsible for these finds and is to immediately stop work where the discovery has been made and advise the PE and the EO of the discovery. The EO will arrange to have the site evaluated. Depending on the evaluation of the discovery the contractor will be advised whether or not it is possible to resume work on the site.

197. This will be the responsibility of the contractor. The PE and the EO will responsible for the supervision and monitoring of the contractor.

198. Clearance and rehabilitation of construction sites and removal of contractor's facilities: It is the contractor's responsibility to address site clean up. This includes the removal all waste materials, machinery and any contaminated soil. All construction sites and work areas are to be rehabilitated so that these can be returned as close as possible to their previous use. This includes the stabilization and landscaping of all of the construction sites. Any borrow pits or quarries that were operated by the contractor are to be reshaped and closed. Any contaminated soil must be removed from fuel and oil storage areas and the site revegetated. No waste is to remain behind after work is completed that will not naturally and safely decompose. Should waste not be removed the Owner is entitled to withhold payment and arrange the clean up and deduct the cost of the clean-up from the final payment amount less an additional 10% for arranging the task.

199. The PE is to ensure that all waste is removed and the site restored. The EO will also inspect and approve the clean up of the site.

### C. Environmental Impacts and Mitigation Measures Needed during Operation

200. During operation the main issues are:

- monitoring water quality within the dewatered section
- human safety at the intake and along the transmission line
- maintenance of the transmission line easement and
- handling of waste materials generated from the powerhouse.

201. The PNG powerhouse staff will be responsible for taking the samples and forwarding them to the Environmental Officer in the PPL office in Port Moresby. The EO will review and evaluate the samples and determine the course of the monitoring program.

202. Human safety - at the intake and powerhouse: A small headpond will be created which will be attractive for swimming. Flow within the headpond will be directed to the intake while surplus flow will be discharged over the spillway. While the spillway will be an obvious visual danger the submerged intake can drag surface objects down which can be held against the grill. This danger is not particularly obvious to children and while the intake has a grill it is recommended that hand holds be placed above and alongside the grill for people to pull themselves out and away from the intake area. Awareness of the dangers need to be created by community awareness meetings as well as placing warning signs around the area. These need to be maintained.

203. While the powerhouse will run constantly for most of the time the number of generators may be started and shut down depending on the load which is expected to fall away at night and again increase early in the morning. Thus below the powerhouse there will be a slight increase in flow by  $1.8\text{m}^3/\text{s}$  as the additional turbine is restarted and this flow is added to the flow that carries on over the weir spillway<sup>14</sup>. Table 5 shows that the lowest monthly mean residual flow occurs in February when  $4.76\text{m}^3/\text{s}$  is released over the spillway. When the  $1.8\text{m}^3/\text{s}$  is returned to the creek from the powerhouse this will increase the flow by 27% and result in a surge height of 20cm in the channel immediately below the powerhouse. This implies an instantaneous start up of the turbine which is unrealistic as turbines are normally spooled up over about a minute in which case the surge wave is reduced, though there will still be a 20cm increase in water depth below the powerhouse, but as the surge moves downstream this will be progressively reduced. There will be little overall impact from any surge below the powerhouse and there is a slightly increased human safety risk from the flow height immediately below the powerhouse. Community awareness meetings and signage will be placed below the powerhouse. PNG Power will be responsible for making these arrangements.

204. Human safety - along the transmission line: the poles for the 33kV transmission line are to carry a sign warning of the dangers of the overhead conductors. While there is no causal link established between electromagnetic radiation and transmission line ideally houses should not be allowed within 15 m of the outer conductor of the transmission line. PNG Power will be responsible for making these arrangements.

205. Maintenance of transmission line easement: the transmission line easement will need to be maintained to ensure that vegetation does not compromise conductor safety requirements. It

<sup>14</sup> As the powerhouse discharge is designed at the 90% flow probability, there is considerable spillway discharge.

is recommended that the easement be cleared under contracts arranged by PNG Power with local communities. PNG Power will be responsible for making these arrangements.

206. Handling of waste materials from the powerhouse: small quantities of lubricating oil will need to be stored on site for maintenance of the turbines and generation equipment. Risks will mainly arise from storage and handling of lubrication oil and only small quantities (<100 litres) should be stored on site. All waste oil is to be collected and disposed of to recycling facilities. On no account is oil to be disposed of in the waterway. All spills are to be immediately cleaned. Any serious spills are to be reported immediately to DEC. The powerhouse manager will be responsible for the correct storage and handling of all oil and lubricants and is to be trained in these techniques including procedures to manage any spills. Solid waste such as paper and food wastes from the powerhouse are to be collected and disposed to a landfill area.

207. The area around the powerhouse is to be kept clean and the grass cut on a regular basis. No equipment will be allowed to be discarded within the powerhouse grounds which are to be kept clean and tidy at all times.

208. PNG Power will be responsible for implementing these procedures.

#### **D. Monitoring**

209. A matrix summarizing the monitoring that is required for the EMP is attached as Annex 2 which shows the monitoring measures that are required together with the frequency of measurement, the means of verification and who is responsible for monitoring the activity. Monitoring is carried out as follows:

210. Pre-construction: during preconstruction the EO will monitor the tasks identified within the EMP.

211. Construction: During construction monitoring of construction activities is carried out to ensure that construction work complies with the requirements of the EMP. Monitoring responsibilities are arranged as follows.

- The contractor has the initial responsibility for monitoring compliance with the Contractor's Environmental Plan (CEP) which is identical to the contractor's responsibilities for monitoring the construction works.
- The Project Engineer is responsible for monitoring the contractor's compliance with the CEP and the PE will be assisted in this role by the EO. A Monitoring checklist is attached as Annex 2.
- The EO also monitors the work but in more of an auditing role. The EO can issue Defect Notices for non-compliant work and depending on the seriousness of the work may instruct the contractor that this is to be completed by a certain date. The Defect Notice is given to the PE who directs the contractor to undertake the work as shown in the Defect Notice. If the work is not completed by the due date then the PE can arrange for the work to be completed by another contractor and the cost deducted from the contract plus 10% as a management charge.
- Monitoring may also be carried out by a Third Party e.g. DEC who may make spot checks on the work being undertaken.

212. Operation: During operation monitoring will be undertaken by the PNG Power Environmental Officer. Monitoring tasks are established in Annex 1 and concern monitoring of

water quality in the dewatered section, maintenance of safety signage, removal of vegetation from the transmission line and waste handling.

## E. Implementation Arrangements

### 1. Implementation Schedule

213. The PPTA will be provided as a multi tranche financing facility (MFF) which allows the borrower to draw the loan down as required. The MFF will consist of two tranches and Divune HPP, Ramazon HPP, and Lake Hargy Interconnection are expected to be scheduled in the first tranche. The project will be designed and constructed over a 2-3 years period.

### 2. Institutional Arrangements

214. PNG Power will have overall responsibility for implementing the EMP. Other organisations involved in implementing the EMP include.

