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Environmental Impact Statement

(Updated ESIA from ESIA 2017)

For Tina River Hydropower Development Project, Solomon Islands

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF ANNEXURES

LIST OF APPENDICES

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EXECUTIVE SUMMARY

This document is an Environmental and Social Impact Assessment (ESIA) Report for the Tina River Hydropower Development Project (TRHDP), a 15-megawatt hydropower scheme on Guadalcanal, Solomon Islands. More precisely, the Project is located in Malango, Ward 20 of the Guadalcanal Province, 30 km southeast of Honiara. The TRHDP is managed by a dedicated Project Office (TRHDP-PO) under the Solomon Islands Ministry of Mines, Energy and Rural Electrification (MMERE). Electricity will be generated by an Independent Power Producer (IPP), Tina Hydropower Limited. The Tina Hydropower Limited (THL) is a Project Company (PC) and duly organised under the law of the Solomon Islands. THL will sell electricity to the Solomon Islands Electricity Authority (SIEA), the state-owned power utility. THL will Build, Own, Operate and Transfer (BOOT) the scheme. It will be the owner of the works during the concession. At the end of the lease, THL will transfer the infrastructure to the Solomon Islands Government or SIEA.

The Project requires an EIS in accordance with the Solomon Island Government (SIG) Environment Act (1998) and World Bank Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts.

E 1. LOCATION

Tina River is located 30 km South East of Honiara at the upstream end of the Ngalimbiu River Basin in Central Guadalcanal.

Figure 0-1 Map of Tina Hydro site in Guadalcanal context

The Project is located in Bahomea, winthin the Malango Ward (Ward 20) of Guadalcanal Province. The Map at Figure 0-2 depicts the dam, reservoir and power station sites in the context of the Black Post Road, Main Highway and Ngalimbiu River.

Figure 0-2 Map of Project Location

E 2. THE PROJECT

Currently, power in Guadalcanal is mainly provided by Lungga diesel power plant. The power supply in Honiara is barely adequate to meet demand, especially during periods of peak power consumption. TRHDP will reduce the peak demand requirement on the current diesel system and reduce the requirements for imported diesel. It is also expected to defer the need for further capital expenditure on the diesel generation plant for up to a decade.

Guadalcanal has abundant hydropower potential that could help the country reduce its dependency on diesel fuel, reduce the country's exposure to the uncertainties inherent in world oil markets, and lower the cost of energy production. The price of electricity in Guadalcanal is one of the highest in the Pacific region mainly due to the nearly total reliance on diesel for its power generation. Environmentally, electricity generated from diesel leads to impacts including: greenhouse gas emissions, air pollution and a risk of oil spills during extraction, processing, sea transport and transfer to Honiara (Entura, 2014). Electricity generated by hydropower has the advantage of allowing Solomon Islands to rely on its own renewable resource, and to import substantially smaller amounts of non-renewable diesel.

The Project consists of a 53 meter high Roller Compacted Concrete dam in an uninhabited area of Malango Ward at an elevation of approximately 122 meters above sea level (masl) and roughly 30 river km from the sea. It also incorporates a 3.3 km tunnel to a powerhouse and a tailrace at elevation 73 masl. The reservoir formed by the dam will extend upstream approximately 2.6km and will have a surface area of about 0.28km^2 at an elevation of 175 masl. The powerhouse will be located 5.4 kilometers downstream from the dam on the left bank of the Tina River, and water will be diverted to the powerhouse from the reservoir through the underground tunnel. Initially, the powerhouse will have 3 turbine/generator units, each with a capacity of 5MW, allowing a maximum discharge of about 18m^3/s and a minimum discharge of 2.4m^3/s. An environmental flow of 1m^3/s will be maintained between the dam and the powerhouse tailrace, a distance of 5.7km.

Figure 0-3 shows an illustration of the proposed Project Scheme.

Figure 0-3 Project Scheme

Construction activities will last three years, and all construction activities will take place on land acquired for the Project in 2014, known as the “Core Area”, as well as along the Black Post Road. The Tina Core Land Company (TCLC), a joint venture between customary landowners and government, will hold rights to the Core Area, including the access road from the power station to the dam site. This land shall be leased to the IPP.

Table 0-1 lists the main project components and characteristics of the TRHDP.

Table 0-1 TRHDP main characteristics (Option 7c) from feasibility study

Project Components	Feasibility Study	Technical Proposal
Dam		
Type of dam	Roller Compacted Concrete (RCC)	Roller Compacted Concrete (RCC)
River Chainage	CH 7km	CH 7 km
Height	53m above the riverbed level	53m above the riverbed level
Base length at river	35m	35m
Base length at crest	200m	207m
Material needed for dam and the two cofferdams	Cement: 5.6 thousand m^3 Fly ash: 9.2 thousand m^3 Aggregate: 160 thousand m^3 Water: 30 thousand m^3 Retarding admix: 0.2-0.4 thousand litres	-
River level at dam	122masl	122masl
Minimum operating level (MOL)	170masl	170masl
Normal operating level	172masl	172masl
Full supply level (FSL)	175masl	175masl
Maximum flood level (MFL)	186.5masl	187.5masl
Spillway		
Release of floods	Up to the 1:10,000 year flood level (3,290m^3/s)	Up to the 1:10,000 year flood level (3,290m^3/s)
	The spillway will release flood water in by the by-passed river, on average, 8% of the time (when the inflow is higher than 24m^3/s)	-
Width	45m	55 m
Height (FSL)	175masl	175 masl
Reservoir		
River Chainage	CH 7km – CH 4.5km	CH 7 km – CH 4.5 km

Project Components	Feasibility Study	Technical Proposal
Number of days for filling	Between 5 and 9 days plus extra time for the minimum environmental flow to be implemented during reservoir impoundment.	-
Volume at FSL	$7Mm^3$	$7Mm^3$
Volume at MOL	$7.8M^3$ +/-	$7.8M^3$ +/-
Surface at FSL	30.52ha +/-	30.52ha +/-
Length	2.5km	2.5km
Power water intake		
Location	162.5masl	160.75 masl
Size	3m diameter	W3.5 m, H3.5 m
Scour outlet		
Location	155masl	150 masl
Head race tunnel		
Internal diameter	3.3m, suitable for flow rates up to $24m^3/s$	W3.5 m, H3.5 m
Flow rate	$24m^3/s$	19 m^3/s
Length	3.3km	3.245 km
Powerstation		
River Chainage	CH 12.7km	CH 12.7 km
Average net head of powerstation	102m	99.3 m
Turbine floor	72masl	73 masl
Turbines	3 Francis x 5MW	3 x Francis of 5 MW
Operating capacity	15MW, $18m^3/s$	15 MW, at 19 m^3/s
Energy production and taking into account a $1m^3/s$ Environmental flow	78.35MWh	-
Environmental Flow		
Riparian outlet for the environmental flow	162.5masl	170 masl
Environmental Flow (EF) in bypassed river section	$1m^3/s$	$1m^3/s$
Minimal flow downstream of the Powerstation during any overnight (off peak) filing	$3.4m^3/s$	$3.4m^3/s$
Road		
Permanent existing Black Post road unsealed	13.3km	13.4km
Permanent access road to powerhouse sealed	1.45km	1.9km

Project Components	Feasibility Study	Technical Proposal
Permanent access road to dam sealed	4.7km	5.6km
Temporary access road to intake portal unsealed	0.25km	-
Permanent road to dam base	0.66km	0.6km
Road to quarries	to be confirmed at detailed design	to be confirmed at detailed design
Transmission line		
Length	23km	23km
Type	33kV double circuit	33kV double circuit
Project cost		
Full scheme	US$133.3 Million + US$ 3.4 Millions (2015.04) Full scheme (initial 3 turbines) + Additional turbine (4th turbine) + extension of the powerhouse	US$140.2 Million (2017.04) For main EPC Cost (3 turbines)
Unit cost for the Project	US$165 to 185/MWh	-
Diesel energy unit cost (Lungga powerstation)	US$330 to 400/MWh	-
River hydrology		
Mean flow at dam	11.5m^3/s	11.5m^3/s
Tina catchment area	150km^2	150km^2
Catchment area above the dam	125km^2	125km^2

Chainage is based on distance from the confluence of the Tina River and the Mbeambea River which is (CH 0). The dam is localized at CH 7.

E 3. BASIS FOR ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

To implement the TRHDP, an Environmental and Social Impact Assessment (ESIA) is required by both the Solomon Islands Government (Schedule 2, Section 16 of the *Environment Act 1998*) and the World Bank (Performance Standard 1 - Assessment and Management of Environmental and Social Risks and Impacts). This ESIA was prepared for MMERE in accordance with SIG national requirements, and World Bank performance standards and safeguard policies.

Flora and fauna surveys were carried out, and project-affected communities were consulted extensively through the use of social surveys and mitigation workshops as part of the preparation of the ESIA. In addition, a program of ongoing consultation has been carried out by the TRHDP PO since 2011.

The ESIA examined changes to baseline environmental and social conditions that could potentially result from the construction and operation of the proposed Project. Measures were proposed to avoid, mitigate or compensate impacts. A cumulative impact assessment was also carried out, and an Environmental and Social Management Plan (ESMP) is included in the document. Under the Solomon Islands' *Environment Act*, the developer of a project must submit the project ESIA to the Ministry of Environment, Climate Change, Disaster Management and Meteorology. Consequently, the IPP will prepare the official ESIA for submission based on this ESIA, along with a Construction ESMP and various other management plans meeting the minimum requirements of the Framework ESMP. An Operation ESMP will be submitted to the Ministry prior to commencement of operations.

E 4. ANALYSIS OF ALTERNATIVES

E.4.1 Alternative Energy Sources

The ESIA includes an analysis of alternative means to meet the present and projected energy demand of Guadalcanal. The analysis compared sources on the basis of energy production; economics; reliability and limitations; and environmental and social benefits and constraints. It covered demand-side management, wave and tidal energy, diesel-fueled generation (which, as a continuation of present practice, is also the « no-action alternative »), standard and pumped-storage hydro, solar, wind, geothermal, and gas-fired thermal. The rationale for the selection of the proposed project was that hydropower is a reliable and proven source of renewable energy within the local environment as it has:

- Suitable hydrological conditions;
- Project locations with minimal social and manageable environmental impacts;
- Availability of natural resources (water);
- Relatively long economic lifetime;
- Low maintenance costs; and
- Reliable base load power supply.

E.4.2 Alternative Locations and Configurations

Previous studies had already identified the Tina River as hydrologically the most attractive river on Guadalcanal for hydropower development. Over the course of two phases of feasibillity studies, receipt of recommendations from the TRHDP-PO's Dam Safety Panel based on geotechnical conditions, and preparation of the ESIA, seven different possibiilities for the location of the dam and configurations of the project were investigated. Two of the options had multiple sub-options so that, in all, ten alternatives were examined. Possible locations ranged from a site near the headwaters in a completely undisturbed reach of the river to a downstream site among riverside settlements. Configurations included building the powerhouse at the toe of the dam and locating it at various distances downstream, entailing tunnels of various lengths.

Location 7c with a dam height of between 35 and 65 m, the preferred option, was chosen based on superior technical, financial, and economic performance, complete avoidance of physical displacement of households, and manageable environmental and social impacts.

E 5. BASELINE CONDITIONS

Information on baseline conditions covers a range of topics and was used to assist project-affected communities, stakeholders and the TRHDP PO to understand the natural and human components of the study areas, from the upstream Tina River catchment to the mouth of the Ngalimbiu River.

E.5.1 Physical Environment

The Ngalimbiu River drains in a northerly direction from some of the highest peaks (2000+ m) on the island of Guadalcanal. The river has two main tributaries, the Tina and Toni rivers. The catchment area of the Tina River is about 150 km^2 compared to 45 km^2 for the Toni River. The Tina River contains a diverse fish community and is unaffected by human development in its upper reaches.

The Tina River is a single channel meandering river. It has torrential behaviour with regular flash floods. The texture of its bed includes gravel, cobbles and boulders, and fine and coarse-grained sand. In the higher elevation headwaters of the Tina River, very large boulders are intertwined with logs. The upper Tina River is characterized by sequences of pools and rapids and sharp meanders. Major boulders, some greater than 3 m diameter, have accumulated along the channel bars. These large boulders indicate that intense floods occasionally occur within this reach.

In its middle reach, the river enters steep limestone gorges where its course is more confined and less meandering. At this location most of the river's course is made of rapids. In many areas, river banks are dominated by rock outcrops. The dam and reservoir site are located in this area.

The river reaches downstream of the dam site flows through an area having shallower shoreline slopes, lower gradient, and many meanders. The powerhouse will be located in this area. The density of human settlements also gradually increases with distance downstream to the confluence with the Toni River, where the river becomes the Ngalimbiu River. The Ngalimbiu River flows across a flat coastal plain characterized by denser human settlement, oil palm plantations, and gravel extraction.

Average daily temperatures in Guadalcanal range from 22°C to 31°C throughout the year, with a yearly average of 26.6°C in Honiara. The island has a tropical moist climate with regular rainfall. Rainfall increases with altitude and is higher on the windward coast (South shore). Annual rainfall at both Honiara, and Honiara International Airport is 1972mm, with summer months being the driest. It was estimated that annual rainfall at the dam site exceeds 2500mm per annum, and in excess of 3500mm of total annual rainfall in the headwater reaches of the Tina River.

Guadalcanal is periodically subjected to tropical cyclones that are most likely to occur between November and April and are associated with extreme rainfall events. The Tina River experiences flash floods almost immediately after heavy rainfall events occur in the upper catchment. Flow and water level can change rapidly during such events.

Soils that cover the steep slopes of the construction area, adjacent to the Tina River, are shallow and unstable. They are comprised of colluvial rock debris. However, in stable areas, soils are deep and leached. A significant number of landslides occur within the Tina River catchment, particularly on the steeper slopes. However, they remain relatively small, and are primarily associated with rockslides along bedding planes. Slope instability is an active and ongoing process within the proposed reservoir area.

The dam site is located in an area of significant seismicity. Along the South Solomon trench, seismicity is predominantly related to subduction tectonics, and large earthquakes are common. Fourteen earthquakes having a magnitude of greater than 7.5, have been recorded since 1900. A Seismic Hazard Assessment for the project was undertaken in 2014.

Alluvial deposits are the predominant riverbed material. Bed load sediment ranges in size from silts and sands in low flow areas, to large boulders in very high flow areas. It is assumed that the depth of alluvium reaches approximately 10 m within the river channel, and up to a depth of 25m in some locations. Alluvial terraces occur adjacent to the current river course and bars. Terraces vary from 1.5m to 5m above the current river level. Bed load sediments are materials likely to be deposited into the storage reservoir

Water quality in the upper Tina River upstream of inhabited areas is good as there are no anthropogenic sources (i.e., no domestic use, no gold panning, etc.) of pollution. Natural peaks in turbidity following flash flood events are considered to be the primary cause of degraded water quality. Air quality is generally excellent in the Project area and there are no air quality non-attainment areas in the vicinity.

Ambient or background noise is consistent with a largely un-mechanised society. Nighttime noise levels typically range from 30dBA to 40dBA, and 40dBA to 50dBA during daytime hours. Occasional spikes up to 75dBA to 80dBA may occur close to villages when chainsaws, petrol powered electrical generators or petrol-powered water pumps are in use.

E.5.2 Terrestrial Environment (Flora and Fauna)

A total of 161 plants species were identified during field surveys. Among them 5 species are listed as being vulnerable, and 19 are listed as being threatened. The majority of flora species listed as either threatened or vulnerable are timber species harvested for the local or export trade. The primary habitats of the study area are comprised of forested and non-forested ecosystems, which represent a mix of modified and natural habitats. The level of disturbance increases with distance downstream in the catchment. The upper Tina River catchment, upstream of the dam site, is dominated by highly valued, undisturbed lowland forests, whereas, the area downstream of the dam site near Choro, is dominated by disturbed forests. This is mainly the result of anthropogenic activities (e.g., logging, settlements, gardens, trails, etc.). Disturbed areas such as Black Post Road, and the proposed access road and transmission line corridor, are colonized by invasive plant species. The pristine montane forests found in the upper Tina River catchment will not be directly affected by the Project.

The fauna baseline study has shown that wildlife species thrive in pristine forests of the upper Tina River catchment, but also in the more anthropogenically altered areas in the middle and lower reaches of Tina River. A total of 60 wildlife species were observed by the ESIA team in the study area (which encompasses the project affected area and wider catchment), including 9 amphibian, 5 reptile, 41 bird, and 5 mammal species. This includes 1 endemic amphibian, 1 endemic reptile, and 25 endemic birds. None of the three species listed as endangered or critically endangered (possibly extinct) identified in literature studies (the White-eyed Starling, King Rat and Emperer Rat) are known to be present in the Project affected habitats. The presence of the White-eyed Starling (Aplornis brunneicapilla) was not detected in the ESIA and feasibility report baseline studies, which extended several kilometers beyond the extent of project construction and operation activities. While the species does appear to have some reliance on primary forest for nesting, it also regularly feeds in semi- and heavily-degraded areas. It is not always easy to find this species during field surveys, and it appears to have movements which are not yet understood. There is thus potential for the species to use the project area at some point.

The Emperor Rat (*Uromys imperator*) is known from only three specimens collected by Charles Woodford between 1886 and 1888, at Aola, a coastal location on northern Guadalcanal, Solomon Islands (IUCN 2016a). Anecdotal information suggests that the species survived until the 1960s. Recent surveys for native rodents have been conducted at sites between 200m and 1,500m. So far, the Emperor Rat has not been detected, increasing fears it is extinct. Later reports suggest that the species became restricted to mossy montane forest (IUCN 2016a). With respect to the TRHDP, the core area of the Project does not overlap with the mossy montane forest, which is found at higher elevations. Therefore, the Project is unlikely to have any effect on the Emperor Rat, should it still exist on Guadalcanal.The King Rat (*Uromys rex*) is listed as endangered and is endemic to the island of Guadalcanal, Solomon Islands, but is absent from large parts of the island. It has been recorded at elevations of 20 and 600 masl. It is an arboreal species that has been recorded from primary tropical moist forest, including relict patches of native forest. There are few recent records of this species. The most recent recorded captures include a single specimen in 1987 from a relict outlier of tall rainforest in the Poha Valley, approximately 35km west of the Project, and two specimens at Gold Ridge in 1989. An intensive survey of Mount Makarakomburu in 1990 failed to locate the species. Relatively recent records in and near the project area, and some apparent tolerance of the species to forest fragmentation and invasive species, suggest that the King Rat may still persist in higher quality forests of the project area. The absence of records on project surveys should not be taken as evidence of the species' absence, since it is extremely difficult to survey for rare, nocturnal, arboreal rodents.

There are no formal protected areas or proposed protected areas that could be affected by the TRHDP. Informal protection of many small, natural sites called "Tambu" is provided by the local population, which protects these areas in a traditional manner.

E.5.3 Aquatic Environment (Fish, Fisheries and Water Quality)

Current water quality in the Tina River does not appear to be a limiting factor for aquatic life, given the low level of pollution.

The householder survey along Tina River shows that fresh river fish do not feature prominently in people's diets, and that canned tuna is now the main source of fish protein. Despite local people's obvious knowledge of the fish species found in the Tina/Ngalimbiu River, from a livelihoods point of view, that the studies suggest that fishing is now only a minor activity. Fishing activities take place during "fishing trips" in the upper catchment, upstream from Choro. The main mode of fishing is by snorkel diving using a spear gun and is sometimes carried out at night. Fishing is a significant source of livelihood only at the mouth of the Ngalimbiu River, where semi-commercial fishing occurs using mosquito seine nets, gill nets, and other methods.

Regarding aquatic ecology, 59 species of fish were recorded within the Tina/Ngalimbiu River system, from the upstream catchment area to the mouth of the river.

In Solomon Islands, as with other mountainous islands of the Indo-Pacific Region, Gobioid fishes are the dominant fresh water fauna, and are mainly represented by members of the Gobiidae and Eleotridae families. Baseline fish surveys showed that the Gobioid group was represented by 34 species (25 Gobiidae, 8 Eleotridae and 1 Rhyacichthidae).

Like other tropical islands of the Indo-Pacific Region, all native species encountered in inland fresh water are migratory species with a life cycle that alternates between ocean and river. Two main migration patterns are followed: catadromous and amphidromous. Eels are catadromous fish with adults migrating to the ocean to spawn, and juveniles migrating back into freshwater systems to grow to maturity. During their upstream migrations, juvenile eels are able to climb to the upper reaches of the Tina River.

Most of the other aquatic species, such as Gobioids Mesopristes and prawns, are amphidromous. Spawning occurs in the rivers, and larvae drift passively to the ocean before migrating back as juveniles to the freshwater system where they grow into adults. The factors triggering upstream migration of juveniles are not completely understood. However, it is postulated that flooding, which causes high turbidity, and lunar cycles, play a role for triggering migration in some species. Without mitigation measures, the hydroelectric project will impact fish migration to, and production within, the upper Tina River catchment. Given current limited knowledge of the Tina River's ecology, monitoring during the project will play an important role in understanding whether planned mitigation is effective in ensuring no net loss of fish species and densities in this catchment.

The upper Tina River catchment plays an important role in fish life cycle but not a critical one since:

- fish within Solomon Islands do not show natal stream homing behavior. Rather, juveniles will colonize any rivers to which they can gain access; and
- the mouth of the Ngalimbiu River is more critical to the life cycle of most fish species than upstream areas, as it is the only entry point to all fish that live within the catchment.

Based on current knowledge, the upper Tina River is a highly valued aquatic habitat but not a “critical habitat” for fish species present in Guadalcanal.

E.5.4 Social Environment

The baseline social studies included a review and consolidation of existing information regarding the project area and its various communities, along with an extensive program of community consultations. More than forty-five (45) village communities attended the survey meetings. Attendees included tribal chiefs, village chiefs, men, women, adolescents, and children. Overall, a total of five hundred and eleven (511) people attended the meetings. Valuable data and information was collected during the course of the social field surveys, from the village communities, and also from various stakeholders, including government ministries and provincial offices.

Kinship is the most important basis for community formation and action among the people of the TRHDP area. After kinship, church membership is the next most important basis for local social organisation and action.

The counts made during the social fieldwork put the Bahomea/Tina population at roughly 1800 persons, representing approximately 362 households. Of these, 9 people live in villages in the by-passed river reach between the dam and powerhouse. This includes the villages of Choro, Koropa and Senge. A further 1098 people live in villages likely to be affected by the quantity and quality of the water in the Tina and Ngalimbiu Rivers during and/or after construction. The remaining 693 people live in villages likely to be directly affected by roadworks, the creation of new roads, and by construction traffic.

In the absence of financial capital, local people use a range of livelihood strategies, including a mix of the following:

- traditional garden cultivation and gathering of staple foods for subsistence needs, combined with occasional hunting;
- cash-earning activities to raise money to pay for imported food, shop goods, school fees, technology, community obligations, and household needs. Such activities typical include one or several of the following:
  - household-scale cash crop production, with the produce sold in the central market in Honiara (The householder survey indicated that 100% of the households grew crops of some kind for home consumption, while 70% said they grew or collected produce for sale,);
  - small-scale timber milling for local and Honiara markets;
  - local day labouring, for example, in timber milling, garden clearing, house building, and other activities;
  - running a small home-based business, such as home baking, natural materials handicrafts, a local shop-canteen selling small items, vehicle hire, and other activities;
  - full or part time employment for a government agency or large company – typically the Gold Ridge Mining Company (GRMC), GPPOL, Earthmovers Logging Company, QQQ enterprises market gardens; and
  - fishing at the mouth of the Ngalimbiu River.

These strategies mostly rely on having good access to:

- local natural capital such as land, forests, rivers, and forest products;
- household human capital, including traditional and formal skills and knowledge, and labour;
- physical capital in the form of tools, equipment and transport infrastructure; and
- social capital in the form of assistance from neighbours, relatives, and fellow church members.

Important strengths of the residents of the project area are the depth of their traditional knowledge and skills and their ability to live in a largely natural environment and acquire a livelihood from it. The Tina River is an important natural resource and feature in the lives of people of the project area. For example, it is:

- the main source of drinking and cooking water for the whole district;
- a source of irrigation water;
- a place to bathe, wash clothes, clean vegetables, and participate in recreational activities, such as swimming;
- a transport corridor;
- a source of food, including fish and crustaceans (although these are a minor part of the residents' diet), and a range of plants found in and around the river and tributary streams;

- a fence and boundary marker (e.g., in some villages pigs are kept on the opposite bank of the river);
- a source of rock, sand and gravel for use in local house building, and for villages in the West Ghaobata area to sell and collect royalty payments; and
- a car wash - in its lowest reaches.

Based on observations made in the villages of the TRHDP area, school attendance appears to be relatively low. The accessibility of health services is a significant issue for communities of the project area. This is particularly problematic in cases of accidents, complications of childbirth, and child diarrhea and fever. All of the local roads are unsealed, inadequately drained, poorly formed, badly located in some places, and lacking an adequate or durable surface.

E 6. IMPACTS AND MITIGATION MEASURES

E.6.1 Mitigation workshops

Mitigation workshops were held in February 2014 to meet with communities and present information on potential impacts of the Project, along with a first draft of possible mitigation measures. The aim of the workshops was to exchange ideas on these measures and to obtain input on people's issues and concerns, including any grievances, regarding the potential project impacts. Following these workshops, stakeholder issues and concerns were addressed in the impact assessment and mitigation sections of the ESIA. Mitigation measures were adapted to local population needs and aspirations.

Communities affected by dam construction and operation activities, landowners who have customary rights in the project-affected area, and downstream affected communities were present at the mitigation workshops. NGOs and government agencies participated in separate workshops. A total of 442 people attended the workshops.

Figure 0-4 Young people discussing the Project's impacts during the village workshops (Antioch (left) and Pachuki (right))

E.6.2 Environmental and Social Impacts and Mitigation

E.6.2.1 Impacts on Physical Environment and Mitigation

Potential physical environmental impacts may include induced seismic activity, local slope instability, soil compaction and erosion, changes in hydrology (surface water and groundwater), changes in sediment transport, temporary impacts on local air quality, and greenhouse gas (GHG) emissions. In turn, impacts on the physical environment may influence the project's viability or sustainability.

A range of mitigation measures have been proposed in the form of management plans and actions to address project construction and operation impacts on the physical environment. These are documented in the Environmental and Social Management Plan contained in Chapter 13. With the application of appropriate mitigation, monitoring and management methods, low to moderate direct and indirect impacts will accrue to the physical environment within the project area.

The Project will have a net GHG reduction potential of 49,500 tCO_2eq per year as a result of reduced use of diesel fuel for power generation. This takes into account potential emissions from the Project during construction, land clearing, and reservoir operation. The Project's net GHG reduction potential for the assumed Project life of 50 years is 2.48 million tCO_2eq.

Figure 0-5 Example of RCC Dam Construction

E.6.2.2 Impacts on Flora and Mitigation

Construction activities will necessitate clearing approximately 115.49 ha of natural vegetation in the Core Area, approximately 50 ha of which is disturbed forest and 9.5 ha of which is undisturbed forest, to create an access road and to prepare the reservoir area. Approximately 15 ha each of riparian and cliff vegetation will also be cleared. Measures to mitigate impacts include conducting a pre-construction road alignment survey to delineate environmentally sensitive areas where valued or protected species are to be avoided or, where avoidance is not possible, transplanted where feasible. Changes in road alignment may be necessary based on this survey. Good international industry practice (GIIP) will be implemented by the construction contractor that is responsible for forest clearing to minimize impacts, including maintaining canopy trees where possible. Some natural habitat will be disturbed beyond the road alignment and footprint of other project components, as a result of colonization by invasive species and fragmentation of habitats.

Project operation will necessitate vegetation control under the transmission line. Herbicides will not be used for vegetation clearance, due to the potential toxic effects on amphibians and reptiles, fish and water quality. Instead, manual vegetation control methods will be employed for the Project to maintain the right-of-way.

The presence of the access road will provide local communities in the project area with improved access to harvest forest resources in areas that are currently accessible only by logging roads, including forest resources located in areas upstream of the dam. The access road would be an agent of change in the area if access is not controlled. Land use along the access road may also change with the arrival of new settlers. For this reason, access to the Core Area will be controlled throughout operation.

Improved access could also facilitate increased presence of people in the area around the dam, which could in turn lead to colonization by invasive plant species on areas cleared by, but no longer required for, the Project. Site restoration using native plant species will be undertaken in affected areas to minimise the potential for invasive plant species to become established. A washing station will be used to clean vehicles of soil that may carry the eggs of African Snails.

As part of the financing provided for the Project, SIG will provide funding to an NGO to undertake studies and consultations to determine the feasibility of establishing a protected area in the upper catchment of the Tina River. The NGO will work closely with customary landowners as in Solomon Islands, establishment of a protected area originates with the landowners of the land. No net loss of biodiversity is to be achieved by supporting the protection of the Tina River upper catchment, protecting the remaining natural habitat within the Core Area, rehabilitating impacted habitat post construction and rehabilitating 9.54 ha of existing modified habitat within the Core Area. These measures will be detailed in the Developer's Biodiversity Management Plan and the Post-Construction Rehabilitation and Revegetation Plan.

E.6.2.3 Impacts on Fauna / Fauna Habitat and Mitigation

E.6.2.3.1 Terrestrial Fauna

The TRHDP will be located within the mid-elevation river gorge and downstream catchment areas where human settlements and commercial logging activities have previously contributed to habitat alteration. No critically endangered or endangered species have yet been found within these project-affected areas. Likewise, there do not appear to beany areas associated with key evolutionary processes or globally significant numbers of migratory or congregatory species. Whilst there are restricted range and endemic species, the habitat available within these project-affected areas represents only a small portion of the larger habitat area available to these species adjacent to, and upstream of, the proposed development. Consequently, the areas directly affected by construction and operation of TRHDP are in the vast majority are not considered critical habitat.

The undisturbed montane forest above 400masl in the upper catchment to the south, west and east of the dam site and reservoir qualify as critical habitat because of this ecosystem's limited global distribution and particularly unique assemblages of species.The TRHDP footprint represents a very small proportion of the overall Tina River catchment (<3% of land area), and only directly impacts a very small area of forest which could potentially be considered Critical Habitat. These impacts are not considered significant. To ensure that indirect impacts to Critical

Habitat found in the higher elevation area are minimised, measures will be put in place through the Tina Core Land Company who will hold the Core Land to restrict access to the upper Tina River catchment through the Core Land, in effect helping to preserve this area from future resource exploitation. This protection will be furthered by measures in the Biodviersity Management Plan to monitor forest clearing, including illegal logging (eg. logging on sloping land above 400 masl).

Forest clearing in the Core Area is the main activity that will adversely affect terrestrial fauna including less mobile species, such as amphibians and reptiles that are unable to avoid being struck by moving equipment and vehicles. Clearing will disturb fauna and fragment habitats upon which they are dependent. Just over 115 ha of vegetation cover will be permanently removed from the project area. Of that amount, 50 ha has forest cover, but only 9.5 ha can be considered primary forest. Half of the other 40 ha is disturbed secondary forest, and the other half is remnant forest, i.e., secondary forest formed by natural revegetation of cleared areas. The 50 ha represents 0.9% of the total area of non-montane forest and 0.3% of all forest in the catchment, In the context of the assemblage of terrestrial vegetation communities and the wildlife habitats they provide, this permanent loss within the Tina River catchment is not considered to be significant. Approximately 15 ha each of riparian and cliff vegetation will also be cleared. The proposed mitigation measures will help to ensure the direct impacts of vegetation clearing are confined to the 115ha. The developer will prepare a Biodiversity Management Plan (BMP) with the objective of achieving no net loss of biodiversity as a result of natural habitat conversion. The BMP will provide for an offset that will include measures to protect the remaining natural habitat in the Core Area and a program to rehabilitate modified habitat.

Some impacts identified during construction of the Project will continue to affect ecosystems during operation. These impacts are related to the access road. The access road will probably be a low-volume road, with impacts being related less to vehicle-wildlife interactions, and more to ecological modifications brought about by opening of the canopy and increased human presence. Together, these will act as agents of change in the areas adjacent to the road. Whether the access road will be beneficial to reptiles is difficult to assess. Some species, such as snakes, may benefit from openings in the forest canopy created when the road is established, while smaller species might be more vulnerable to feral cats. Grassland birds will be able to colonize areas along the access road. The access road will allow villagers to move into areas that are currently not heavily exploited, putting pressure on wildlife and other natural resources.

Impacts will also arise due to the operation of the dam, including reduction in water recharge of riparian micro-wetlands along Tina River. Conversely the changing water level of the reservoir will open up new aquatic/terrestrial contact zones providing new wetland habitats. These changes will have both positive and negative impacts on amphibians and aquatic insects.

Mitigation measures include controlling access into undeveloped areas as well as specific measures to mitigate impacts on individual species, such as no or low lighting (directed downwards) and fauna underpasses in stream culverts along the access road. Development and implementation of management and monitoring plans that apply good international industry practice (GIIP) will be employed to reduce the level of disturbance to wildlife.

E.6.2.3.2 Aquatic Fauna

Most impacts to the aquatic ecosystem of the Tina River, including fish and other aquatic organisms, are associated with the physical presence and operation of the dam and power station. Potential impacts during construction are short-term, mainly involving increases in suspended sediment concentrations and turbidity downstream as a result of land clearing and cofferdam installation. Possible spills of fuel, concrete washwater, and other chemicals could also affect water quality. Mitigation and monitoring measures including sediment traps and fuel tank bun ding are included in the ESMP to address these impacts.

Beginning with cofferdam installation and continuing throughout the life of the project, flow in the 5.7 km reach of river that is bypassed by the headrace tunnel would be drastically reduced, except in periods of heavy rainfall when water would spill over the dam. Simulation of the hydro operation indicated that floods or freshets would occur on average every 6 weeks, and their average duration would be between 4 to 6 days. Release of an environmental flow of 1 m^3/s will be required to avoid damage to the aquatic ecosystem in that reach; this has been determined to be sufficient to preserve the aquatic ecosystem and permit fish movement up and downstream. The $1m^3/s$ EF release at the base of the dam would act as an attraction flow to attract fish into the area for trapping before being hauled over the dam, as described below. It will have the further advantage of ensuring river users along the by-passed section or river (i.e., at Choro, Koropa, Sengue) continue to have access to some water, and that the aquatic ecology of the by-passed stretch of river is supported. Villages located along the bypassed section that depend on the river for drinking will be provided with alternative water supplies.

The dam and reservoir, and to some extent the associated by-passed section of the Tina River, will represent a barrier to the upstream and downstream migration of all native fish species that currently utilise the river system upstream of the dam site. Unless mitigation measures are implemented it is anticipated that most of, if not all, native fishes will disappear from the upstream Tina River catchment. In addition, fish mortality in the powerhouse turbines is a potential impact, as fish become entrained into the power intake of the reservoir and are conveyed to the turbines via the headrace tunnel and penstocks. Mortality of upstream migrating juvenile fish would also occur if they are attracted to the outflow of the powerhouse and then climb into the turbines.

The EF of $1m^3/s$ would be required to enable fish to move up the by-passed section of river to the base of the dam. This EF would be supplemented naturally by up to $1m^3/s$ of additional dry season inflow from the lateral tributaries to the by-passed section of river. Fish density and species richness are likely to be greater with a flow of $1m^3/s$ than with the current median flow of 11.1 m^3/s. The estimated fish density at an environmental flow of 1 m^3/s is approximately 50 fish per 12 m^2. This is slightly less than the average of 60.4 fish/$12m^2$ observed in the Toni River and considerably higher than the 6.7 fish/$12m^2$ observed in the Tina River. Similarly, the estimated number of species per quadrat with an environmental flow of $1m^3/s$ is 2.1 compared to the observation of 2.61 and 1.17 in the Toni and Tina rivers, respectively.

A 1 m^3/s flow will provide for fish passage and maintain pool habitat for the pool dwelling species and good riffle habitat for the riffle dwelling species that comprise the majority of fish in the river. In addition, the study suggests there will be an improvement in habitat quality resulting from a reduction in the amount of fine gravel and sand in the river channel.

A minimum of $2.4m^3/s$ will be released to the river from the powerhouse or dam during nighttime hours and those parts of the day when power is not being generated to maintain habitat for aquatic organisms downstream and dampen somewhat the fluctuations in flow between full power generation and reservoir refilling. When combined with the $1m^3/s$ EF release from the dam, this will mean a minimum dry season flow in the river immediately below the powerhouse of $3.4m^3/s$ -- more if small upstream tributaries continue to discharge during the dry season.

An extensive examination of alternative technologies to enable fish migrating upstream to pass the dam led to the conclusion that a combination of a trap-and-haul system at the dam and an EF of $1m^3/s$ from the dam, and a trap-and-haul system at the powerhouse, is considered the only potentially viable system to ensure fish can continue to populate the upper catchment area.