- (i) **Government agencies** such as DEC who will be responsible for environmental approval.
- (ii) **The Department of Lands** who will be responsible for assessing and paying compensation.
- (iii) The **contractor** who will be responsible for mitigating and reporting on environmental activities during construction.

215. **Department of the Environment and Conservation (DEC).** The Department of Environment and Conservation is responsible for the administration and enforcement of the Environment Act 2000 and its regulations.

216. DEC have advised the PPL that the small hydropower developments have been assessed as a level 2B activity requiring PPL to submit an Environmental Application which is in a similar format to the IEE. Following approval DEC will issue an Environmental Permit for level 2 and 3 projects. No work can commence until the Environmental Permit is issued.

217. **The Department of Lands** will be responsible for assessing and paying compensation for loss of land and privately owned assets according to the RAP.

218. **PNG Power Ltd (PPL).** The lending facility will be a Multi Tranche Finance Facility (MFF) that is planned to last for six years. The first tranche will be drawn down in the first three years of the project, the second tranche will be drawn down over the next three years. For the purposes of this assessment the budget requirements are established only for the first tranche while the environmental safeguards that are required to support the project over all of the tranches are included in the environmental assessment and review framework (EARF).

219. PNG Power (PPL) will arrange for a Project Management Unit (PMU) to be established within the PPL structure. The PMU will be managed by a Project Manager (PM) and will include engineering, social and environmental personnel. During construction the on-site supervision of the construction program will be managed by the Project Engineer (PE). Both the PM and the PE have roles in ensuring that the EMP is actioned which is formalised by attaching the following to their Statement of Duties.

- (i) *The Project Manager will be responsible for ensuring that the environmental safeguards are implemented so as to meet their intended requirements. This*

*includes ensuring that the construction section and tendering conditions for the EMP is attached to the Bid and Contract documents.*

- (ii) *The Project Engineer (PE) will be responsible for supervising the implementation of the EMP during construction. The PE will be assisted by the Environmental Officer (EO) and the Environmental Specialist (ES). The PE will be responsible for conveying any instructions from the EO or the ES to the contractor.*

220. Included as part of the PMU team, will be three staff - an Environmental Officer (EO), a Land Acquisition Officer (LAO), and a Community Development Officer (CDO). The EO will be responsible for environmental related matters, the LAO will be responsible for land acquisition and compensation issues and the CDO will be responsible for community development program of the affected communities. These staff will report to the Project Manager (PM) of the PMU.

221. During pre-construction the EO will ensure that issues that need to be addressed by the PMU Design Engineers are considered in the design. The EO will prepare a Design Brief containing these requirements for action by the PMU technical design team. The EO will also review and revise the EMP as required and extract the construction section from the EMP so that these may be attached to the Bid and Contract Documents. The EO will arrange public consultation with the LAO to advise affected communities of the scope and scheduling of the sub-project to raise awareness within the communities of the likely phasing of events that will occur within their social boundaries.

222. Prior to construction commencing the EO will also evaluate and approve the Contractor's Environmental Plan (CEP) that will be prepared by the Contractor as a condition of the contract. Following approval of the CEP the EO will arrange to induct the contractor to the construction site whereby the details of the CEP are confirmed with the contractor. When the EO considers that the contractor is competent to undertake compliance with the CEP the EO advises the PMU Project Supervising Engineer (PE) that the contractor may now commence work.

223. While the Contractor's SE will undertake day-to-day supervision of the CEP, the PE who will be assisted by the EO will have overall site supervision responsibilities for ensuring that the Contractor is meeting the CEP requirements.

224. During operation, the EO will also undertake regular monitoring as required by the EMP. The EO may issue Defect Notices concerning non-compliant work which are channelled to the contractor via the PE.

225. The EO will prepare IEEs and Notification of Preparatory Works for other sub-projects as required to meet the requirements of the MFF lending facility.

226. During the first tranche which will take three years an international Environmental Specialist (ES) will also be appointed to the PMU for a period of 5 months to assist the EO in establishing the environmental program. The ES will be located within the PMU and will directly assist the EO in carrying out his duties. The ES will work with and train contractors to assist them in proactively understanding their contractual requirements. The ES is to be familiar with contract preparation, evaluation and supervision so as to advise the EO in the steps required to carry the environmental safeguards across to the Bid and Contract documents, the evaluation of bids, selection of the contractor and the monitoring of the contractor's work. The ES will need to be recruited prior to tendering so as to ensure that the environmental safeguards are integrated into the contractual documents. The ES will have several intermittent inputs over the two years

with the first input of three months scheduled during pre-construction to assist in the formation of the environmental work program and facilitate the integration of the EMP with the contractual document. The remaining two inputs of two months are to be used as two, one month inputs to commence the construction program and the last input is required at the end of the construction period and at the beginning of the operation period. The social and environmental team will use PMU facilities and be supplied with computer facilities, transport and specialised equipment including; a portable water quality meter, a noise meter, a GPS with a support mapping package and digital cameras from the PMU budget.

227. **The Contractor.** The contractor's responsibilities include;
- (i) Prior to construction commencing the contractor will address the construction section of the EMP which has been attached to the Bid and Contract Documents and develop this into a detailed Contractor's Environmental Plan (CEP) that amplifies the conditions established in the EMP. The CEP also identifies persons who will be responsible for undertaking the work within the contractor's team. It will include a basic monitoring plan and a reporting program.
  - (ii) The CEP will be submitted to the EO who will approve it and forward a copy to DEC for their information.
  - (iii) Following approval of the CEP the contractor is required to attend a site induction meeting where the CEP is further discussed directly with the contractor to ensure that all compliance conditions are understood.
  - (iv) Following this the EO advises the PE that the contractor is now cleared to commence work.

228. The contractor will prepare a quarterly compliance report that will be submitted to the PMU. The report will also contain the Monthly Accident Report. The EO will submit the report to DEC and include a copy for the ADB in the project's quarterly progress report prepared to meet the ADB loan requirements.

229. Environmental Assessment of Subsequent Projects: the sub-projects are part of a MFF lending facility and additional sub-projects may be added as required. An Environmental and Review Framework (EARF) has been prepared to guide the preparation of subsequent sub-projects.

### 3. Budget

230. The sub-project will be one of three sub-projects to be implemented over three years as part of the first tranche drawdown from the loan agreement. A summary of the budget is shown in Table 7. The budget shown in Table 7 applies only to the environmental costs. Costs for the social measures are presented in the social development report.

231. As the sub-project will be one of several funded under the MFF facility, the PMU costs for national staff, travel and accommodation and those for the international consultant (the ES) are also shown as these will be common to sub-projects implemented during this tranche (Table 7). The PMU costs including the contingency are \$647,000 which includes funding one national staff - the EO in the PMU and one international staff. The ES is funded for five months and this cost is also included as part of the PMU cost.

232. Other staff including the LAO and the CDO will also be located within the PMU to assist in these programs. The costs of these positions is shown in the budget for the SDP.