If necessary, this would be further augmented by netting swimming species of fish as they congregate in the mouth of the river or at the base of the dam, for transport and release above the dam. The proposed mitigation would be undertaken using an adaptive environmental management approach in accordance with the EBRD's policy for hydropower projects. This approach would evaluate the effectiveness of the system and look at other means of ensuring upstream fish passage, in the event that a trap-and-haul system is not successful.

Figure 0-6 shows a trap system with ramp leading to a holding tank and piped water supply installed at Waitaki Dam, New Zealand. Fish from the trap are to be released in or upstream of the reservoir at a location that will avoid the possibility of fish being entrained by spillway or power station flows. The ramp allows migratory fish to climb to the trap, where they remain until transferred to an upstream location.

Figure 0-6 Example of trap system

Installation of fish screens is recommended at the power intake structure to prevent entrainment of eels during their downstream migration. This should be supplemented with periodic releases over the spillway to facilitate movement of adult eels during peak migration conditions. Likewise, a fish barrier or repelling system is recommended for installation in the powerhouse tailrace to prevent mortality of upstream migrating juvenile Syciinids when they enter the turbines. Further, it is recommended that the potential to farm fish within the reservoir be considered if this could be accomplished using species of fish that are native to the Tina River, and which could thrive in a lentic environment. Monitoring of species would need to be done to verify the efficacy of such a program.

Although none of the fish species utilizing the Tina/Ngalimbiu River system will be permanently lost from Solomon Islands if these mitigation measures are not implemented, the loss of viable fish populations from the upper Tina River catchment is an unnecessary impact that can largely be avoided, given the apparent efficacy of mitigation measures that are available.

Fish populations and benthic invertebrates will be monitored upstream and downstream of the dam beginning prior to construction in order to determine actual impacts on fishes and the aquatic ecosystem in this pristine portion of the Tina River and provide a basis for adaptive management if neejded. Comparative monitoring will also take place in the Toni River. Aquatic invertebrates will also be monitored downstream, since they are good indicators of long-term impacts on water quality.

E.6.2.4 Social Impacts and Mitigation

The social survey fieldwork covered all of the settled area within the anticipated direct, indirect, infrastructure, and wider impact areas. A high level of participation by the village communities was achieved, with all levels of community members attending focus community workshops and follow up consultations, including adults, youth, women and children.

Several types of social impacts could occur, as a result of the TRHDP. These include:

- direct physical effects on nearby people and households, such as: intrusive noise and vibration, shock waves from blasting, dust and air emissions, soil and groundwater contamination, degraded water quality, and visual intrusion, all of which have the potential to affect health, wellbeing and/or use of local amenities. Physical impacts were identified as a major concern in the vicinity of the dam, tunnel and power house construction (e.g., noise and vibration). This is particularly the case for people living in the villages of Habusi, Managikiki, Namopila, Pachuki and Senge;
- loss of access to the abundant clean fresh water provided by the Tina River during construction and in the low flow river stretch;
- destruction and/or loss of: access to fishing areas on Tina River; food garden areas; hunting areas; plant and related materials; and other important resources; with negative impacts on wellbeing;
- opportunities for improved incomes through employment on project construction and operations, and in new ventures;
- increased risk of disruptions to movement and accidents, given the increase in project-related transport;
- improved road mobility between villages in the project area and between the project area and Honiara;
- threats to indigenous land, natural resources, security, and local culture from intrusion by outsiders;
- potential reduction in gravel extraction over the long term;
- safety issues related to daytime powerhouse flow releases of 24 m^3/s, and;
- opportunities for improved quality-of-life, through the provision of replacement services and facilities.

The people and communities most likely to be adversely affected by the project are those living in or utilising areas for their livelihoods, that are close to the proposed project sites.

In addition, people in most riverside communities, especially women, expressed concern about the potential for the failure of the hydropower storage dam and the devastation and loss of life that would occur in the unlikely event that this happened. Members of the indigenous communities expressed anxiety about the potential for social conflict between landowning groups and with the SIG over land and resource ownership and access rights, royalties, compensation payments, and access to development opportunities and benefits.

To most local people and communities, the Project is seen as offering the opportunity for their villages, churches, and houses to be electrified. Stakeholders believe the construction of the

Project will provide opportunities for direct and indirect employment and training in the trades, plant and machinery operation, administration, and security work. The creation of the access roads and the upgrading of the existing Black Post-Tina-Mangakiki Road are seen by local people as a considerable benefit to the community. The TRHDP will be accompanied by a community benefit share fund anitipcated to provide non-cash development benefits to the host community. This fund is outlined further in the Community Development Plan.

People in the wider project area believe that the TRHDP may be a good and, perhaps, easy, source of income. This is expected to come from access fees, meeting fees, royalties from use of the river water and construction materials, and rents for use of the land for infrastructure and project sites.

To mitigate potential impacts and enhance benefits the following measures will be implemented:

- Priority be given to job-seekers from the Bahomea and Malango landowning tribes, ahead of other national employment;
- The TRHDP developer and its construction contractors be required to implement a Workers' Code of Conduct covering, at the very least, working hours and conditions, safety, vehicle use, care for the environment, and socially and culturally acceptable behavior in the villages of the project area (see Annex 18 of the Annex report);
- All communities using the river as the main supply source for fresh water will be provided with reliable alternative clean water supply prior to start of construction;
- Road safety concerns on Black Post Road will be addressed by: installing roadside fencing adjacent to village areas, speed controls near residential areas, creation of safe crossing points, bus stop bays, and using best practices for the transport of dangerous goods;
- Use-rights for the storage reservoir and its margins, dam and powerhouse access roads, and other land acquired for the project Core Area will be defined by the Tina Core Land Company (TCLC) together with the Developer as lessee;
- The benefits-sharing program instituted by the SIG and the TRHDP PO will focus on delivering social services, education, training, and improved facilities to host communities. Cash payments and top-down delivery through individual leaders willbe avoided and both gender specific programs and gender mainstreaming will be incorporated into the fund design;
- Prior to construction, the TRHDP PO will put in place a protocol for managing cultural heritage. The protocol in the ESIA includes arrangements for avoidance or relocation of cultural or heritage assets, and for compensation where avoidance of assets is not possible or feasible;
- The TRHDP PO acknowledges the effects of project construction and operation on squatters and settlers;
- Consultations will continue with project-affected people and communities, including downstream communities, throughout the life of the Project, using culturally appropriate, inclusive and proven methods and arrangements of stakeholder engagement; and
- Impacts on gravel extraction will be monitored.

E.6.2.5 Land Acquisition and Livelihoods Restoration Plan

World Bank Environmental and Social Safeguard Policies require that where a project undertaken by a Client of the Bank involves land acquisition or restriction of access to sources of livelihood, the relevant Operational Policies (OP) must be followed. In the case of the acquisition of the project land, the relevant policies are OP 4.12 (Involuntary Resettlement) and OP 4.10 (Indigenous Peoples).

A usual consequence of these two safeguards would be the preparation of Resettlement Action Plan and an Indigenous Peoples Plan (IPP). For the TRHDP, the project area was selected to be sufficiently far upstream and sufficiently small that no residential buildings or households will need to be relocated. Therefore, to provide clarity to all stakeholders, the nomenclature for the resettlement action plan was changed to Land Acquisition and Livelihoods Restoration Plan (LALRP) to reflect that land was being acquired, and that the consequent impacts on livelihoods and livelihood assets were assessed and mitigated in accordance with the Safeguards. An IPP was not prepared in accordance with the provision of OP 4.10 that provides that a separate IPP is not required when the overwhelming majority of the project beneficiaries are indigenous peoples, and the elements of an IPP are incorporated into the project design.

A LALRP has been prepared that identifies the actions that have been and will be taken to avoid, minimise, mitigate, or compensate for the adverse livelihoods impacts of the land acquisition and restrictions on land use arising from the Project. The Plan seeks to achieve an equitable and socially and economically sustainable situation for the people whose land is being acquired. This includes ensuring those affected by the acquisition are engaged in its planning and have opportunities to participate in devising and implementing livelihood preservation and restoration. The key points of the plan are:

- Land acquisition was undertaken with the explicit, written consent of the customary landowning tribes ;
- Landowing tribes receive payment for full market value of their acquired land including the value of commercial timber ;
- Support provided to landowning tribes to establish, manage and invest in a corporation owned by their tribe (co-operative society) including accounting support. The TRHDP PO designed the framework legislation and rules for each society in close consultation with tribes to provide a culturally relevant governance structure ;
- To prevent elite capture, and provide sustainable income, through the rules of the co-operative societies, land acquisition payments are divided between future investment, customary obligations, individual payments and administrative costs. Individual payments are made directly to individual bank accounts set up by TRHDP PO for every women, man and child in each tribe. Payments for children held in trust for school fees until 18 ;
- Creation of the Tina Core Land Company (TCLC) to hold the Core Area, a joint venture with SIG, with 50% of shares provided (free) to the customary landowninng tribes to ensure an ongoing ownership of the land and role in its future use and development ;
- Targeted measures for gender equality including presence of women on tribal corporation executive committees ; and
- Survey of all assets on project affected land, including gardens and fruit trees, identification of their owners (with or without formal rights to land) and entitlement matrix for compensation and livelihood restoration (see LALRP).

E.6.3 Free Prior Informed Consent (FPIC)

The flow of information from the TRHDP PO to the affected communities appears to have been of a high standard. The TRHDP PO recruited a well-known indigenous media person to develop and document its information sharing and awareness raising activities. The TRHDP PO has made use of a variety of culturally acceptable means for communicating with local communities and stakeholders. Important communications have been, and continue to be, done face-to-face, starting with tribe and village chiefs, and senior women, and then extending out to the wider village communities. Local communications are undertaken by the project's indigenous community relations staff and Community Liaison Assistants (CLAs) and endorsed by community leaders. A wide variety of communications tools have been used to inform the communities and to receive comment and advice in return. Among these are: printed materials, including a project booklet; face-to-face briefings and discussions with groups of community leaders, individuals, community interest groups (e.g., mother's clubs, and church groups) and agency representatives; mobile phone and SMS; presentations using video, photographs, maps, and posters; and site visits. Information briefings to local communities and various groups of stakeholders at key points in the project planning process has been done in local languages and has been accompanied by the use of audio-visual aids.

Based on the records of the TRHDP PO, discussions with TRHDP PO staff and CLAs, observations, and explicit comments from participants during the 2013 ESIA village community workshops and 2014 mitigation workshops, it appears that:

- There is broad support among local communities for the Project and there is no clear direct opposition to it. A minority of clan leaders and aspirants have objected publically to the land identification and acquisition process undertaken by the Bahomea Land Identification Committee (BLIC) and to the market value valuation of acquired land by the Commissioner of Lands.
- Hydroelectric development is widely seen as the most preferred and least destructive development opportunity for the Tina/Ngalimbiu River catchment (others being gold mining and logging of primary forest);
- community concerns about the project are generally confined to the mitigation of potential impacts and the securing of benefits;
- There has been a comparatively high level of participation of community members of both genders and all ages in the TRHDP PO's activities.
- There is wide-spread understanding of the purpose of the TRHDP, and what it generally involves, although the details of particular hydropower generation options are not well understood, especially by women;
- There is a high degree of trust of the TRHDP PO and the information it has provided, and a sense that local peoples' concerns are being heard and dealt with, even though there is little trust in government, generally;
- There has been considerable discussion within the communities about the Project, including its benefits and potential impacts; and
- SIG acquired the Core Area with the prior, written, negotiated consent of the identified customary land-owning tribes (see LALRP).

TRHDP planning to date appears to comply with the requirement of FPIC and, to date, community consent has been achieved at each stage.

E.6.4 Environment Social Management Plan

The Environmental and Social Management Plan allocates responsibilties for implementing each of the identified mitigation measures. The ESMP will form the minimum standards for the

Developer’s Construction Environment Social Management Plan (CESMP) and Operations Environment Social Management Plan (OESMP). The Ministry of Environment, Climate Change and Disaster Management will review and approve the final CESMP and OESMP, with support from the Project Office.

The ESMP sets out the roles and responsibilities of implementing actors, including their capacity building requirements, together with an implementation schedule.

Monitoring measures include an independent environmental and social safeguard specialist to undertake regular monitoring and auditing to ensure compliance with ESMP measures.

E 7. CUMULATIVE IMPACTS

There are four important sources of disturbance in or near Tina/Ngalimbiu catchment that when combined with the TRHDP could result in cumulative impacts. These include:

- GPPOL’s Oil Palm production;
- Potential expansion of mining on the Gold Ridge tenement;
- Artisanal and commercial harvesting of timber; and
- Gravel extraction on the Ngalimbiu River.

As shown in Table 0-2, many of the cumulative impacts are related to land tenure issues, water quality issues, loss of biodiversity and economic growth in the area.

Table 0-2 Summary of cumulative impacts

Impacts of TRHDP	Timber Harvesting	GPPOL Oil Palm	Gold Ridge Mine	Gravel Extraction
Decrease in slope stability, leading to increased soil erosion, and decreased water quality during construction	Low risk of cumulative impacts as long as no clear cutting is allowed nearby Tina River High risk of cumulative impacts if, in the future, clear cutting is practiced nearby Tina River		If new gold mines are exploited in the SPL 194, there is a high risk of cumulative impacts in the Tina/Ngalimbiu River Catchment	Cumulative impacts along the Ngalimbiu River
Disturbance to aquatic habitats and aquatic life during construction		Aquatic habitat disturbance from drainage of the palm fields in the Ngalimbiu River Catchment		
Disturbance of water uses during construction				
Colonization by invasive species		Oil Palm has opened the way for plant and wildlife invasive species		

Impacts of TRHDP	**Timber Harvesting**	**GPPOL Oil Palm**	**Gold Ridge Mine**	**Gravel Extraction**
Habitat fragmentation	Risk of cumulative impacts if additional logging activities take place in the may increase in the upstream area thanks to improved access	Oil Palm has transformed some downstream areas into monoculture fields		
Direct habitat and biodiversity loss				
Land Related Issues	Land dispute	Land tenure alienation and land dispute	Land tenure alienation and land dispute	
Employment	Creation of unskilled employment	Creation of unskilled and skilled employment.	Creation of unskilled and skilled employment.	Creation of unskilled employment
Food security pressure		Increased pressure on food security	Increased pressure on food security	
Challenges to cultural and traditional practices		Added pressure on traditional norms and cultural practices	Added pressure on traditional norms and cultural practices	
Substance abuse and increased criminal activities	Substance abuse and alcohol related abuse among men	Substance abuse and alcohol related abuse among men	Substance abuse and alcohol related abuse among men	
Visual intrusion	Degradation of landscape quality	Degradation of landscape quality	Degradation of landscape quality	Degradation of landscape quality
Degraded water quality	Suspended solids release due to logging	Herbicides and fertilizers pollution in both water and sediment in Ngalimbiu River	Turbidity, metal and heavy metal pollution in both water and sediment in Matepono River and in the Tina/Ngalimbiu River if SPL 194 is developed	Increase of turbidity in the Ngalimbiu River

Impacts of TRHDP	Timber Harvesting	GPPOL Oil Palm	Gold Ridge Mine	Gravel Extraction
Pressures on natural resources availability	Improved livelihoods – leads to increased population and related increased pressures on land and availability of natural resources	Improved livelihoods – leads to increased population and related increased pressures on land and availability of natural resources	Improved livelihoods – leads to increased population and related increased pressures on land and availability of natural resources	
Natural hazards and dam safety	Removal of forest upstream of dam, leading to floods, landslides and debris flows that could threaten the dam			

Regarding the probability of occurrance of the cumulative impacts, it should be noted that Gold Ridge Mine has been closed since April 2014 and has been sold to a local consortium that may not have the capacity to reopen it. Resumption of mining activity is not very likely, expansion into the Toni or Tina catchments even less so. There are no known plans for oil palm cultivation to expand in the catchment, and TRHDP will not add to oil palm's most significant potential impacts – water pollution caused by agrochemicals and wastewater discharges. Gravel extraction is also unlikely to expand and may in the long term diminish as the dam traps sediment.

Many constraints limit the implementation of global actions to mitigate cumulative impacts, particularly the lack of capacity of the SIG, the mixed-land tenure system in the area, and the lack of transparency of some local industries. Since TRHDP will be located in the upstream area of the Tina River system, mitigation measures designed for the Project will also address some of the cumulative impact issues. A second phase of cumulative impact assessment will be conducted by the SIG, after which the SIG will prepare a Cumulative Impacts Management Strategy.

E 8. EFFECTS OF THE ENVIRONMENT ON THE PROJECT

The Project will be designed and operated to withstand the various environmental calamities that could affect the project, including seismic events, landslides and debris flows, and severe weather-related events, to ensure the structural integrity of all its components, especially the dam.

Plans relating to dam safety and response to operations related emergency events will be prepared by the Developer.A Construction and Quality Assuranace Plan,and an Operations and Maintenance Plan, will be submitted for review and approval prior to Bank Appraisal. An Instrumentation and Emergency Response Plan will be developed during the project design phase, and will be submitted for review and approval prior to project commissioning.

SIG has conducted a Climate Risk Assessment that reached the following conclusions.

- Precipitation changes projected by climate models are distributed fairly uniformly over the year; by 2050 projected changes range between a decrease of 15% and an increase of 15%, on average no significant change.
- Temperatures are projected to increase uniformly over the year. By 2050 the increase will be between 0.5 ^{0}C and 2 ^{0}C,
- Based on an analysis of multiple climate projections, it is concluded that by 2050 the average basin runoff can vary between 80% (-20%) and 120% (+20%) of the present runoff; by 2090 the range would likely be between 70% and 130% of the present runoff.
- Generated annual energy could vary most likely between -20% and +10% of the energy generated under the baseline hydrological conditions. This range of annual energy generation is reflected in the economic analysis.
- On a global scale, tropical cyclones are likely to show an increase in rainfall rates of the order of 20% within 100 km of the cyclone centre, which could cause for the Tina River basin an increase in extreme flows of 25% to 30%. The operation manual, dam break analysis and emergency preparation plans should take the possibility of extremely high flash flood flows during tropical cyclone conditions into account.

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1. INTRODUCTION

1.1 BACKGROUND

The Tina River Hydropower Development Project (TRHDP or "Project") is expected to be the first major hydroelectric project in Solomon Islands. Tina River is located 30 km South East of Honiara at the upstream end of the Ngalimbiu River Basin in Central Guadalcanal. Hydropower from Tina River will provide a total annual energy output of 78.35GWh when fully absorbed. The Tina River catchment and proposed transmission line route are situated in the Malango Ward, within Central Guadalcanal District. The Project is managed by a Project Office under the Ministry of Mines, Energy and Rural Electrification (MMERE).