**Table 7: Budget requirements**

<b>Item</b>	<b>Amount</b>
<b>Whole Project PMU Costs</b>	
Local staff costs	80,000
Local staff travel & accommodation costs	20,000
International staff (5 person-months)	90,000
Travel (International)	10,000
Travel (Domestic)	15,000
Contingency	20,000
<b>TOTAL Costs</b>	<b>220,000</b>

## **XI. CONCLUSIONS AND RECOMMENDATIONS**

233. The sub-project will develop a small 3MW hydropower run-of-river project on the Luwini Creek in Oro Province. The IEE report has reviewed the environmental impacts associated with the sub-project and has developed a comprehensive EMP to address these activities. Overall there are few impacts associated with the development of the power station. Land acquisition will be about 22 ha. All land ownership issues will be resolved by the PNG Department of Lands. While the Luwini Creek will be blocked by the weir this will not have any serious impacts on fish production as none of the fish are migratory. No significant flora or fauna were identified nor were any rare and endangered species. The population of the surrounding areas is located in five villages with scattered settlements and is about 1500 persons.

234. Pre-construction requirements include addressing stormwater management and the preparation of the EMP as a contractual document. Compensation will be paid for any losses during this time.

235. Construction activities will be localised and intense for the 24 month construction period but will be of a relatively small size. The major issue will be work in and alongside the stream channel to construct the weir foundations, clearing of vegetation and trenching over 2.6 km to bury the supply pipe and construction of a 3.5 km long access road to the weir and powerhouse. Vegetation will be disposed of by inviting the local communities to retrieve this as fuelwood. All other construction impacts are of a routine nature and can be dealt with by the EMP. During construction the contractor will be initially responsible for monitoring and supervising compliance with the EMP. The PE will be assisted by the EO to supervise the contractor while the EO will monitor the work and report any defects to the PE as required.

236. The project will be managed by the PPL as the implementing agency. PPL will form a PMU which will include three staff - an EO, a SDS and a CDS. The EO will be supported by an internationally recruited ES.

237. Based on the above it is concluded that the project has few adverse impacts and all impacts can be satisfactorily managed by the application of the EMP. The Project is classified as a Category B project that requires an IEE to be completed. The IEE shows that all impacts can be satisfactorily mitigated and an EMP has been prepared that contains practical and realizable mitigation measures.

238. The IEE concludes that adverse environmental impacts arising from the construction of the Divune HPP can be minimized to insignificant levels. Therefore, a full EIA is not warranted.

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## APPENDIX 1: ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

	IMPACT MITIGATION				IMPACT MONITORING			
Project Activity	Potential Environmental Impact	Proposed Mitigation Measure	Implementing Responsibility	Mitigation Cost	Parameter to be monitored	Frequency and means of Verification	Monitoring responsibility	Monitoring Cost
<b>PRE-CONSTRUCTION ACTIVITIES</b>								
Acquisition of land and payment of compensation.	i. 22 ha of customary land required for the facilities. ii. Compensation will need to be determined for clearing tree crops from the easement.	Resettlement Action Plan	PNG Power and Lands Department	To be determined	i. Land transferred to PNG Power. ii. Landowner satisfaction	Once verify transfer	SDS, EO	Part of PMU design preparation cost
Access road: provision of stormwater drainage	Excessive soil erosion and loss of water quality.	Adequate turn-offs provided at: 2 m Vertical Intervals for bare earth channels: 4m VI for vegetated channels or armoured channels. Culverts provided with flared outlets and stable discharge areas.	DE and EO	Cost included in design	Construction specifications.	Once, verify inclusion in specifications	Project Engineer and EO	Part of PMU design preparation cost
Provision for low flow release	Loss of aquatic habitat and water quality	i. Fit control gate at intake ii. Spillway to be located before control gate to return flow to watercourse.	DE and EO	Cost included in design	Construction specifications.	Once, verify inclusion in specifications	Project Engineer and EO	Part of PMU design preparation cost
Provision of climate change requirements in design	Under sized structure. Early failure of structure	i. Provide low release gate in weir to support a 200l/s environmental flow to cope with increased low flows.	DE and EO	Project technical cost	Design incorporates climate risk requirements	Once verify design.	EO	Part of PMU design preparation cost.
Siting of sub-project facilities and transmission line. Vegetation losses	Loss of vegetation.	i. Wherever possible limit area to be cleared. lii. For transmission lines limit clearing to meet conductor safety clearances.	DE	Cost included in design	Construction specifications.	Once, verify inclusion in specifications	Project Engineer and EO	Part of PMU design preparation cost
Anti-climbing barriers fitted on transmission poles	Power outages from wildlife climbing poles and shorting conductors.	Fit 0.5m wide aluminium sleeve to power pole at least 3m above ground.	DE	Cost included in design	Construction specifications.	Once, verify inclusion in specifications	Project Engineer and EO	

	IMPACT MITIGATION				IMPACT MONITORING			
Project Activity	Potential Environmental Impact	Proposed Mitigation Measure	Implementing Responsibility	Mitigation Cost	Parameter to be monitored	Frequency and means of Verification	Monitoring responsibility	Monitoring Cost
Inclusion of Appendix 5 <i>Prohibited Investment Activities</i> in B&C document	Loss of environmental values from application of banned materials.	Appendix 5 Prohibited Activities to be included as a requirement under "Special Conditions of Contract" within the B&C document.	PM and EO	PMU cost	Appendix 5 attached to B&C documents	Once verify that Appendix 5 has been attached of the B&C documents.	EO and PM	Part of PMU design preparation cost
<b>CONSTRUCTION ACTIVITIES</b>								
Control of invasive species	Loss of indigenous vegetation.	i. EO to evaluate sites for presence of invasive species. ii. If site is free of invasive species the PE is to advise the contractor that all earth must be removed from machinery and machinery washed down before moving to site. iii. Any outbreaks are to be controlled and this is the contractor's responsibility. iv. Applies to all sub-contractors under the contractors responsibility.	EO, PE and contractor	Costed by contractor and cost carried into contract.	Site kept free of invasive species.	Monthly during wet season or as required until site has been cleared of introduced invasive species. Verify that contractor has washed down machinery..	Contractor, PE and EO	Contractor's monitoring costs met by contractor. EO and PE costs met by PMU.
Preparation of site and establishment of contractor's facilities (quarries, concrete batching areas etc).	Maintains environmental integrity of site.	i Sites do not interfere with welfare or social cohesion of surrounding communities ii. Site is limited to reduce unnecessary clearing of vegetation. iii. Sanitary soakage areas to be sited so that they do not discharge to surface water systems. vi. Vehicle parking areas and workshops to be provided with oil and water separators.	Contractor	Costed by contractor and cost carried into contract.	Site developed according to EMP specifications.	Weekly or as required until site has been established. Verify that contractor's facilities meet EMP requirements.	Contractor, PE and EO	Contractor's monitoring costs met by contractor. EO and PE costs met by PMU.
Clearing of sites and removal and disposal of vegetation	Minimise loss of vegetation	i. Limit area to be cleared ii. Identify areas of significant vegetation. iii. Areas to be defined by clear boundary. iv. 10 m wide buffer zones established around water	Contractor	Costed by contractor and cost carried into contract.	Site cleared and vegetation removed according to EMP specifications.	Weekly or as required until site has been established. Verify that contractor's facilities meet	Contractor, PE and EO	Contractor's monitoring costs met by contractor. EO and PE costs met by PMU.

	IMPACT MITIGATION				IMPACT MONITORING			
Project Activity	Potential Environmental Impact	Proposed Mitigation Measure	Implementing Responsibility	Mitigation Cost	Parameter to be monitored	Frequency and means of Verification	Monitoring responsibility	Monitoring Cost
		courses. v. Machinery operators to understand boundaries. vi. Vegetative material to be disposed of by communities for fuel wood or vii if an impediment to work may otherwise be burnt by clean fires.				mitigation requirements.		
Work in and alongside stream channel	Increased turbidity of downstream areas.	i. Avoid establishing coffer dam when possible, or working immediately alongside stream channel during wet season. ii. Plan operations to avoid creating excessive downstream turbidity. iii. All excavated material to be placed on land side of trench. If area is unavailable this is to be hauled out. iv. No oil or other pollutants to be released to watercourse. v. Work to stop if background turbidity increases above acceptable criteria. vi. Provide alternative water supply to affected village/s.	Contractor	Costed by contractor and cost carried into contract	Turbidity not to exceed 25 NTU as specified by Environmental Act 2000.	i. While work in stream bed is being undertaken. ii. Turbidity measurements taken 50m downstream of weir. iii. Community complaints.	Contractor, PE and EO	Contractor's monitoring costs met by contractor. EO and PE costs met by PMU.
Excavation of construction sites	Loss of topsoil resources	i. Limit excavation area. ii. Remove and store topsoil. iii. Sort and store other excavated materials as required.	Contractor	Costed by contractor and cost carried into contract	Topsoil recovered.	Monthly and then as required. Topsoil recovered and stored and available for later re-use.	Contractor, PE and EO	Contractor's monitoring costs met by contractor. EO and PE costs met by PMU.
Prevention of soil erosion on construction site.	a. Soil erosion from excavation b. Eroded soil interfering with construction activities.	i. Limit excavation area. ii. Apply soil conservation and erosion protection technologies. iii. Use sediment basins. iv. Avoid operating machinery in adverse ground conditions. v.	Contractor	Costed by contractor and cost carried into contract	Soil erosion and sediment supply to water courses controlled.	Monthly and then as required. Sites are stable.	Contractor, PE and EO	Contractor's monitoring costs met by contractor. EO and PE costs met by

	IMPACT MITIGATION				IMPACT MONITORING			
Project Activity	Potential Environmental Impact	Proposed Mitigation Measure	Implementing Responsibility	Mitigation Cost	Parameter to be monitored	Frequency and means of Verification	Monitoring responsibility	Monitoring Cost
		Protect and revegetate newly excavated areas as soon as possible						PMU.
Removal and disposal of spoil.	a. Loss of significant vegetation from poor siting of spoil dumps. b. Lowered water quality from eroded material. c. Loss of visual amenity from poorly located dumpsites	i. Excavated material to be disposed of outside and away from the work area where it can be re-used if required. ii. Material which cannot be re-used is to be landscaped so as not to erode back into canal and revegetated. iii. All disposal areas to be protected to avoid movement of material from sites.	a. Contractor to arrange location of dumping sites with PE. b. PE and EO	Costed by contractor and cost carried into contract	Sites properly prepared and maintained.	Monthly and then as required. Spoil heaps are stable.	Contractor, PE and EO	Contractor's monitoring costs met by contractor. EO and PE costs met by PMU.
Prevention of erosion on finished work areas	a. Loss of soil resources. b. water quality affected.	Rehabilitation of all excavated sites including replacement of topsoil and revegetation of disturbed areas.	Contractor and EO will advise on revegetation requirements	Costed by contractor and cost carried into contract	Completed work areas are stable (non-eroding).	Monthly and then as required. Sites are stable and not eroding.	Contractor, PE and EO	Contractor's monitoring costs met by contractor. EO and PE costs met by PMU.
Clearing transmission line easement.	i. Excessive vegetation losses. ii. Air quality issues from burning vegetation	i. Establish easement width to be cleared to meet and conductor clearance specifications. ii. Wherever possible limit burning of cleared vegetation.	Contractor	Costed by contractor and cost carried into contract	RoW cleared to specified width and height.	At start of work and then as required. Transmission line easement cleared to specifications.	Contractor, PE and EO	Contractor's monitoring costs met by contractor. EO and PE costs met by PMU.
Storage and handling of construction materials. Fuel and lubricants.	Pollution of soil and water resources	i. Storage areas to be prepared to avoid deterioration of materials. ii. Fuel should be stored in properly sealed containers. Larger than 5000 l to be stored on bunded concrete platform with 110% storage capacity. iii. All fuel storage areas to be security fenced and provided with oil and water separators. Fuel hoses to be locked and provided with a shut off valve at	Contractor	Costed by contractor and cost carried into contract	Storage areas prepared. Fuel and oil storage and handling procedures practiced and well understood	Initially once to approve storage and handling procedures then as required. Verify that storage and handling of construction materials, fuel and lubricants	Contractor, PE and EO	Contractor's monitoring costs met by contractor. EO and PE costs met by PMU.

	IMPACT MITIGATION				IMPACT MONITORING			
Project Activity	Potential Environmental Impact	Proposed Mitigation Measure	Implementing Responsibility	Mitigation Cost	Parameter to be monitored	Frequency and means of Verification	Monitoring responsibility	Monitoring Cost
		the tank. iv. All refuelling to be done at least 20 m away from waterways by trained personnel. v. All waste oil and oil filters to be collected and if possible recycled, otherwise to be disposed of to landfills. vi. Accidental spill handling action plan.				meet these requirements.		
Noise and vibration	Noise and vibration nuisance to surrounding communities. Impact will be mainly limited to weir site, powerhouse and access road.	i. If particularly noisy activities are required work may need to be limited to daylight hours. ii. Noise not to exceed 45dBA at boundary of workplace.	i. and ii. contractor	Costed by contractor and cost carried into contract.	i. Noise complaints from surrounding communities. ii. Noise measurement	At start of noisy activities then as required. Community complaints. 45 dBA measured at workplace boundary.	Contractor, PE and EO	Contractor's monitoring costs met by contractor. EO and PE costs met by PMU.
Dust management	Dust may be generated from activities. Will affect air quality of workplaces and surrounding areas	When dust is carried towards residential areas or becomes problematic on-site the contractor is to apply dust control measures	Contractor	Costed by contractor and cost carried into contract.	Work areas are acceptable with regards to generation of dust.	i. As determined by wind and site conditions.. ii. Complaints from communities.	Contractor, PE and EO	Contractor's monitoring costs met by contractor. EO and PE costs met by PMU.
Public access to site	Accidents to surrounding communities	Erect warning signs and barriers around work areas. Site can only be accessed with permission of contractor	Contractor	Costed by contractor and cost carried into contract.	Warning signs and barriers erected around work places. Access to work areas controlled.	Weekly. Accident reports involving community.	Contractor, PE and EO	Contractor's monitoring costs met by contractor. EO and PE costs met by PMU.
Community Safety from increased vehicle movements	Accidents to surrounding communities from vehicles transiting villages.	i. All vehicles to be properly maintained and operated in accordance with road laws. ii. All loads to be properly secured and fugitive loads to be covered	Contractor	Costed by contractor and cost carried into contract.	Trucks and vehicles operated safely	Weekly. Accident reports. Community complaints	Contractor, PE and EO	Contractor's monitoring costs met by contractor. EO and PE costs met by