Electricity will be generated by an Independent Power Producer (IPP), Tina Hydropower Limited. The Tina Hydropower Limited (THL) is a Project Company (PC) and duly organised under the law of the Solomon Islands. THL will sell electricity to the Solomon Islands Electricity Authority (SIEA), the state-owned power utility. THL will Build, Own, Operate and Transfer (BOOT) the scheme. It will be the owner of the works during the concession. At the end of the lease, THL will transfer the infrastructure to the Solomon Islands Government or SIEA.

The Project requires an EIS in accordance with the Solomon Island Government (SIG) Environment Act (1998) and World Bank Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts.

The dam will be located in an uninhabited area approximately 3.5km upstream of the last village situated on the Tina River. The dam will be a Roller Compacted Concrete (RCC) dam. A 15MW (installed capacity) generating station will be located 4.5km downstream of the dam, with a headrace tunnel conveying water from the dam to the powerhouse.

The following photographs (Figures 1-1 through 1-4) show the Scheme Layout, reservoir, dam and powerhouse site, which are all located in the valley.

Figure 1-1 Scheme Layout

Source : Entura 2014

Source: Technical Report 2017

Figure 1-2 Approximate location of the reservoir (Tina Valley) looking upstream

Source: BRLi, 2013

Figure 1-3 Approximate location of the dam (Tina Valley) looking upstream

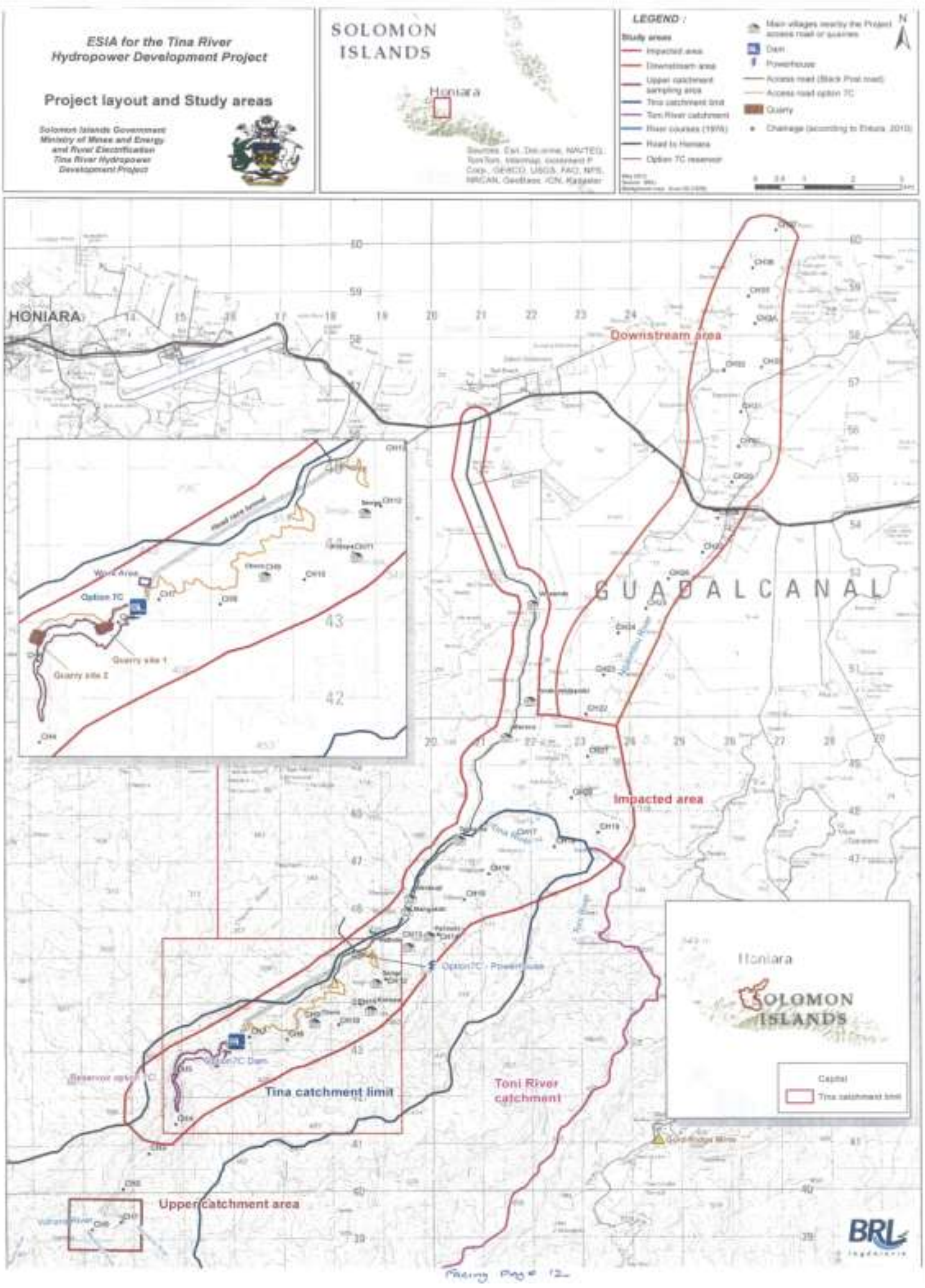
Source: BRLi, 2013

Figure 1-4 Approximate location of the left bank powerhouse looking downstream

Source: BRLi, 2013

The following map Figure 1-5 Map of scheme elements and study locations shows the location of the dam, powerhouse and access road within the Central Guadalcanal region. It also indicates the extent of the Tina catchment, the extent of the project affected area, the downstream area and the location of ESIA study sites both within and outside the affected area.

Figure 1-5 Map of scheme elements and study locations



1.2 PROJECT PROPONENT

The proponent responsible for developing the Project, is the Tina Hydropower Limited (THL), THL is a Project Company (PC) and duly organised under the law of the Solomon Islands. THL will sell electricity to the Solomon Islands Electricity Authority (SIEA), the state-owned power utility.

The following contact information applies to the Project:

Entity Responsible for Project Development:	TRHDP Project Office
Address:	Suite 304, Hyundai Mall Mendana Avenue Honiara, Solomon Islands
Principal Contacts for the ESIA:	Fred Conning, Deputy Project Manager Fred.conning@tina-hydro.com
Project Website:	www.tina-hydro.com

Entity of Project Developer:	Tina Hydropower Limited
Address:	PO Box 419, 2nd Floor, Alvaro2.0 Building, Mendana Avenue, Honiara, Solomon Islands, Tel) +677 25115
Principal Contacts for the ESIA:	Mr. Jaeil Ryoo, CEO jiryoo6901@gmail.com Joshua Kera, Environment and Social Assistant j.johnkera@gmail.com

1.3 PARTIES RESPONSIBLE FOR PREPARING THE ESIA

Several consultants have been involved in preparing the ESIA as follows.

1.3.1 Initial ESIA Preparation

Initial ESIA studies were undertaken, and initial ESIA documents prepared, by BRLi, an engineering company based out of Nimes, France. BRLi was assisted locally by Solomon Environment Services (SES). The initial ESIA report and supporting annexes were submitted in November 2013. The following consultants were responsible for preparing the initial ESIA:

Gilles Pahin – Team leader;

Gerard Fitzgerald – Sociologist;

Lawrence Foanaota – Anthropologist;

Loïc Trébaol – Aquatic ecology and hydrobiology specialist;

Edgar Pollard – Local fauna specialist;

Robson S. Hevalao – Local aquatic ecologist;

Myknee Sirikolo – Local botanist; and

Eric Deneut - Assistant team leader and biologist.

1.3.2 Supplementary Specialty Studies

Based on reviews conducted by environmental and social safeguard policy specialists from the World Bank, and by the environmental and social experts on the TRHDP Panel of Experts, a number of areas were identified that required additional specialist input. The following is a list of the specialist consultants and the studies for which they were responsible:

- Ian Jowett – Supplementary fish and aquatic habitat assessment study for determining minimum environmental flow requirements.
- Gerard Fitzgerald – inputs into TRHDP's Land Acquisition and Livelihood Restoration Plan for determining compensation and restoration actions related to the land acquired for the project and livelihood assets impacted by this acquisition.

Both the fish and aquatic habitat studies and the Land Acquisition and Livelihood Restoration Plan have been completed.

1.3.3 ESIA Quality Review and Final Edit

The initial ESIA prepared by BLRi was amended to reflect the comments received from various reviewers, include the supplementary information developed by the subject specialists, and to ensure that the ESIA conformed to World Bank Operational Directives, and World Bank Performance Standards.

The current document reflects the compilation of this additional information, along with a quality review and final edit. This activity was performed by:

- TRHDP, Project Office, MMERE
- R. Scott Hanna, Senior ESIA Specialist, Roberschan Environmental.

1.4 Purpose Of The Project

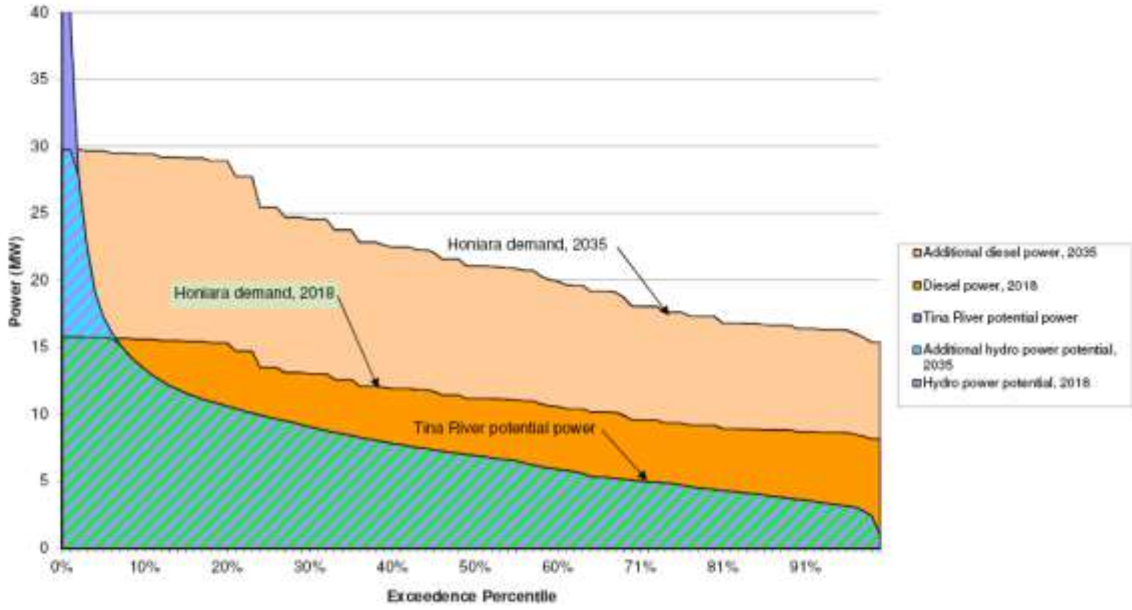
Currently, the Lungga diesel power plant is the main provider of electricity in Guadalcanal. The capital city and key population centre, Honiara, suffers from power shortages, especially during peak demand periods. With increasing population growth and industrialization, Solomon Islands will require an increased supply of reliable power. TRHDP aims to reduce the peak demand requirement from the current diesel system and reduce the need for a backup diesel generating plant. Together, this will defer the need for further investment in Diesel power generation for more than a decade.

The price of electricity in Guadalcanal is amongst the highest in the Pacific region and is directly the result of having to rely on the importation of costly diesel fuel to generate electricity. Guadalcanal has abundant hydropower potential that could help the country reduce its dependency on oil, reduce uncertainties inherent with world oil markets, and reduce the cost of electricity production.

Electricity generated from diesel leads to environmental impacts such as: greenhouse gas emissions, air pollution and a risk of oil spills during extraction and sea transport to Honiara. Hydropower, as the preferred alternative, has the advantage of allowing Solomon Islands to rely on its own renewable resource to generate electricity rather than importing non-renewable carbon-based resources to generate electricity.

Figures 1-6 and 1-7 show the power demands of Honiara and the power potential of the TRHDP during dry and wet seasons. These two figures illustrate that in both dry and wet seasons, TRHDP will make a significant contribution to power supply in Honiara. Wet year inflows will see the station able to operate at full capacity for most of the time – with unused water being spilled around 40% of the time. In the driest three years on record (i.e. an event with about 10% probability) the station will only rarely be able to utilise all three 5 MW machines.

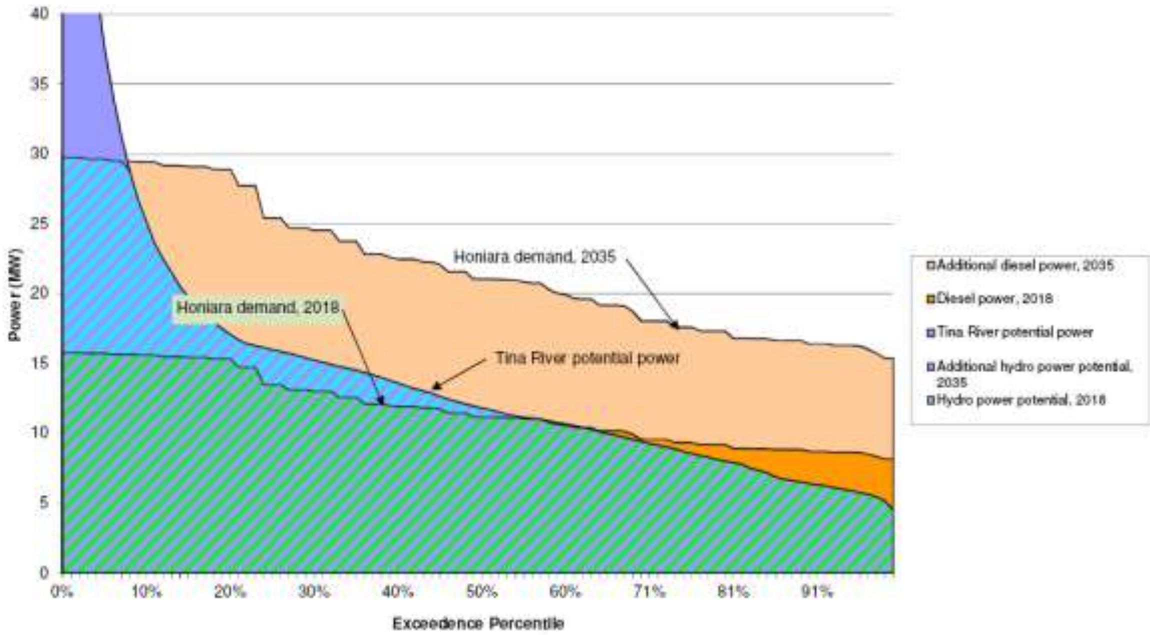
Figure 1-6 Power demand and TRHDP power potential during dry seasons



Source: Entura, 2014

In those dry years it is expected that the hydro power station will be used to reduce the need for diesel capacity in the high demand times of the week – between 8 a.m. and 6 p.m. If diesel produced a steady 8MW for the whole of this period of the day, the hydro could produce all of demand which exceeded that base load, in any circumstances modelled. The hydro could also meet all demand above a 6 MW baseload, for all but 4 weeks in the driest year.

Figure 1-7 Power demand and potential power from TRHDP during wet seasons



Source: Entura, 2014

In 2014, the unit cost of diesel energy production in Guadalcanal coming from the Lungga power plant was US$ 330/MWh. The unit cost of diesel energy production is expected to rise to US$380 to US$ 422/MWh within 20 years. The unit cost of hydro from the TRHDP is estimated to be US$ 185/MWh and could decrease to US$ 165/MWh, which is significantly lower than the unit cost of diesel. As the diesel price increases in future years, the differential will also increase significantly.

1.5 OBJECTIVES OF THE ESIA STUDY

The objectives of the ESIA are to:

- Comply with Solomon Islands legal requirements for the formulation of an Environment Impact Statement under the *Environment Act 1998* since the TRHDP is a prescribed development under schedule 2 (section 16)
- Comply with World Bank/IFC requirements and Performance Standards, including IFC PS 1: Assessment and Management of Environmental and Social Risks and Impacts
- Determine the full range of environmental and broad social impacts of the project within the existing environmental, socio-economic and cultural context of the project area to:
- inform the detailed design and implementation stages regarding how to avoid or manage the assessed impacts; and
- achieve development consent through the timely approval of the outcome of the ESIA.
- Provide an analysis of the project area communities and an assessment of the full range of social impacts and benefits of the project within the project area, with particular focus on social impacts associated with IFC PS 7: Indigenous Peoples.
- Assess and discuss impact on natural habitat, gender aspects and cultural heritage as required by the World Bank safeguard policies and IFC Performance Standards.

Analysis of the impacts of Solomon Islands Government's land acquisition on the owners and users of the project land, and compliance with WB OP 4.12 (involuntary resettlement), are addressed separately in the Land Acquisition and Livelihood Restoration Plan.

1.6 ESIA STUDY METHODOLOGY

Preparation of the ESIA has involved several stages, including:

- Identifying the impacted area and study area.
- Identifying and reporting on baseline environmental and social conditions.
- Analysing impacts, and identifying measures to avoid or mitigate impacts, including the use of Mitigation Workshops.
- Reporting on impacts and mitigation.

1.6.1 Area of Influence and Study Area

1.6.1.1 Area of Influence

The Project's Area of Influence (AOI) is defined as the geographical area affected by the Project's construction and operation activities. This area excludes the wider area which may be affected by cumulative impacts. The AOI includes the Direct Impact Area, Upstream Area, Downstream Area and Infrastructure Area.

- **Direct Impact Area (DIA):** The DIA is the direct physical footprint of the project being the land on which all project related infrastructure will be located and all construction will be undertaken. The DIA consists of:
  - **Core Area** – 397 Ha site acquired by SIG in 2014 encompassing all land required for the construction and operation of the dam, reservoir, powerstation, and the portion of the access road from Mangakiki Village to the powerhouse and dam site (also known as Road Lot 2). The Tina Core Land Company (TCLC) will own the Core Area, including the access road. The company is a joint venture between customary landowners and SIG. The map in Figure 1-8 shows the location of the Core Area in red.