	IMPACT MITIGATION				IMPACT MONITORING			
Project Activity	Potential Environmental Impact	Proposed Mitigation Measure	Implementing Responsibility	Mitigation Cost	Parameter to be monitored	Frequency and means of Verification	Monitoring responsibility	Monitoring Cost
		iii. Drivers to be fired if ignore safety requirements.						PMU.
i. Use of hazardous materials and ii. Prohibited activities	Health dangers to workers and the environment. Loss of water quality	i. Contractor to provide list of all HAZCHEM products to be used on site ii. List verified against HAZCHEM. iii. Contractor to display MSDS sheets in work areas. iv. Contractor to abide by Appendix 5 Prohibited Activities (SPS, June 2009)	Contractor and EO.	Costed by contractor and cost carried into contract.	a. List of chemical compounds and their hazard ratings. b. Appendix 5 activities	At start of work and whenever any hazardous compounds are to be brought to site. b. No Appendix 5 activities initiated	Contractor, PE and EO	Contractor's monitoring costs met by contractor. EO and PE costs met by PMU.
Increased construction traffic and incoming workers	Workplace accidents and health of workers. Loss of productivity.	i. Erect warning signs and barriers around work areas ii. No drugs or alcohol allowed on-site iii. Noise and dust to be controlled. iv. Workers to be provided with safe working environment including provision of safety equipment. v. Potable water to be supplied as well as toilet and washing facilities. vi. Work Statements prepared for activity vii. Workers to be inducted to site by contractor and site hazards explained. h. Medical and first aid facilities provided together with a person qualified in first aid.	Contractor	Costed by contractor and cost carried into contract.	Provision of safe and healthy workplace, safety procedures and equipment. First aid equipment.	Spot checks and weekly inspections. Accident record.	Contractor, PE and EO	Contractor's monitoring costs met by contractor. EO and PE costs met by PMU.
Worker camps establishment/incoming workers (i): Location of camps and employment of local labour	Social unrest from poor location of camps and perceived bias in employment policy if local workers not hired	i. Camps to be located and managed to reduce social conflicts. ii. Local communities to be preferentially offered employment for unskilled work	Contractor	Costed by contractor and cost carried into contract.	Local people employed	i. Monthly checking of employment records. ii. Complaints from surrounding	Contractor and PE, EO	Contractor's monitoring costs met by contractor. EO and PE costs met by PMU.

Project Activity	IMPACT MITIGATION				IMPACT MONITORING			
	Potential Environmental Impact	Proposed Mitigation Measure	Implementing Responsibility	Mitigation Cost	Parameter to be monitored	Frequency and means of Verification	Monitoring responsibility	Monitoring Cost
Worker camps establishment/incoming workers (ii): provision of adequate living conditions	Poor health and loss of worker productivity.	i. Provide acceptable work camp conditions. ii. potable water iii. adequate food rations, iv. recreational facilities	Contractor	Costed by contractor and cost carried into contract.	Worker satisfaction	communities. i. Monthly checking of first aid records. ii. Complaints from workers.	Contractor and PE, EO	Contractor's monitoring costs met by contractor. EO and PE costs met by PMU.
Worker camps establishment/incoming workers (iii): Camp water heating and cooking. Use of fuel wood.	i. Unsustainable removal of forest resources to detriment of surrounding communities. ii. Disturbance to forests, wildlife, and biodiversity	i. Locate camp away from significant forest areas. ii. Limit collection and use of fuel-wood. iii. Contractor provides gas and kerosene for water heating and cooking	Contractor	Costed by contractor and cost carried into contract.	Harvesting of fuel wood	Monthly Verify camp cooking facilities.	Contractor and PE, EO	Contractor's monitoring costs met by contractor. EO and PE costs met by PMU.
Worker camp establishment/ Incoming workers (iv): Hunting and sale of wildlife by workers	i. Unsustainable loss of wildlife and ii. affect on biodiversity.	i. Labour employment agreement enforced by contractor that bans hunting and trading in wildlife. ii. Provision of adequate camp rations	Contractor	Costed by contractor and cost carried into contract.	Wildlife being traded from camp area	Monthly Verify prosecution and dismissal of employees for wildlife infringements..	Contractor and PE, EO	Contractor's monitoring costs met by contractor. EO and PE costs met by PMU.
Worker camp establishment/incoming workers (v): Clearing land for gardens	i. Cause of social conflict from surrounding communities.	Contractor to provide adequate and nutritionally balanced rations	Contractor	Costed by contractor and cost carried into contract.	Illegal occupation of land that has been cleared for gardens.	Monthly Complaints from communities	Contractor and PE, EO	Contractor's monitoring costs met by contractor. EO and PE costs met by PMU.
Disposal of waste materials	Soil and water pollution.	All waste materials to be collected and sorted; (i). those that can be recycled and (ii) those that need to go to an approved landfill site for disposal.	Contractor	Costed by contractor and cost carried into contract	Sites cleaned of materials. Materials dumped in approved sites	Spot checks and weekly inspections. Waste being collected and disposed of to meet requirements.	Contractor, PE and EO	Contractor's monitoring costs met by contractor. EO and PE costs met by PMU.
Chance discovery of archaeological and cultural sites	Loss of cultural values	No known sites. Chance discoveries are to be notified to the PE who will advise the EO.	Contractor, PE and EO	Costed by contractor and cost	Contract document, and	Yearly. Notification of chance	Contractor, PE and EO	Contractor's monitoring costs met by

		IMPACT MITIGATION			IMPACT MONITORING			
Project Activity	Potential Environmental Impact	Proposed Mitigation Measure	Implementing Responsibility	Mitigation Cost	Parameter to be monitored	Frequency and means of Verification	Monitoring responsibility	Monitoring Cost
		EO to advise on procedure.		carried into contract.	specification	discoveries		contractor. EO and PE costs met by PMU.
Clearance and rehabilitation of construction sites and removal of contractor's facilities.	Re-establishes environmental values	i. All solid waste to be removed from sites and disposed in approved landfills. ii. All contaminated soil to be removed. iii. All sites to be rehabilitated and restored to original condition. iv. Drainage to be re-established. v. To be included as part of Final Inspection before payment made.	Contractor	Costed by contractor and cost carried into contract	Sites cleared, waste removed, sites landscaped and revegetated.	At completion of construction. Site has been cleared of materials, rehabilitated and returned to original state.	Contractor, PE and EO	Contractor's monitoring costs met by contractor. EO and PE costs met by PMU.
<b>OPERATION ACTIVITIES</b>								
Monitoring water quality in dewatered section	Loss of water quality in dewatered section during extremely low flows.	Institute water quality monitoring program to evaluate water quality in the dewatered section.	PNG Power	PNG operating cost	Water quality to be monitored at following locations: i. above intake in headpond. ii. below intake in watercourse. iii. above powerhouse. iv. below powerhouse. Parameters to be measured: i. pH, temperature and dissolved oxygen,	Initially monthly and whenever flows cease over the weir spillway. Review after 12 months.	EO, PNG Power	PNG Power cost

	IMPACT MITIGATION				IMPACT MONITORING			
Project Activity	Potential Environmental Impact	Proposed Mitigation Measure	Implementing Responsibility	Mitigation Cost	Parameter to be monitored	Frequency and means of Verification	Monitoring responsibility	Monitoring Cost
Human safety - transmission lines	Potential loss of life	<ul style="list-style-type: none"> <li>i. Fit warning signs to poles.</li> <li>ii. Conduct hazard awareness meetings.</li> <li>iii. No houses within 15 m of transmission line</li> </ul>	PNG Power transmission line staff	PNG operating cost	<ul style="list-style-type: none"> <li>i. warning signs fitted</li> <li>ii. hazards awareness meetings organised.</li> <li>iii. Houses outside 15 m exclusion zone</li> </ul>	<ul style="list-style-type: none"> <li>i. warning signs fitted and maintained.</li> <li>ii. Number of awareness meetings organised.</li> <li>iii. No houses within 15 m exclusion zone.</li> <li>iv. Accidents reported</li> </ul>	EO, PNG Power	PNG Power cost
Maintenance of transmission line easement.	Damage to power lines and circuits from vegetation interfering with lines integrity.	<ul style="list-style-type: none"> <li>i. Vegetation under transmission lines to be cleared as required to meet safety operating specifications.</li> <li>ii. Employ local communities to clear easement.</li> <li>iii. Limit use of herbicides.</li> </ul>	PNG Power transmission line staff	PNG operating cost	Transmission lines kept clear of vegetation.	Annually. Transmission line easement kept clear of vegetation.	EO, PNG Power	PNG Power cost
Handling of waste materials from the powerhouse.	Soil and water pollution. Loss of aesthetics.	<ul style="list-style-type: none"> <li>i. Waste oil collected</li> <li>ii. Office waste removed</li> <li>iii. Site kept tidy and no waste allowed to build up in yard.</li> </ul>	PNG Power	PNG operating cost	Waste collected and disposed of. Site kept clean and all old and surplus equipment disposed of to landfills or recycling depots.	Annually. Site is presentable.	EO, PNG Power	PNG Power cost

EO = Environmental Officer attached to PNG Power; PE = Project Engineer based in PMU; SDS Social Development Specialist; MSDS material safety data sheet,

## APPENDIX 2: MONITORING CHECKLIST

### HPP Sub-project: IEE MONITORING REQUIREMENTS

1. For this project, a table summarizing the monitoring requirements shown in the Environmental Management Plan (EMP) is attached as Appendix A for pre-construction and construction. The matrix shown in Appendix A shows the mitigation measures, monitoring requirements and responsibilities of the various persons that need to be addressed during design/pre-construction, construction and operation phases. Only the main monitoring requirements are shown in Appendix A and will need to be revised as follows.
  - At the start of the project and before monitoring begins the Environment Officer (EO) will review the monitoring activities shown in Appendix A and update the monitoring requirements to conform with any changes that have been made to the sub-project design and activities.
2. Monitoring will be addressed as follows.
  - During **pre-construction** monitoring of these activities will be carried out by the EO. The EO in association with the Design Engineer (DE) will be responsible for ensuring that the issues that are to be addressed by the technical design team are implemented as required in the EMP.
  - During **construction** monitoring will be carried out as follows; the contractor will have the initial responsibility for self-monitoring his work which will be undertaken according to the CEP. The contractor will appoint a person on his team who will have overall responsibility for ensuring that the CEP requirements are complied with. The PE will supervise and monitor the contractor's work and direct the contractor accordingly. The EO will support and assist the PE in monitoring the contractor's work. The EO will also independently monitor the construction activities and will issue Defect Notices for non-complying work to the contractor via the PE.

## APPENDIX 3: ENVIRONMENTAL MONITORING PLAN: HPP sub-project

Project Activity	Applies to	Proposed Mitigation Measure	Parameter to be monitored	Frequency and means of Verification	Monitoring responsibility	Achieved Yes or No	Date of Verification	Name of person verifying	Signature of person verifying	Remarks: e.g. Defect Notice Issued etc
<b>PRE-CONSTRUCTION</b>										
Acquisition of land and payment of compensation.	Pre-construction	Resettlement Action Plan	i. Land transferred to PNG Power. ii. Landowner satisfaction	Once verify transfer	SDS, EO					
Access road provision of stormwater drainage	Design	Adequate turn-offs provided at 2 m Vertical Intervals. Culverts provided with flared outlets and stable discharge areas.	Construction specifications.	Once, verify inclusion in specifications	ES					
Provision for low flow release	Loss of aquatic habitat and water quality	i. Fit control gate at intake ii. Spillway to be located before control gate to return flow to watercourse.	Design incorporates low flow release requirements	Once, verify inclusion in specifications	DE and EO					
Siting of sub-project facilities and transmission line. Vegetation losses	Design	i. Wherever possible limit area to be cleared. lii. For transmission lines limit clearing to meet conductor safety clearances.	Included in construction specifications.	Once, verify inclusion in specifications	DE and EO					
Anti-climbing barriers fitted to transmission poles	Design	Fit 0.5m wide aluminium sleeve to power pole at least 3m above ground.	Included in construction specifications	Once, verify inclusion in specifications	DE					
Review EMP and extract construction section of EMP	EMP	EMP to be revised and re-issued at the completion of the pre-construction tasks.	EMP revised and changes incorporated in it.	Once. EMP re-issued.	PM					
Inclusion of Appendix 5 <i>Prohibited Investment Activities</i> in B&C	Bid and Contract Documents	Appendix 5 Prohibited Activities to be included as a requirement under	Appendix 5 attached to B&C documents	Once verify that Appendix 5 has been attached of the B&C	EO and PM					