    NB: The Core Area acquisition in 2014 also included the customary land component of the Infrastructure Corridor, however this area of land acquired for the road and transmission line is defined as part of the Infrastructure Corridor for the purposes of assessing impacts in this ESIA.
  - **Infrastructure Corridor –** Encompassing a 50metre corridor from Mangakiki Village to the Black Post Turnoff to accommodate the access road and dual 66kV transmission lines, and the transmission line route from Black Post Road to the existing Lunnga Power Station.

- **Upstream Area:** The Upstream Area is the portion of the Tina River Catchment located upstream of the dam and reservoir. Impacts considered in this area include impacts on migratory fish and other aquatic species and impacts of potential reduced access to the hunting and fishing grounds of local communities.

- **Downstream Area** : The Downstream Area is the area downstream of the dam to tide-water, (i.e., dam to the confluence with the Toni River, where the Tina and Toni Rivers then become the Ngalimbiu River, and beyond to where the river enters Iron Bottom Sound). The downstream area may be affected by changes in the Tina River flow pattern and water quality. Over the long term, erosion and deposition of materials on the riverbanks may modify the way the river is used for such purposes as household water supply, and exploitation of gravel deposits.

- **Infrastructure Area** : Infrastructure Area is the geographical area within which people and communities are likely to be affected by the Infrastructure Corridor (modifications to, and use of, the access roads and transmission line corridor). It extends beyond the DIA to include villages or communites that may be impacted by noise, dust, traffic or electricity safety concerns.

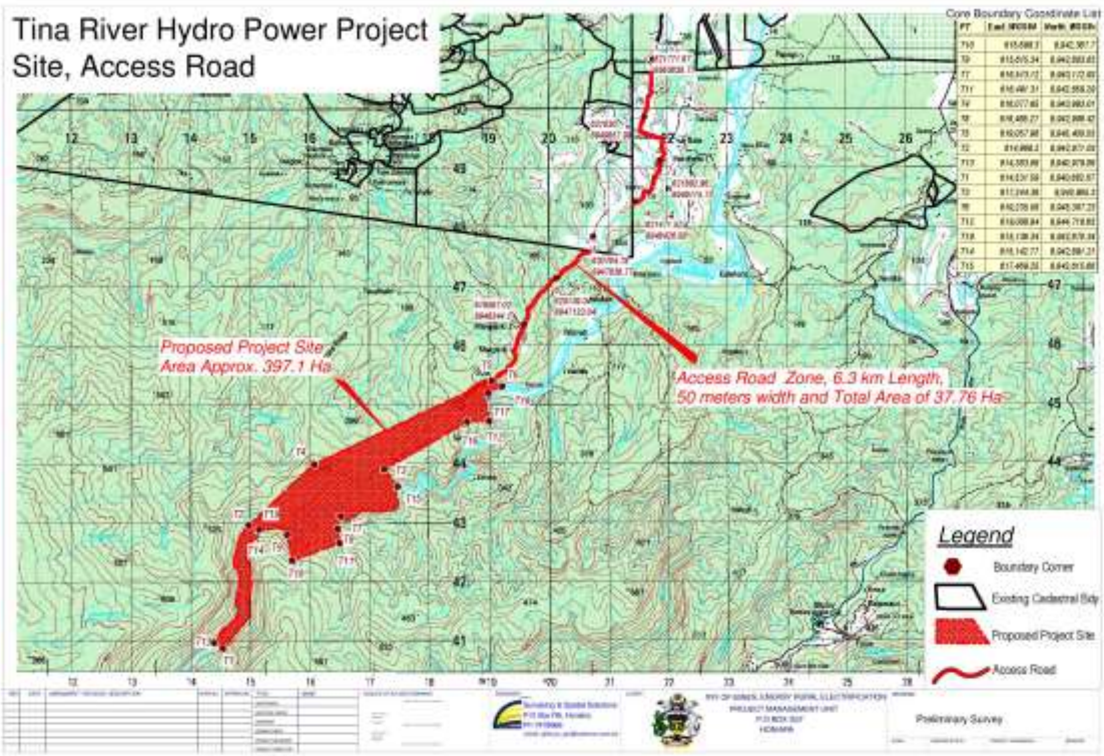
1.6.1.2 Study Area

The study area was selected on the basis of being either part of the Project's Area of Influence or indicative of the wider environmental setting. The study area extends beyond the Project's Area of Influence and is defined as the area in which all potential positive and negative, direct and indirect impacts, including cumulative impacts, may accrue as a result of the project. This includes the entire Tina River and Toni River catchments. It also includes communities that will not be directly affected by the TRHDP, including Behaha and Malango communities, both of which have land interests in the Core Area but are not affected by physical siting of project infrastructure.

For discussion purposes, the Study Area has been broken down into various subunits as follows. The approximate boundary of the Study Area and the subunits described below are shown in the map in Figure 1-8:

- **Area of Influence -** defined above.
- **Toni River Catchment Area** - this area covers the entire Toni River catchment from headwaters to confluence with the Tina River, covering approximately 45km^2. It was studied as part of the cumulative impact **assessment**, since the Toni River meets the Tina River to form the Ngalimbiu River. Development of mining activities may occur in the Toni River catchment area, since part of the catchment is included in the Gold Ridge Special Prospecting License (SPL 194).
- **Terrestrial Upper Catchment** – The area of terrestrial habitat in the Tina River Catchment above the dam and reservoir.
- **Wider Impact Area (WIA)** – The term used in the Social Impact Assessment (see Section 8.1.2.5) to describe the people and communities in Malango who have ownership rights to land and resources in the Core Area, but who do not reside within the Area of Influence.

Figure 1-8 Core Area and portion of road infrastructure corridor



Source: TRHDP PO, 2014

1.6.2 Identification of Baseline Conditions

The first stage of the ESIA process involved collecting and assembling information on baseline conditions from the study area and preparing a report that described the current state of the environmental and social components. The baseline included a description of the physical environment, aquatic ecosystem (e.g., fish and aquatic habitat), terrestrial ecosystem (e.g., fauna and flora), and the social environment (e.g., socio-community and socio-cultural aspects and villagers' sources of livelihood). The information was gathered from both extensive on-site surveys and review of secondary sources.

The objectives of collecting and assembling baseline information include:

- identifying baseline human and natural environment conditions and the sensitive areas to inform stakeholders and project affected communities;
- Establish the pre- project environmental conditions of the project area so that it can be compared to post project conditions.
- enabling TRHDP to understand the area of influence and its sensitive sites and how these may be affected by project components;
- informing stakeholders and Project affected communities about the ESIA process;
- preparing for the Mitigation Workshops; and
- assessing current policies as a measure of compliance with National, Provincial and IFC/World Bank policies.
- Baseline environmental and socio-economic / socio-community information, including information on sensitive areas, was documented in a baseline report.

1.6.2.1 Literature Review

In preparing the ESIA information was obtained from a number of secondary data sources through a literature review process. The following types of data sources were accessed:

- TRHDP Pre-feasibilty and Feasibility study reports;
- Other TRHDP project documents and TRHDP website;
- Solomon Island Government publications, including data obtained from various ministries;
- Publications of various South Pacific organisations;
- Scientific journal publications;
- ESIA documents published for other projects in the Solomon Islands;
- World Bank and IFC publications;
- Maps and satellite imagery (e.g., Google);
- Local newspaper articles;
- Information available from various websites (e.g., annual reports for mining companies).

1.6.2.2 Field Studies and Surveys

Secondary data obtained from the literature review was updated and supplemented by primary data collected through field studies and surveys. These included:

Environmental

- Field visits and sampling took place from 05 to 17 August 2013.

Social

- Field surveys were carried out from 29 August to 25 September 2013.

Combined Environmental and Social

- Mitigation workshops - seven workshops with local stakeholders during February 2014 (see Section 1.6.3.1)

1.6.3 Identification of Impacts and Mitigation Measures

The baseline report was reviewed by the Panel of Experts that provided comments that were addressed by carrying out additional analysis during the impact identification stage, and subsequent to this, when the initial ESIA was reviewed.

The following sections summarise the steps followed to identify potential impacts and select mitigation measures:

1.6.3.1 Impact Assessment Methodology

The following steps were used to identify and analyse environmental and social impacts that could potentially accrue as a result of project actions or activities associated with project design and construction, operations and maintenance, and decommissioning and restoration:

- **Define Areas of influence (AOIs)** – identify the area within which a project action or activity could potentially affect a given environmental or social resource or attribute. AOIs differ between attributes.

- **Identify Impact Sources** - identify the project actions or activities (impact sources) likely to affect environmental or social attributes within the AOIs. An impact identification matrix was used for this purpose.
- **Assess Impacts** – assess each impact according to a set of impact criteria, including: duration (temporary vs permanent); reversibility (reversible vs irreversible); extent (site specific vs local vs regional); magnitude or intensity (minor, moderate, major), and probability of occurrence (low, moderate, high).
- **Assess Impact Significance** - assess significance of each identified impact. Impacts can be both positive and negative. Negative or adverse impacts are rated using the criteria of duration, extent, magnitude/intensity (major, moderate or minor); and probability of occurrence.
- **Application of identified mitigation measures** – identify measures to avoid or reduce negative or adverse impacts.
- **Identify Residual Impacts** identify residual effects of the impact after mitigation (significant or not significant).

An impact identification and mitigation matrix was produced. This was used to lead discussions in a series of mitigation workshops. The matrix identified the main impacts and mitigation measures of the TRHDP. The matrix was simplified and used during mitigation workshops to engage local populations and stakeholders and stimulate discussions.

Seven mitigation workshops were carried out between from 04 to 08 February 2014. The objectives of these workshops included:

- Presenting potential impacts of the Project;
- Discussing possible mitigation and compensation measures with stakeholders and Project Affected People; and
- Obtain input regarding grievances and answer questions.

Table 1-1 identifies mitigation workshop dates, venues, participant groups and number of participants. Additional details on the workshops are provided in Annex 13 of the Annex Report (list of participants) and Annex 12 (minutes of the meetings and lists of grievances and questions).

Table 1-1 Mitigation workshops

Date	**Venue**	**Target communities or stakeholders**	**Number of participants**
04 Feb 2014	Heritage park	Ministries and Task force	30 persons
05 Feb 2014	Heritage park	NGOs	14 persons
05 Feb 2014	Tina Village	Communities affected by dam operation	114 persons (including people from surrounding communities such as Antioch and Marava)
06 Feb 2014	Ado	Landowners who have customary rights in the impacted area but that are physically outside of it	60 persons

Date	Venue	Target communities or stakeholders	Number of participants
06 Feb 2014	Mataruka	Landowners who have customary rights in the impacted area but that are physically outside of it	120 persons
08 Feb 2014	GPPOL community building	Downstream affected communities	74 persons
08 Feb 2014	Rate school	Communities affected by dam operation and construction activities	30 persons

1.6.3.2 Environmental Impact Analysis

Impacts on the following valued physical and natural environmental attributes / components were assessed:

- Physical assets
- Small-scale logging, forest and timber milling
- Gravel extraction
- Water supplies, availability and quality
- Livelihoods and key resources
- Natural capital
- Cultural heritage
- Terrestrial flora
- Terrestrial fauna and terrestrial fauna habitats
- Aquatic ecosystems

Impacts accruing as a result of the following were also assessed:

Changes of flow downstream of the dam

1.6.3.3 Social Impact Analysis

Impacts on the following valued social attributes / components were assessed:

- Health, safety and well-being
- Women and vulnerable groups
- Social relations
- Social organisation
- Local customs and way of life
- Employment
- Education and skills
- Ecotourism
- Livelihood strategies
- River and water resource use
- Local financial capital and economic development, royalties, resource rents

Impacts accruing as a result of the following were also assessed:

- Project construction workforce
- Uninvited visitors, job-seekers and settlers

1.6.4 Impact and Mitigation Reporting

The final step in preparing the initial ESIA involved analyzing and describing impacts and issues raised by communities, and proposing measures to avoid, mitigate and compensate for adverse impacts. Impacts are changes that will accrue to both environmental and social attributes as a result of a project's actions or activities. In addition, environmental and social management and monitoring are proposed for construction and operations phases of the Project. The ESIA, as required by the World Bank and IFC, also analyses cumulative impacts (see Chapter 10).

1.6.5 Supplementary Studies and Finalising ESIA

In response to comments received from the World Bank's environmental and social safeguard policy specialists, and from the TRHDP Panel of Experts, two additional technical studies have been undertaken to address outstanding issues and questions. Key pieces of information from the supplementary studies have been incorporated into this ESIA document, and the studies have been appended as annexes. The impact analysis has also been amended based on new relevant information obtained from the supplementary reports, and mitigation measures adjusted appropriately.

The supplementary reports undertaken since the initial draft ESIA was completed for review, and which have now been incorporated into this current document, include:

1. "Report on Engineering Geological Assessment for Proposed 7C Dam Site", prepared by by GeoRisk Solution (2014). This study highlights the need for further investigations to answer questions regarding uncertainty associated with geological conditions. The following recommendations for further work were identified by Entura (2014):
    - Storage area: the presence of Karstic limestone in the future storage area needs further study to ensure water tightness and dissolution rate following impoundment of the reservoir. Karstic limestone represents a potential leakage pathway. Additional risks to the reservoir are posed by landslides.
    - Dam site 7C: additional mapping and drillholes are required to characterize the ground conditions upstream and downstream of the dam.
    - Quarry sites: additional mapping and drilling is recommended to better define the suitability of the identified quarry sites. No information is provided for quarry site access roads.
    - Headrace tunnel: a drilling program is required to characterize the rock mass conditions in the tunnel alignment.
    - Powerstation: slope stability and foundation conditions are a concern and field mapping in the vicinity of the proposed powerhouse is required.
    - Access road alignment will require field mapping.
2. "Tina River Hydropower Development – assessment of effects on aquatic ecology and possible mitigation measures", prepared by Ian Jowett of Jowett Consulting Limited (March 2016). This study assesses the effects on the aquatic environment of the proposed project, including:

- potential effects of environmental flow and fish passage requirements;
- assessment of minimum environmental flow requirements;
- hydro peaking;
- morphological changes resulting from reduced sediment load; and
- possible mitigation measures.

1.7 STAKEHOLDER ENGAGEMENT AND ESIA DISCLOSURE

The TRHDP PO has been engaged in communication with local communities since 2011 and is involved in an on-going process of community outreach activities, including:

- Development of a stakeholder engagement plan,
- Informative meetings prior to project experts visiting the site (e.g., prior to drilling activities, ESIA surveys, etc.),
- Establishment of Community Liaison Assistant (CLAs) and capacity building to help the PO communicate and identify grievances from the community, as part of the Stakeholder Engagement Plan,
- Community awareness meetings, which inform people about mitigation and entitlements provided by the project (in line with World Bank and ADB policies on resettlement and indigenous peoples),
- Meeting with landowners, community leaders, women, youth, elders, etc.,
- Mitigation workshops.

Since 2011, the TRHDP PO has organized more than 250 outreach activities with communities, summarised in Annex 14.

Key ESIA findings were shared with communities at 15 mitigation workshops over 4 weeks across Ghaobata, Malango and Bahomea, attended by 512 participants, 45% of whom were women. The minutes of these meetings are provided in Annex 12.

In response to the outcomes of the workshops and stakeholder feedback, the ESIA was further revised and disclosed in 2016. Appendix N provides a table of community feedback received during the 2014 ESIA consultations and how that feedback has been incorporated into the revisions of the ESIA and project design.

Following disclosure of the revised ESIA in 2016, TRHDP PO conducted additional ESIA consultations with target communities and key stakeholders in October/November 2016. Table 1-2 identifies consultation workshop dates, venues, and participant groups and Table 1-3 provides a summary of the community feedback and its incorporation in ESIA revision.

Table 1-2 Stakeholder Consultations for Revised ESIA

Date	**Venue**	**Target communities or stakeholders**
20 October 2016	Hyundai Mall, Honiara	Ministry of Environment and NGOs
31 October 2016	Rate Village, Bahomea	Downstream and infrastructure corridor affected communities affected by dam operation and construction activities

Date	Venue	Target communities or stakeholders
1 November 2016	GPPOL community building, Ghaobata	Lower Downstream affected communities

Table 1-3 Resolution of Community Concerns - ESIA Consultations Oct 2016

Community	Consultation Feedback	Project Outcome
Ngalimbiu Communities	Concerns of reduction in gravel available for commercial extraction	Gravel monitoring by a river geomorphologist provided in the ESMP in section 13.2.2. Drill holes demonstrate areas of deep gravel depth, suggesting sufficient gravel for a significant number of years.
	Dam safety concerns for downstream villages. Dam will 'answer to nature's call'	Dam design complies with dam safety panel requirements. Dam safety panel visited communities in 2012. ESMP section 13.2.2 requires a village level consultation program on modern day dam engineering, construction and operation complemented by community briefings from the World Bank's dam safety panel.
	Concern that environment and safety measures discussed will not be implemented or overseen.	Environment and safety measures to be incorporated into all project agreements. New contractual arrangements section 13.7.3 added to ESMP. Project Finance to include funding for TRHDP-PO and MMERE to provide oversight of THL and EPC contractor E&S implementation.
Bahomea and Infrastructure Corridor Communities	Concerns of dam safety and question regarding possibility of relocation	Dam design complies with dam safety panel requirements. Dam safety advisory panel (DSAP) visited communities in 2012. ESMP section 13.2.2 requires a village level consultation program on modern day dam engineering, construction and operation complemented by community briefings from the World Bank's dam safety panel. Relocation not advised by DSAP. WB safeguards do not support unnecessary relocation.

Community	Consultation Feedback	Project Outcome
	Could the dam be used to provide a water supply for communities and Honiara	Not a component of the current hydropower project.
	Village water supplies to be built before construction starts	Section 13.2.2.6 revised to clarify that all downstream communities whose use is affected by the Project will receive alternative water supplies before construction commences.
	Employment to prioritise host communities. Concerns of influx of people and workers from other islands.	Project related employment to prioritise host communities, ESMP section 13.2.2.2. Requirement incorporated into Implementation Agreement between SIG and THL.
	Will downstream fish migration be impacted by the dam once upstream migration measures are implemented	Downstream fish migration predicted to follow freshes and small floods and make use of spillway.
	Electrification for villages	Electrification for priority infrastructure a component of the JSDF Community Benefit Share Pilot, at section 13.5.1.1.
	Important that dust reduction and malaria prevention plans are properly implemented	Air Quality Management and Dust Control Plan and Community Health and Disease Vector Management Plan to be provided by the Developer. Further information on these plans, and details of timeframes and approvals inserted in section 13.4.