Project Activity	Applies to	Proposed Mitigation Measure	Parameter to be monitored	Frequency and means of Verification	Monitoring responsibility	Achieved Yes or No	Date of Verification	Name of person verifying	Signature of person verifying	Remarks: e.g. Defect Notice Issued etc
document		"Special Conditions of Contract" within the B&C document.		documents.						
EMP construction conditions included in Bid Documents	Bid and Contract Documents	EMP construction conditions included in B&C documents in Part II - Requirements; Section 6 - Employers Requirements. List EMP construction section as a Special Condition of Contract.	EMP construction conditions attached to B&C documents.	Once verify EMP construction section attached to B&C documents.	EO and PM					
<b>CONSTRUCTION ACTIVITIES</b>										
Contractor prepares CEP	Contractor	Contractor prepares Contractor's Environmental Plan (ESM) that establishes the contractor's management and compliance requirements with the construction section of the EMP.	CEP prepared by contractor and approved by EO	Once. CEP; (a) prepared and (b) approved.	EO					
Induction of contractor to site.	Contractor	Before commencing work the CEP conditions are confirmed with the contractor at an on-site meeting. When the EO considers that the contractor is competent to comply with the SEMP the EO advises the PE that the contractor can now mobilise.	Record of induction meeting and decision advising contractor to mobilise.	Once. Verify that induction has been carried out and contractor is competent to undertake CEP.	EO					

Project Activity	Applies to	Proposed Mitigation Measure	Parameter to be monitored	Frequency and means of Verification	Monitoring responsibility	Achieved Yes or No	Date of Verification	Name of person verifying	Signature of person verifying	Remarks: e.g. Defect Notice Issued etc
Control of invasive species	Contractor and all construction sites.	<ul style="list-style-type: none"> <li>i. EO to evaluate sites for presence of invasive species.</li> <li>ii. If site is free of invasive species the PE is to advise the contractor that all earth must be removed from machinery and machinery washed down before moving to site.</li> <li>iii. Any outbreaks are to be controlled and this is the contractor's responsibility.</li> <li>iv. Applies to all sub-contractors under the contractors responsibility.</li> </ul>	Site kept free of invasive species.	<p>Monthly during wet season or as required until site has been cleared of introduced invasive species.</p> <p>Verify that contractor has washed down machinery.</p>	EO, PE and contractor					
Clearing of sites and removal and disposal of vegetation	Construction sites	<ul style="list-style-type: none"> <li>i. Limit area to be cleared</li> <li>ii. Identify areas of significant vegetation.</li> <li>iii. Areas to be defined by clear boundary.</li> <li>iv. 10 m wide buffer zones established around water courses.</li> <li>v. Machinery operators to understand boundaries.</li> <li>vi. Vegetative material to be disposed of by communities for fuel wood or</li> <li>vii if an impediment to work may otherwise be burnt by clean fires.</li> </ul>	Site cleared and vegetation removed according to EMP specifications.	<p>Weekly or as required until site has been established.</p> <p>Verify that contractor's facilities meet mitigation requirements.</p>	Contractor, PE and EO					

Project Activity	Applies to	Proposed Mitigation Measure	Parameter to be monitored	Frequency and means of Verification	Monitoring responsibility	Achieved Yes or No	Date of Verification	Name of person verifying	Signature of person verifying	Remarks: e.g. Defect Notice Issued etc
Work in and alongside stream channel	Weir and pipeline	<ul style="list-style-type: none"> <li>i. Avoid establishing coffer dam or working immediately alongside stream channel during wet season.</li> <li>ii. Plan operations to avoid creating excessive downstream turbidity.</li> <li>iii. All excavated material to be placed on land side of trench. If area is unavailable this is to be hauled out.</li> <li>iv. No oil or other pollutants to be released to watercourse.</li> <li>v. Work to stop if background turbidity increases above acceptable criteria</li> <li>vi. Provide alternative water supply to affected village/s.</li> </ul>	Turbidity not to exceed 25 NTU as specified by Environmental Act 2000.	<ul style="list-style-type: none"> <li>i. While work in stream bed is being undertaken.</li> <li>ii. Turbidity measurements taken 50m downstream of weir.</li> <li>iii. Community complaints.</li> </ul>	Contractor, PE and EO					
Excavation of construction sites	Construction sites	<ul style="list-style-type: none"> <li>i. Limit excavation area.</li> <li>ii. Remove and store topsoil.</li> <li>iii. Sort and store other excavated materials as required.</li> </ul>	Topsoil recovered.	Monthly and then as required. Topsoil recovered and stored and available for later re-use.	Contractor, PE and EO					
Prevention of soil erosion on construction site.	Construction sites	<ul style="list-style-type: none"> <li>i. Limit excavation area.</li> <li>ii. Apply soil conservation and erosion protection technologies.</li> <li>iii. Use sediment basins.</li> <li>iv. Avoid operating machinery in adverse ground conditions.</li> <li>v.</li> </ul>	Soil erosion and sediment supply to water courses controlled.	Monthly and then as required. Sites are stable.	Contractor, PE and EO					

Project Activity	Applies to	Proposed Mitigation Measure	Parameter to be monitored	Frequency and means of Verification	Monitoring responsibility	Achieved Yes or No	Date of Verification	Name of person verifying	Signature of person verifying	Remarks: e.g. Defect Notice Issued etc
		Protect and revegetate newly excavated areas as soon as possible								
Removal and disposal of spoil.	Spoil disposal areas	i. Excavated material to be disposed of outside and away from the work area where it can be re-used if required. ii. Material which cannot be re-used is to be landscaped so as not to erode back into canal and revegetated. iii. All disposal areas to be protected to avoid movement of material from sites.	Spoil disposal sites properly prepared and maintained.	Monthly and then as required. Spoil heaps are stable.	Contractor, PE and EO					
Prevention of erosion on finished work areas	Construction areas	Rehabilitation of all excavated sites including replacement of topsoil and revegetation of disturbed areas.	Completed work areas are stable (non-eroding).	Monthly and then as required. Sites are stable and not eroding.	Contractor, PE and EO					
Clearing transmission line easement.	Transmission line easement	i. Establish easement width to be cleared to meet and conductor clearance specifications. ii. Wherever possible limit burning of cleared vegetation.	RoW cleared to specified width and height.	At start of work and then as required. Transmission line easement cleared to specifications.	Contractor, PE and EO					
Storage and handling of construction materials. Fuel and lubricants.	Storage areas for materials, fuel and lubricants	i. Storage areas to be prepared to avoid deterioration of materials. ii. Fuel should be stored in properly sealed containers. Larger than 5000 l to be stored on bunded concrete	Storage areas prepared. Fuel and oil storage and handling procedures practiced and well understood	Initially once to approve storage and handling procedures then as required. Verify that storage and handling of construction materials, fuel and lubricants meet these	Contractor, PE and EO					