Community	Consultation Feedback	Project Outcome
	Will there be improvements to education and clinics? Education is priority.	Funding for education and clinics are expected to be key priorities for the Community Benefit Share Fund. Fund priorities to be determined with reference to community consultations as part of fund design and ongoing operations. Discussion of the Benefit Share Fund updated in section 13.5.1.

The TRHDP PO continues to conduct ongoing consutlations with communities. In addition, the Ministry of Environment, Climate Change, Disaster Management and Meteorology will undertake further stakeholder consultations in 2017 in accordance with timeframes under the *Environment Act.*

1.8 STRUCTURE OF THE ESIA REPORT

Following the Executive Summary, the ESIA report is divided into the following parts and sections. Additional supporting information is provided in Appendices at the back of this ESIA document, as well as Annexes contained within a separate stand-alone Annex Report.

Part A – Introduction, Project Selection, Rationale and Regulatory Framework

Section 1: Introduction - This chapter provides a general background to the Tina River Hydropower Development Project (TRHDP or the "Project"), its project proponent and purpose. This chapter also briefly describes the objectives and methodology of the ESIA study.

Section 2: Project Description - This chapter describes in detail the project context, access, components, actions and activities of the Project, and its associated project support facilities. It also broadly describes the activities in the project area, the project requirements and the expected implementation schedule.

Section 3: Institutional and Legal Framework - This chapter summarizes the applicable legislative and regulatory context in the Solomon Islands, and notes the World Bank Group's and IFC's requirements including the World Bank's Environmental and Social Safeguards Policies and IFC Performance Standards.

Section 4: Analysis of Alternatives - This section describes the analysis of project alternatives, the reasoning for selecting the preferred option (Option 7c) over other location options on the Tina River, over the "No Project" option, and over other power generation alternatives in the Solomon Islands.

Part B – Baseline Conditions

Section 5: Physical Environmental Baseline - This section describes existing baseline conditions for the physical environment within the project area of influence.

Section 6: Biological Environmental Baseline – Terrestrial - This section describes existing baseline conditions for the terrestrial biological environment (flora and fauna) within the project area of influence.

Section 7: Biological Environmental Baseline – Aquatic - This section describes existing baseline conditions for the aquatic biological environment (flora and fauna) within the project area of influence.

Section 8: Socio-economic / Socio-community Baseline - This section describes existing baseline conditions for the social environment within the project area of influence.

Part C – Impact Assessment and Mitigation

Section 9: Assessment of Impacts on the Physical Environment - This section describes potential environmental impacts that are anticipated to accrue as a result of construction and operation of the TRHDP. It identifies and discusses impacts to the physical environment, and briefly outlines the measures proposed to avoid, minimize, and mitigate potential impacts, following good international industry practice (GIIP) for the hydropower sector.

Section 10: Assessment of Impacts on the Terrestrial Biological Environment - This section describes potential environmental impacts that are anticipated to accrue as a result of construction and operation of the TRHDP. It identifies and discusses impacts to the terrestrial biological environment, and briefly outlines the measures proposed to avoid, minimize, and mitigate potential impacts, following GIIP for the hydropower sector.

Section 11: Assessment of Impacts on the Aquatic Biological Environment - This section describes potential environmental impacts that are anticipated to accrue as a result of construction and operation of the TRHDP. It identifies and discusses impacts to the aquatic biological environment, and briefly outlines the measures proposed to avoid, minimize, and mitigate potential impacts, following GIIP for the hydropower sector.

Section 12: Assessment of Socio-economic / Socio-community Impacts - This section describes the potential social impacts of the TRHDP, and the social impact assessment SIA methodology and constraints of the Social Impact Assessment (SIA). It highlights the communities' perceptions regarding potential adverse social impacts (e.g., impacts on health, safety and well-being), and potential benefits (e.g., electrification, employment, education and skills, ecotourism). This section also briefly outlines the measures proposed to avoid, minimize, and mitigate potential impacts, following GIIP for the hydropower sector.

Part D – Environmental and Social Management

Section 13: Environmental and Socio-economic / Socio-community Management Plan Framework – This section provides the framework for an environmental and social management and monitoring plan framework in accordance with World Bank Operational Policy 4.01 – Annex C. It identifies mitigation measures, monitoring requirements, an implementation schedule and budget, and project context. Detailed commitments and responsibilities are included in a separate stand-alone environmental and social management plan (ESMP).

Part E – Cumulative Impacts Assessment, Natural Hazards and Dam Safety

Section 14: Cumulative Impacts Assessment - As required by the World Bank and IFC, analysis of cumulative impacts is required. Therefore, this section follows the six steps suggested by the IFC for identifying valued environmental and social components (VECs), identifying past, present or reasonably foreseeable projects or activities that in combination with TRHDP could result in cumulative impacts, and recommending measures for addressing these impacts. The TRHDP is assessed for cumulative impacts with mining, oil palm, timber harvesting, and gravel extraction activities. A second phase of cumulative assessment culminating in a Cumulative Impacts Management Strategy will be carried out during project implementation.

Section 15: Effects of the Environment on the Project – This section examines potential natural hazards that alone or in concert could affect components of the project, particularly dam safety.

Part F – Conclusions and References

Section 16: Conclusions **–** This section summarises the environmental and social impacts that will potentially remain after mitigation measures have been applied (i.e., residual impacts) and identifies whether these residual impacts are significant, or not. An overall conclusion is made regarding the Project.

Section 17: References **–** This section identifies the secondary data sources used in compiling the ESIA document.

2. PROJECT DESCRIPTION

This chapter describes in detail the project context, access, components, actions and activities of the Project, and its associated project support facilities. It also broadly describes the activities in the project area, the project requirements and the expected implementation schedule.

The Project description is based on Option 7C as defined in the Feasibility Study, dated March 2014.

2.1 PROJECT CONTEXT

2.1.1 Background to Site Selection

The Tina River Hydropower Development Project (TRHDP) is expected to be the first major hydroelectric project in the Solomon Islands. Tina River is located 30 km South East of Honiara at the upstream end of the Ngalimbui River Basin in Malango Ward 20, Central Guadalcanal District. The Tina River catchment and proposed transmission line route are in the Malango Ward within Central Guadalcanal District. During the project feasibility phase, Entura (2010-2014) studied several sites for locating a hydropower facility along the Tina River. The siting options studied by specific study phase included:

- Phase 1 of the Feasibility Study considered a series of 6 options (option 1 to 6) located along the stretch of the Tina River from its confluence with the Mbeambea River (upstream catchment) to its confluence with the Toni River (Entura, 2010).
- Phase 2 studied Option 6. It reached the conclusion that the Option was too technically risky to proceed further. At the time the ESIA work was set to commence, Option 6e was determined to be the best option (Entura, 2012). A further five options (6 b-f) were identified for possible detailed evaluation.
- Phase 3 involved a re-evaluation of Option 6e against a new option, Option 7c. Option 7c emerged from the Phase 3 studies as the preferred option (Entura, 2014).

Since K-water and HEC consortium became a developer that has priority in 2015, the consortium implemented the bidding design based on feasibility study (Entura, 2014) and submitted the Technical Proposal (2017).

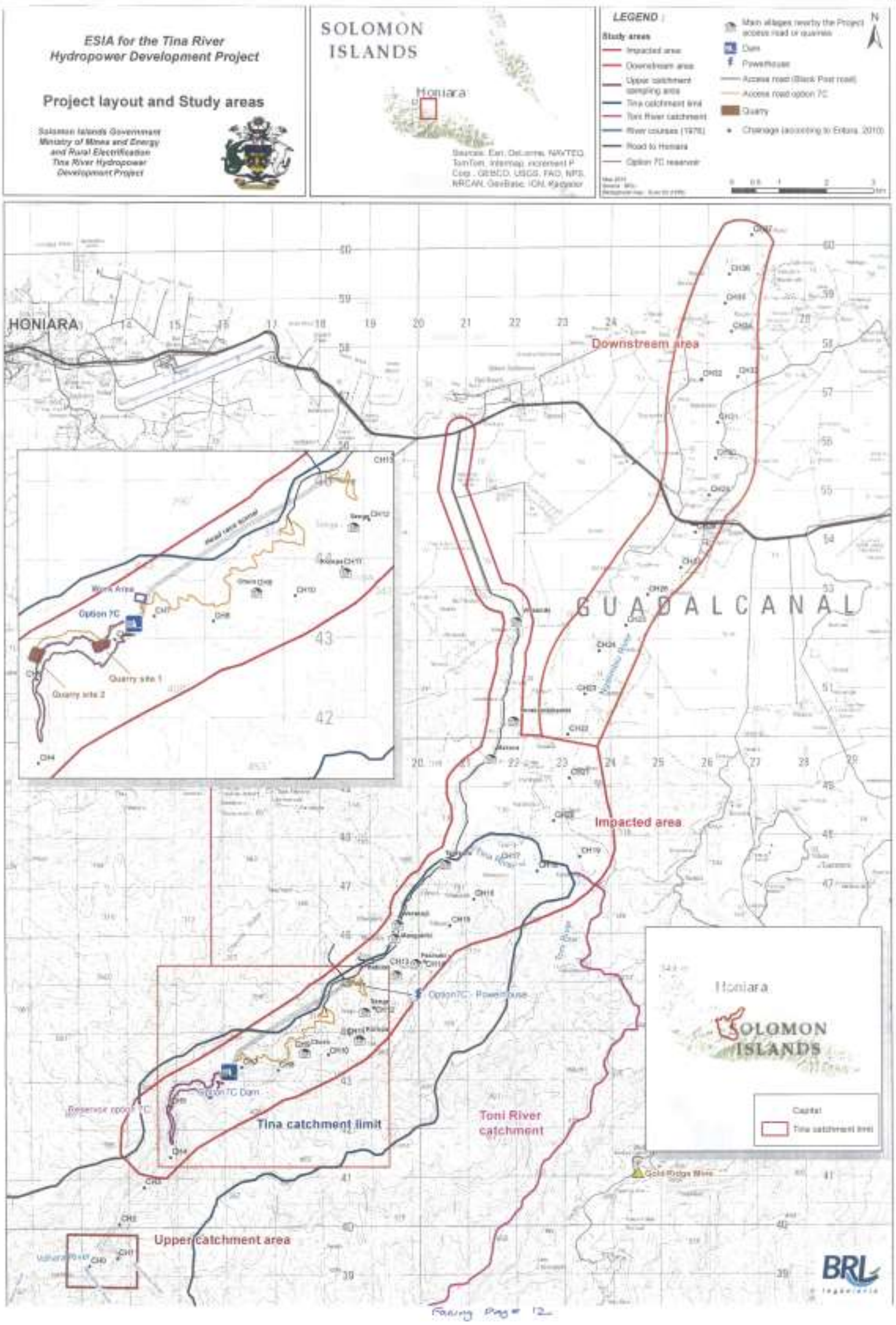
2.1.2 General Area Description

The Tina River is derived from the joining of three rivers: the Mbeambea, the Voraha and the Njarimbisu rivers. The Tina River catchment area is roughly 150km^2. The Tina River joins the Toni River, a much smaller river with a catchment of about 45km^2, to form the Ngalimbiu River, which flows through a coastal plain before discharging into Iron Bottom Sound on Guadalcanal's North coast. This coastal plain is more highly developed than the upstream areas of the catchment, and has more settlements and agriculture activity. At its headwaters, Tina River flows through a very narrow, steeply sided and incised, limestone gorge. In its mid reaches, the slopes gradually become less steep and are dotted with a few human settlements and gardens. A map of the project area is included as Figure 2-1.

The Project area landscape is comprised of volcanic mountains, dissected river ridges in the South and central areas, and low terraces and fertile flood plains toward the North coast. The flora and fauna in Guadalcanal is both rich in diversity and endemism. The project site is dominated by tropical moist forests and is associated with a majority of low altitude forests, grasslands and mix of habitats. The Tina River upper catchment area is comprised of undisturbed montane forests and aquatic ecosystems.

The majority of the actual inhabitants of the project area are descendants from former settlements located at the base of Mount Popomanaseu, the highest mountain in the Solomon Islands. These inhabitants migrated closer to the North coast plain and Honiara. Most villages are located on the left bank of the Tina River. An unsealed road (Black Post Road) links these settlements with the sealed road to Honiara.

Figure 2-1 Map of project area



2.2 THE RETAINED OPTION – SITE 7C

2.2.1 Project Description

The project comprises a 53 m (crest-river bed) high dam located at an elevation of approximately 123 masl, and roughly 30 river km from the sea, a 3.3 km tunnel to a powerhouse and tailrace at elevation 73 masl. The reservoir formed by the dam will extend upstream approximately 2.6 km and will have a surface area of about 0.28 km^2 at an elevation of 175 masl. The operating range of the reservoir formed by the dam will be 5 m but the reservoir will normally be held about 3 m below the full reservoir level to increase utilisation by storing water during floods and freshes and reducing the number of spill events.

Initially, the powerhouse will have 3 turbine/generator units, each with a capacity of 5MW, allowing a maximum discharge of about 18 m^3/s, and a minimum discharge of about 2.4 m^3/s.

An environmental flow will be maintained between the dam and powerhouse tailrace. The river distance between the dam and tailrace is 5.4 km.

Table 2-1 shows the Project main components

Table 2-1 Main Project characteristics (Option 7c) as described in the feasibility study and Technical Report

Project Components	Feasibility Study	Technical Proposal
Dam		
Type of dam	Roller Compacted Concrete (RCC)	Roller Compacted Concrete (RCC)
River Chainage	CH 7km	CH 7 km
Height	Crest height 53m ; abutment height 64m	53m above the riverbed level
Base length at river	35m	35m
Base length at crest	200m	207m
Material needed for dam and the two cofferdams	Cement: 5.6 thousand m^3 Fly ash: 9.2 thousand m^3 Aggregate: 160 thousand m^3 Water: 30 thousand m^3 Retarding admix: 0.2-0.4 thousand litres	
River level at dam	122masl	122masl
Minimum operating level (MOL)	170masl	170masl
Normal operating level	172masl	172masl
Full supply level (FSL)	175masl	175masl

Project Components	Feasibility Study	Technical Proposal
Maximum flood level (MFL)	186.5masl	187.5masl
Spillway		
Release of floods	Up to the 1:10,000-year flood level (3,290m^3/s)	Up to the 1:10,000 year flood level (3,290m^3/s)
	The spillway will release flood water via the by-passed river, on average, 20% of the time (when the inflow is higher than 18m^3/s)	
Width	45m	55 m
Height (FSL)	175masl	175 masl
Reservoir		
River Chainage	CH 7km – CH 4.5km	CH 7 km – CH 4.5 km
Number of days for filling	Between 5 and 9 days plus extra time if minimum environmental flow is implemented during reservoir impoundment.	-
Volume at FSL	7Mm^3	7Mm^3
Volume at MOL	7.8M^3 +/-	7.8M^3 +/-
Surface at FSL	30.52ha +/-	30.52ha +/-
Length	2.5km	2.5km
Power water intake		
Location	162.5masl	160.75 masl
Size	3m diameter	W3.5 m, H3.5 m
Scour outlet		
Location	155masl	150 masl
Head race tunnel		
Internal diameter	3.3m, suitable for flow rates up to 24m^3/s	W3.5 m, H3.5 m
Flow rate	18m^3/s	19 m^3/s
Length	3.3km	3.245 km
Powerhouse		
River Chainage	CH 12.7km	CH 12.7 km
Average net head of powerstation	97m	99.3 m
Turbine floor	72masl	73 masl

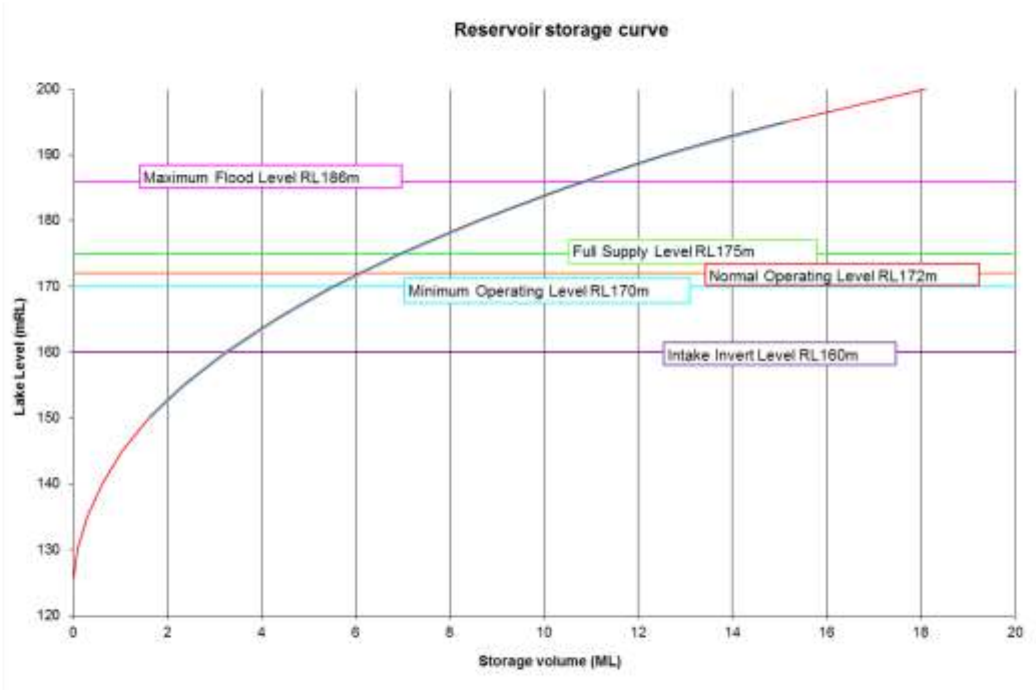
Project Components	Feasibility Study	Technical Proposal
Turbines	3 x Francis of 5MW	3 x Francis of 5 MW
Operating capacity	15 MW, at 18m^3/s	15 MW, at 19 m^3/s
Energy production, taking into account a 1m^3/s Environmental flow	78.35 GWh per annum	
Environmental Flow Outlet Port		
Riparian outlet for the environmental flow	162.5masl	170 masl
Environmental flow	1m^3/s	1m^3/s
Road		
Permanent existing Black Post road unsealed	13.3km	13.4km
Permanent access road to powerhouse sealed	1.45km	1.9km
Permanent access road to dam sealed	4.7km	5.6km
Temporary access road to intake portal unsealed	0.25km	-
Permanent road to dam base and mini-hydro sealed	0.66 km	0.6km
Road to quarries	to be determined as part of detailed design	to be confirmed at detailed design
Transmission line		
Length	23km	23km
Type	33kV double circuit	33kV double circuit
Project Cost		
Project Cost	US$133.3 Million + US$ 3.4 Millions Full scheme (initial 3 turbines) + Additional turbine (4th turbine) + extension of the powerhouse	US$140.2 Million (2017.04) For main EPC Cost (3 turbines)
Unit cost for the Project	US$165 -185/MWh	-
Diesel energy unit cost (Lungga powerstation)	US$330 - 400/MWh	-
River hydrology		
Mean flow at dam	11.5m^3/s	11.5m^3/s

Project Components	Feasibility Study	Technical Proposal
Tina catchment area	150km^2	150km^2
Catchment area above the dam	125km^2	125km^2

Chainage is based on distance in kilometres from the confluence of the Tina River and the Mbeambea River, which is (CH 0km). The dam is localized at CH 7km.

The graph in Figure 2-2 illustrates the reservoir storage curve.

Figure 2-2 Reservoir storage curve



Source: Entura, 2014

2.2.2 Site 7c Scheme Construction Activities

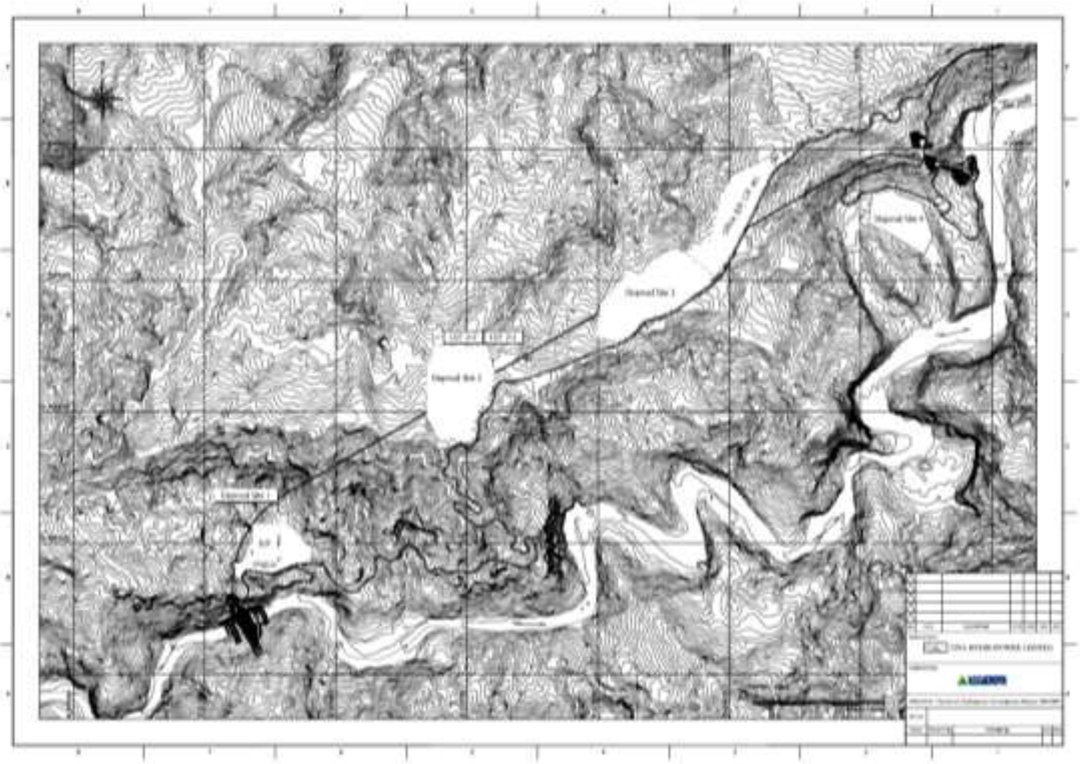
According to Entura (2014), the following activities will be included as temporary work:

- Construction of temporary and permanent access roads
- Temporary site office
- Two cofferdams
- Clearing for tunnel portals, pipeline, power house site
- Stripping the main dam foundation
- Clearing vegetation from the reservoir area
- Temporary concrete batch plant
- Temporary pug mill
- Temporary explosive magazine
- Temporary rock crushing mill

The dam construction activities will take place within the Core Area (see Figure 2-1).

The dam construction activities will take place within the Core Area and EPC contactor has plan of temporary work layout as below (see Figure 2-3).

Figure 2-3 Temporary Work Layout



Source: Tina Hydropower Limited, 2019

2.3 PROJECT COMPONENTS

2.3.1 Dam

2.3.1.1 Choice of Dam

The dam will be a Roller Compacted Concrete (RCC) dam, located in the narrow gorge of the river. The spillway will release flood flows up to the 1:10,000 year flood level (3,290m^3/s). The spillway will release floodwater in by the by-passed river on average 8% of the time (when the flow is higher than 18 m^3/s)

According to Entura (2014), a RCC dam was selected over an embankment dam for the following reasons:

- RCC dams can tolerate over-topping during construction whereas clay core embankment dam will not tolerate over-topping. This is a major element, since flash floods can occur in the Tina River. An embankment dam would need large diameter concrete lined diversion tunnels with high cofferdams to ensure river diversion during flood events. RCC dams require smaller conduit and cofferdam.

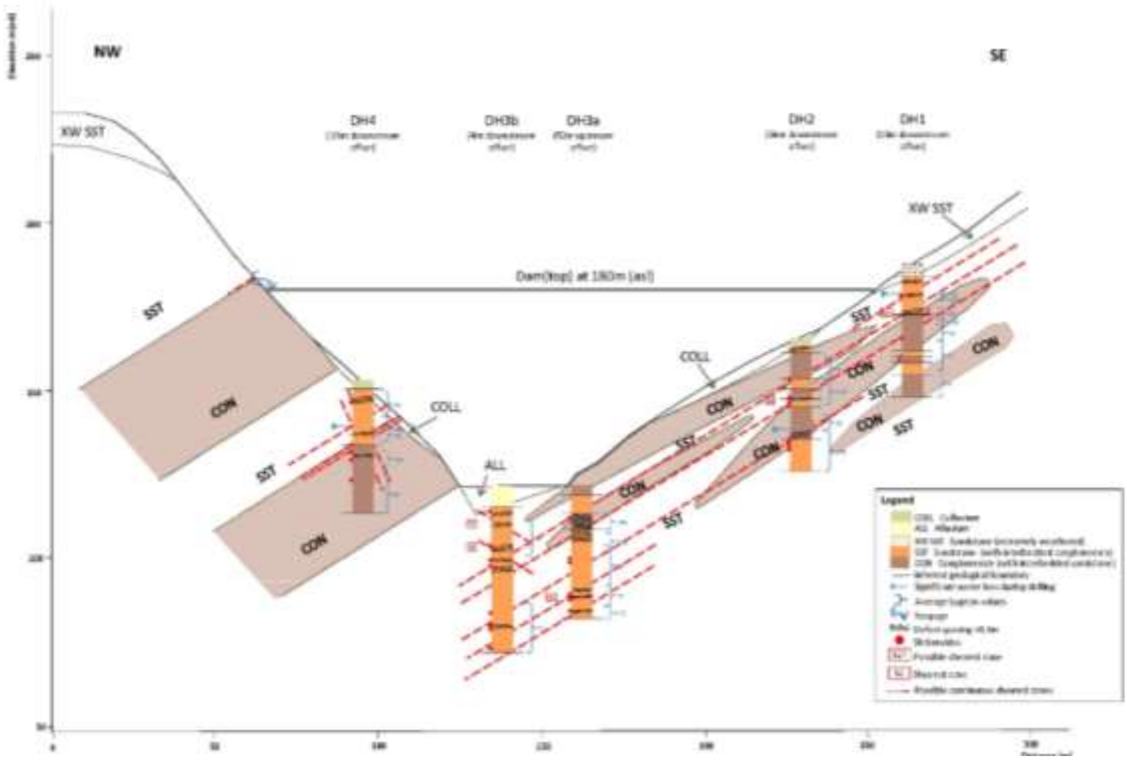
- RCC dams can be built with an integral spillway over the dam wall, whereas an embankment dam must have a separate spillway.

An embankment dam would require significant quantities of clay core material, gravel and rock fill. A source of clay was not identified during Entura's field investigations (Entura, 2014).

Dam height was optimized to maximize energy production. Entura (2014) selected the optimum full supply level to be at RL175. In addition, height is limited to RL175 for stability and water tightness reasons, as above this level there is a risk of leakage through Karst features. The height of the dam spillway crest will be 53 m above the riverbed level (RL 122) with abutments which extend on each side to 64metres to provide dam stability. The dam at Site 7c will have a narrow base (35 m) and steep abutments, resulting in minimum concrete volume for a RCC dam. At crest level the dam will be 200 m wide. A roadway will be located at RL 186.5m. Figure 2-4 illustrates the geology of the dam site.

Also, Technical Proposal (2017) based on feasibility study by Entura (2014) included the bidding design implemented by K-water and HEC.

Figure 2-4 Geology at dam site



Source: GeoRisk Solutions (2014)

2.3.1.2 Construction

The dam will be constructed as a roller compacted concrete (RCC) structure, and require approximately 200,000m^3 of roller compacted concrete. The RCC dam, and its two cofferdams, will require an estimated volume of 160,000m^3 of aggregate. The construction of the dam and cofferdams will require the following material:

- Cement: 5.6 thousand m^3. Cement will be imported from outside the country, due to limited capacity to supply it locally.

- Fly ash (pozzolan): 9.2 thousand m^3. This material is required to extend the cement paste, and will be imported from outside the country.
- Aggregate: 160 thousand m^3. Aggregate will be sourced locally from quarries and from the river beds as mentioned below.
- Water: 30 thousand m^3. Water will most likely be pumped from the Tina River, from a location adjacent to the dam site and RCC batch plant, immediately upstream of the cofferdam.
- Retarding admix: 0.2-0.4 thousand litres. Retarding mix will be sourced from outside the country.

According to Entura (2014), available materials that are close to the dam site at Site 7c include: volcanics, river alluvium, sandstone, conglomerate, calcarenite and limestone. Entura assessed the suitability of these locally available materials as RCC aggregates and concluded that river alluvium and limestone are suitable and calcarenite, sandstone and conglomerate may be suitable but would need additional testing. Finally, volcanic material sources are too distant from the dam site and their exploitation would be costly. Additionally, Entura (2014) identified various criteria to be considered when choosing a quarry site: slope stability, isolation from regular flooding accessibility and location. Ideally, quarry sites will be submerged during reservoir impoundment.

Two locations have been identified as potential material sources:

- Quarry 1: Calcarenite - an estimated 2.5 thousand m^3 of material is available. The quarry is located at CH 6.2km to 6.5km.
- Quarry 2: Limestone - an estimated of 1.35 thousand m^3 of material is available. Access is more difficult than Quarry 1. This quarry is located at CH 5.4km to 5.5km.

Screening operations for aggregates will occur near the river. At the time the initial ESIA was prepared, the location of stockpiles had not yet been determined. Material from the head race tunnel excavation will be integrated into the crushing operation. One feed mixing plant (pugmill) and concrete batching plants will be required to blend the material and produce the concrete. They will be located in the core construction area.

The RCC will be placed in 300mm layers. It is planned to place two layers a day over a period of about 5 months in the 2nd dry season. Both faces will be grout enriched. Concrete may be delivered to the site using a conveyor as shown in Figure 2-5. Dam construction will start once the cofferdams and diversion conduit and access road are serviceable. Additional concrete work, in the 3rd dry season, will take place for a period of 3 to 4 months.

Construction will start with excavation of the abutments. Abutment stripping will commence at the beginning of the 2nd dry season, when excavation for the foundations of the dam will be carried out in the riverbed. Hydraulic excavators, rear dump haul trucks, air track drills and rock breakers will be used for dam site excavation.

Figure 2-5 Typical RCC dam construction with concrete conveyor

Source: Entura, 2014

Plan, profile and cross section views of the dam, showing its various components, are provided in Figures 2-6, 2-7 and 2-8 of the Feasibility Study and Figures 2-9, 2-10 and 2-11 of the Technical Study.