Project Activity	Applies to	Proposed Mitigation Measure	Parameter to be monitored	Frequency and means of Verification	Monitoring responsibility	Achieved Yes or No	Date of Verification	Name of person verifying	Signature of person verifying	Remarks: e.g. Defect Notice Issued etc
		platform with 110% storage capacity. iii. All fuel storage areas to be security fenced and provided with oil and water separators. Fuel hoses to be locked and provided with a shut off valve at the tank. iv. All refuelling to be done at least 20 m away from waterways by trained personnel. v. All waste oil and oil filters to be collected and if possible recycled, otherwise to be disposed of to landfills. vi. Accidental spill handling action plan.		requirements.						
Noise and vibration	Construction sites	i. If particularly noisy activities are required work may need to be limited to daylight hours. ii. Noise not to exceed 45dBA at boundary of workplace.	i. Noise complaints from surrounding communities. ii. Noise measurement	At start of noisy activities then as required. Community complaints. 45 dBA measured at workplace boundary.	Contractor, PE and EO					
Dust management	Construction sites	When dust is carried towards residential areas or becomes problematic on-site the contractor is to apply dust control measures	Work areas are acceptable with regards to generation of dust.	i. As determined by wind and site conditions.. ii. Complaints from communities.	Contractor, PE and EO					
Public access to site	Construction sites	Erect warning signs and barriers around work areas. Site can only be accessed with permission of contractor	Warning signs and barriers erected around work places. Access to work areas controlled.	Weekly. Accident reports involving community.	Contractor, PE and EO					

Project Activity	Applies to	Proposed Mitigation Measure	Parameter to be monitored	Frequency and means of Verification	Monitoring responsibility	Achieved Yes or No	Date of Verification	Name of person verifying	Signature of person verifying	Remarks: e.g. Defect Notice Issued etc
Community Safety from increased vehicle movements	Villages along haul routes	<ul style="list-style-type: none"> <li>i. All vehicles to be properly maintained and operated in accordance with road laws.</li> <li>ii. All loads to be properly secured and fugitive loads to be covered</li> <li>iii. Drivers to be fined if ignore safety requirements.</li> </ul>	Trucks and vehicles operated safely	Weekly. Accident reports. Community complaints	Contractor, PE and EO					
<ul style="list-style-type: none"> <li>i. Use of hazardous materials and</li> <li>ii. Prohibited activities</li> </ul>	Materials brought to site	<ul style="list-style-type: none"> <li>i. Contractor to provide list of all HAZCHEM products to be used on site</li> <li>ii. List verified against HAZCHEM.</li> <li>iii. Contractor to display MSDS sheets in work areas.</li> <li>iv. Contractor to abide by Appendix 5 Prohibited Activities (SPS, June 2009)</li> </ul>	<ul style="list-style-type: none"> <li>a. List of chemical compounds and their hazard ratings.</li> <li>b. Appendix 5 activities</li> </ul>	At start of work and whenever any hazardous compounds are to be brought to site. b. No Appendix 5 activities initiated	Contractor, PE and EO					
Workplace health and safety	Construction sites	<ul style="list-style-type: none"> <li>i. Erect warning signs and barriers around work areas</li> <li>ii. No drugs or alcohol allowed on-site</li> <li>iii. Noise and dust to be controlled.</li> <li>iv. Workers to be provided with safe working environment including provision of safety equipment.</li> <li>v. Potable water to be supplied as well as toilet and washing facilities.</li> <li>vi. Work Statements prepared for activity</li> </ul>	Provision of safe and healthy workplace, safety procedures and equipment. First aid equipment.	Spot checks and weekly inspections. Accident record.	Contractor, PE and EO					

Project Activity	Applies to	Proposed Mitigation Measure	Parameter to be monitored	Frequency and means of Verification	Monitoring responsibility	Achieved Yes or No	Date of Verification	Name of person verifying	Signature of person verifying	Remarks: e.g. Defect Notice Issued etc
		vii. Workers to be inducted to site by contractor and site hazards explained. h. Medical and first aid facilities provided together with a person qualified in first aid.								
Worker camps establishment/incoming workers (i): Location of camps and employment of local labour	Worker camps and workers	i. Camps to be located and managed to reduce social conflicts. ii. Local communities to be preferentially offered employment for unskilled work	Local people employed	i. Monthly checking of employment records. ii. Complaints from surrounding communities.	Contractor and PE, EO					
Worker camps establishment/incoming workers (ii): provision of adequate living conditions	Worker camps and workers	i. Provide acceptable work camp conditions. ii. potable water iii. adequate food rations, iv. recreational facilities	Worker satisfaction	i. Monthly checking of first aid records. ii. Complaints from workers.	Contractor and PE, EO					
Worker camps establishment/incoming workers (iii): Camp water heating and cooking. Use of fuel wood.	Worker camps and workers	i. Locate camp away from significant forest areas. ii. Limit collection and use of fuel-wood. iii. Contractor provides gas and kerosene for water heating and cooking	Harvesting of fuel wood	Monthly Verify camp cooking facilities.	Contractor and PE, EO					
Worker camps establishment/incoming workers (iv): Hunting and sale of wildlife by workers	Worker camps and workers	i. Labour employment agreement enforced by contractor that bans hunting and trading in wildlife. ii. Provision of adequate camp rations	Wildlife being traded from camp area	Monthly Verify prosecution and dismissal of employees for wildlife infringements..	Contractor and PE, EO					
Worker camps establishment/incoming workers (v): Clearing land	Worker camps and workers	Contractor to provide adequate and nutritionally balanced	Illegal occupation of land that has been cleared for	Monthly Complaints from communities	Contractor and PE, EO					

Project Activity	Applies to	Proposed Mitigation Measure	Parameter to be monitored	Frequency and means of Verification	Monitoring responsibility	Achieved Yes or No	Date of Verification	Name of person verifying	Signature of person verifying	Remarks: e.g. Defect Notice Issued etc
for gardens		rations	gardens.							
Disposal of waste materials	Construction sites Worker camps Contractor's work areas	All waste materials to be collected and sorted; (i). those that can be recycled and (ii) those that need to go to an approved landfill site for disposal.	Sites cleaned of materials. Materials dumped in approved sites	Spot checks and weekly inspections. Waste being collected and disposed of to meet requirements.	Contractor, PE and EO					
Chance discovery of archaeological and cultural sites	Construction sites	No known sites. Chance discoveries are to be notified to the PE who will advise the EO. EO to advise on procedure.	Contract document, and specification	Yearly. Notification of chance discoveries	Contractor, PE and EO					
Clearance and rehabilitation of construction sites and removal of contractor's facilities.	Construction sites Worker camps Contractor's work areas	i. All solid waste to be removed from sites and disposed in approved landfills. ii. All contaminated soil to be removed. iii. All sites to be rehabilitated and restored to original condition. iv. Drainage to be re-established. v. To be included as part of Final Inspection before payment made.	Sites cleared, waste removed, sites landscaped and revegetated.	At completion of construction. Site has been cleared of materials, rehabilitated and returned to original state.	Contractor, PE and EO					

EO = Environmental Officer attached to PNG Power; PE = Project Engineer based in PMU; SDS Social Development Specialist; MSDS material safety data sheet.