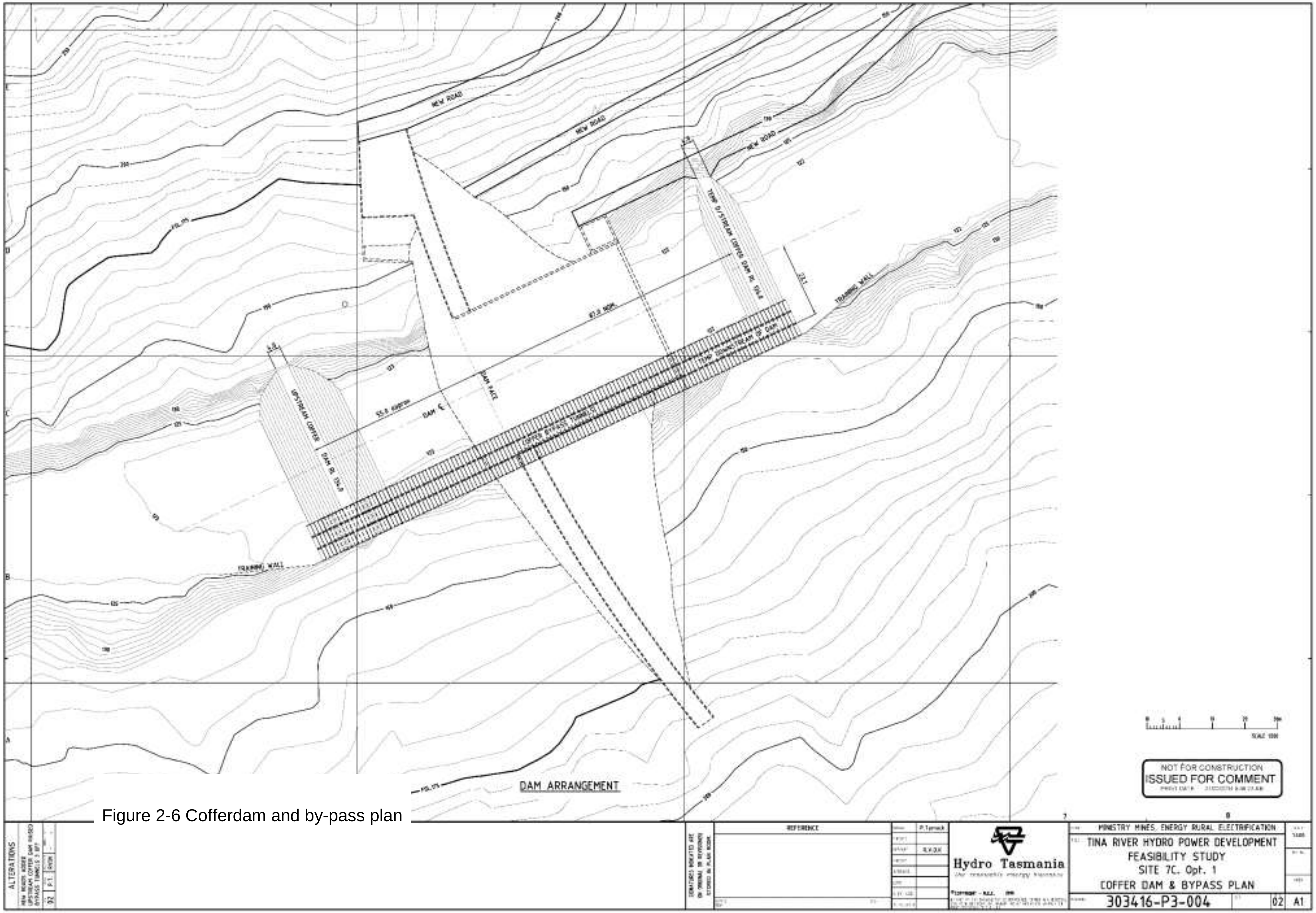


Figure 2-6 Cofferdam and by-pass plan

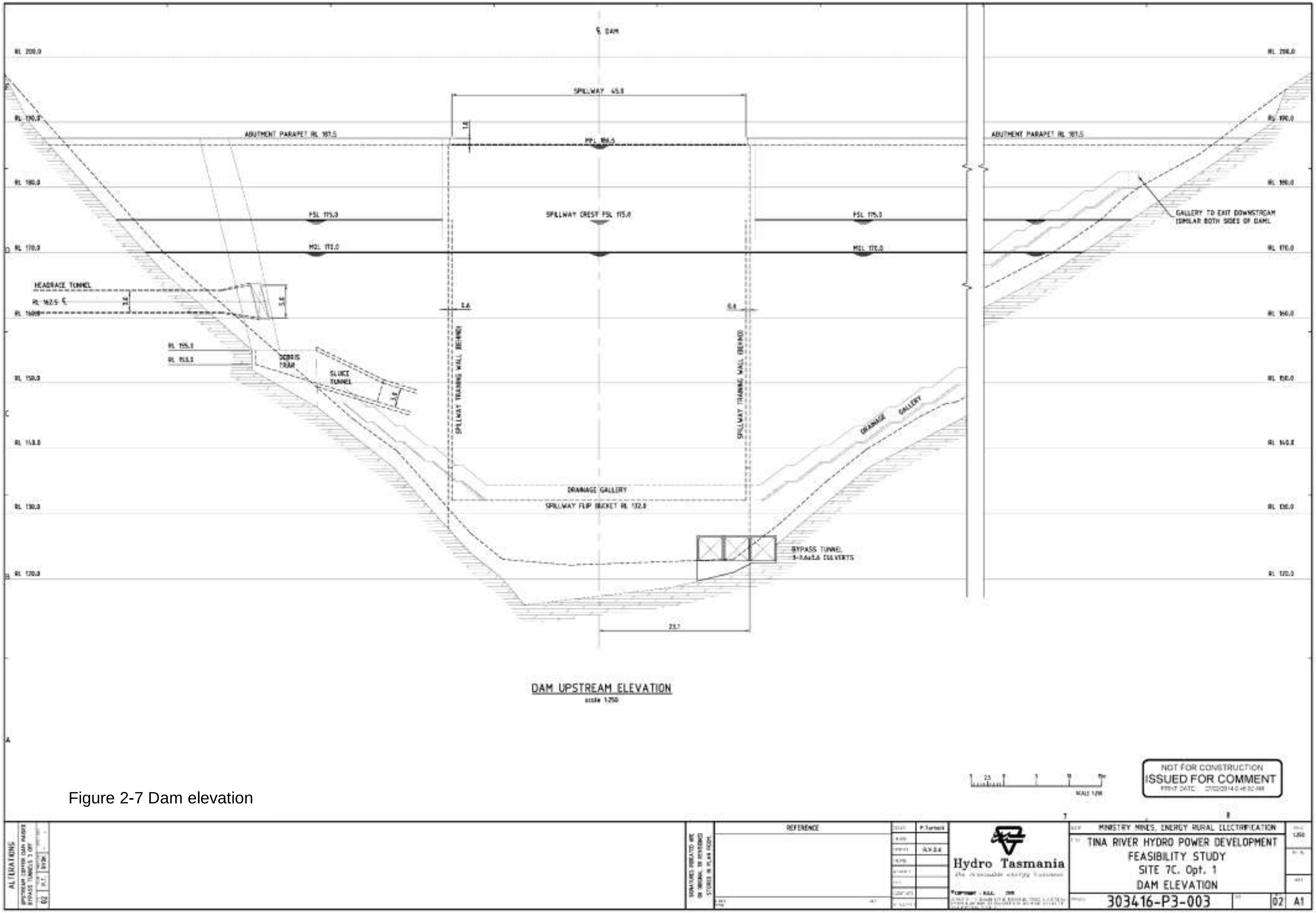


Figure 2-7 Dam elevation

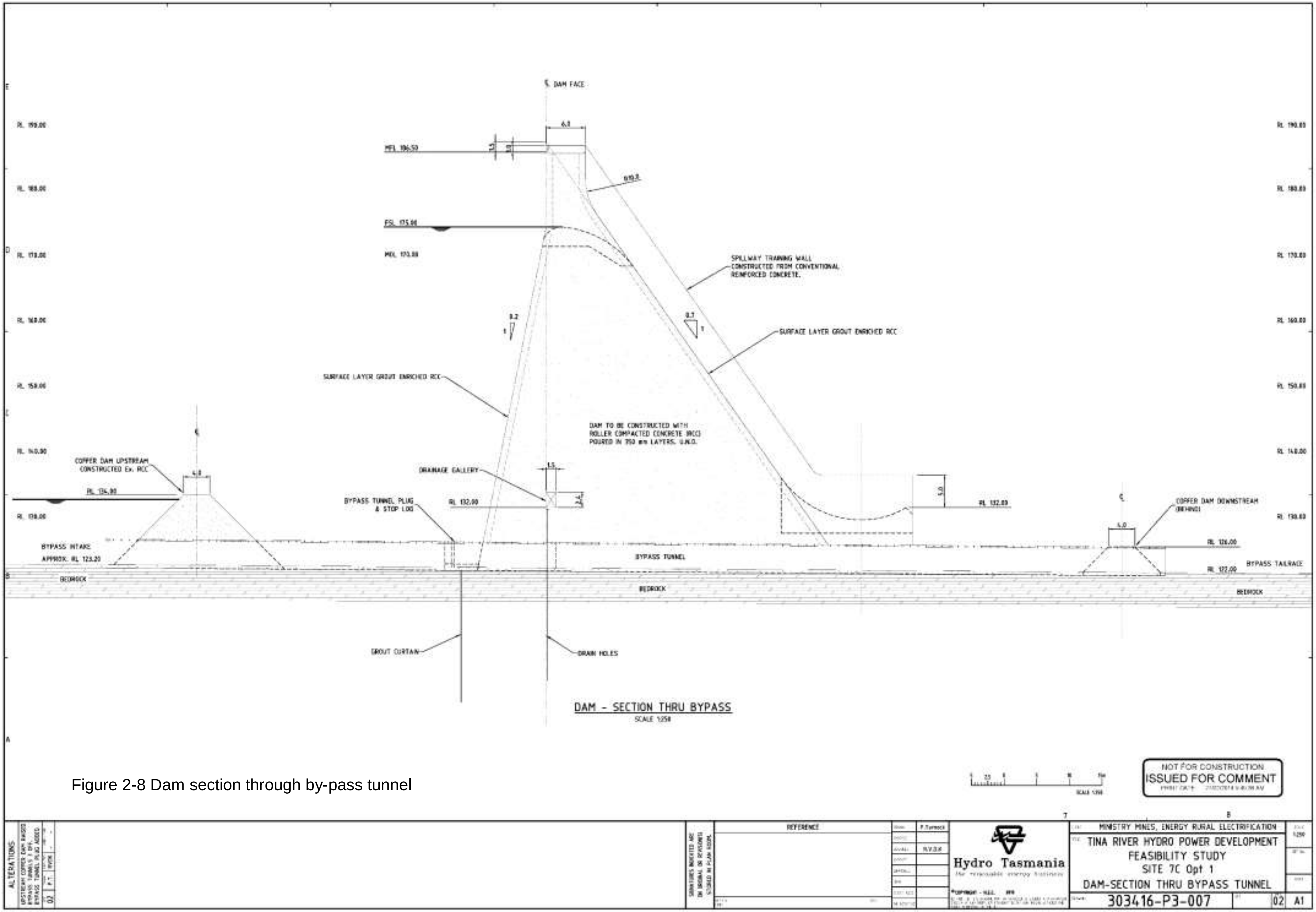


Figure 2-8 Dam section through by-pass tunnel

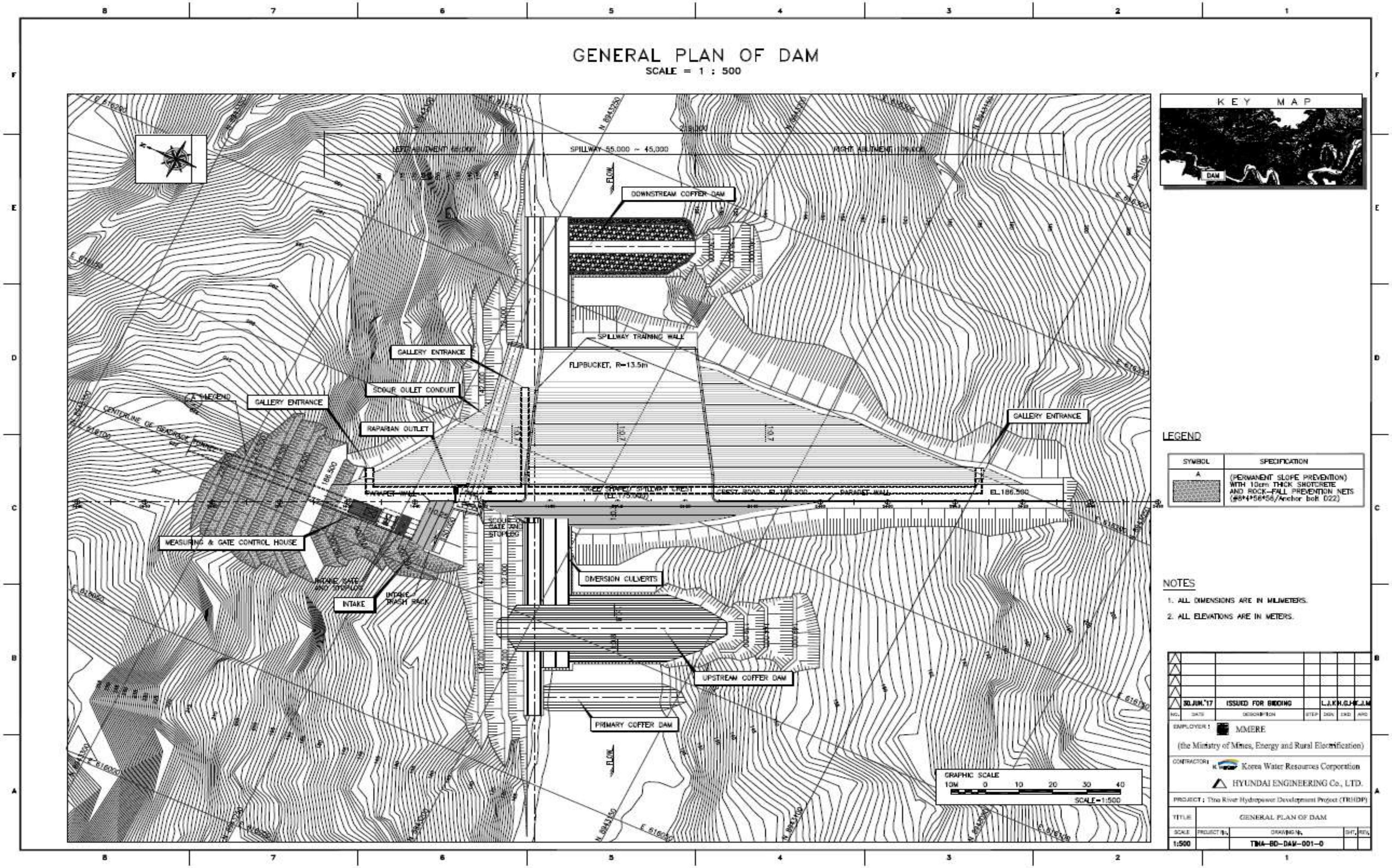


Figure 2-9 General plan

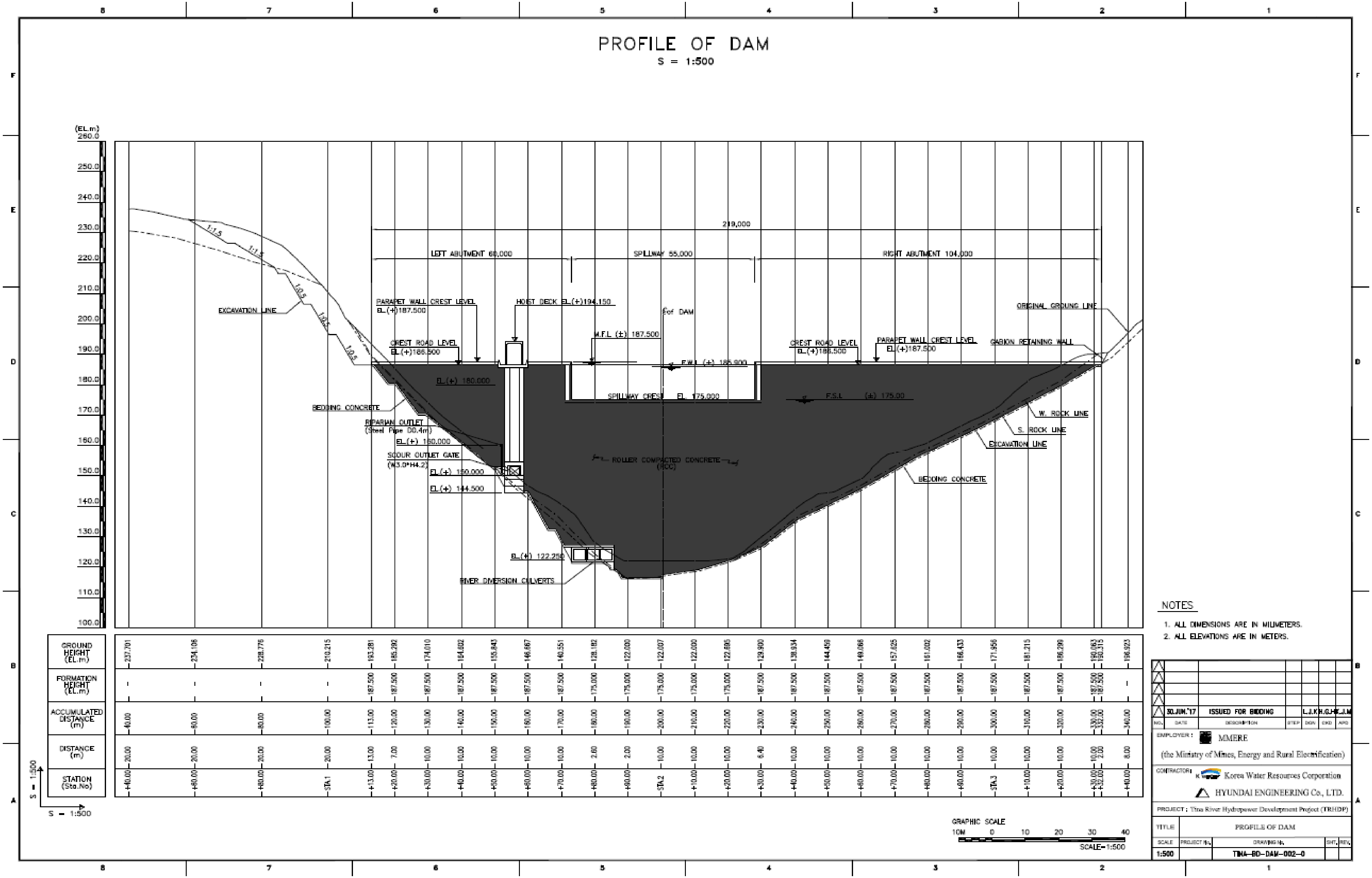


Figure 2-10 Profile of dam

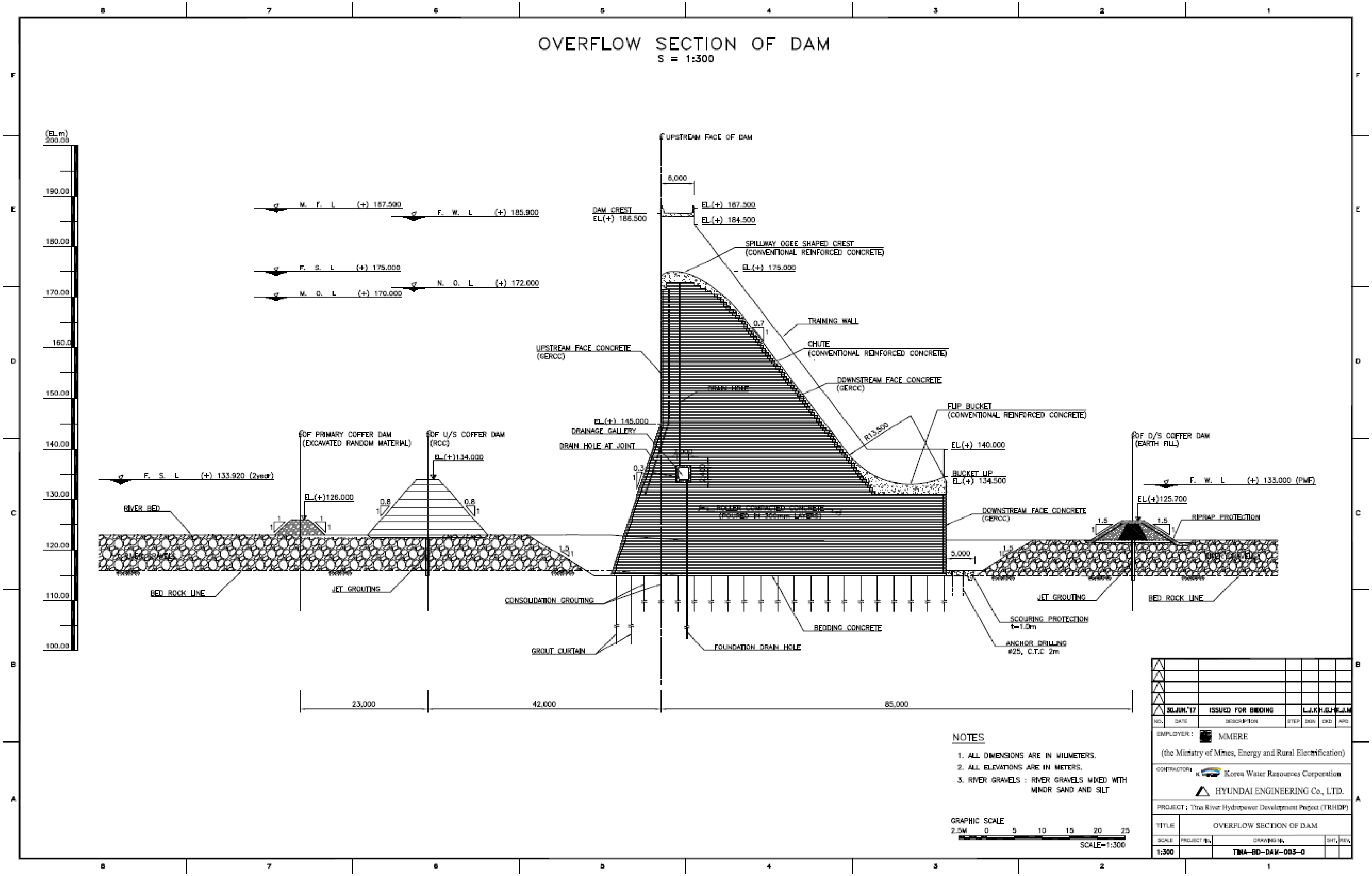


Figure 2-11 Profile of dam

2.3.2 Reservoir

The reservoir will have a volume of 7Mm^3 at FSL and will extend upstream approximately 2.6 km with a surface area of about 0.28 km$^{2.}$ Based on available hydrological data, the reservoir will take between 5 to 9 days to fill to sediment scour outlet (the bottom of inlet at 150 masl) is reached. An environmental flow will be maintained during reservoir filling,

Once the water level has reached 150 masl, the scour outlet could release flow. Implementing a minimum environmental flow during filling will increase the time required to fill the reservoir as shown in the Table 2-2.

Table 2-2 Time required to fill reservoir under varying flow conditions

Inflow (m^3/s)	Days to fill (to reach 175masl) without minimum environmental flow	Days to fill (to reach 175masl) with 1m^3/s* environmental flow
3	26.8	Not determined
4	20.1	26.8
5	16.1	20.1
6	13.4	16.1
7	11.5	13.4
8	10.1	11.5
9	8.9	10.1
10	8.1	8.9

* as suggested in Section 12 and Appendix L.

2.3.2.1 Coffer Dam and Diversion Conduit

Feasibility study (Entura) planned three rows of B3.6m×H3.6m diversion culverts on the right side of the river and up & downstream cofferdams of RCC type and 2-year flood of 360m3/s was applied on a design flood.

With regards to the above, main consideration in Technical Proposals (2017) ares as follows:

- Relocation of diversion culvert: Right bank has a risk of collapse during excavation due to joints developed in the same direction as a natural slope and requires crossing of the river. Therefore, the diversion culvert has been relocated to the left bank that is relatively safe and can eliminate the necessity of river crossing.

- Phased river diversion plan: A review on the flow gauging data showed that it rains frequently at dam site even during the dry season, and thus is prone to unexpected floods. Therefore, a phased plan using a primary cofferdam has been established in order to carry out all the works under dry condition.

- Gradient of upstream cofferdam: 1:0.8, the smallest gradient as much as possible that can allow construction without formwork, has been applied in accordance with the USBR (2005).

- Type of downstream cofferdam: It has been changed to a central core rockfill type in consideration of economic feasibility and convenient demolition after completion of the dam.

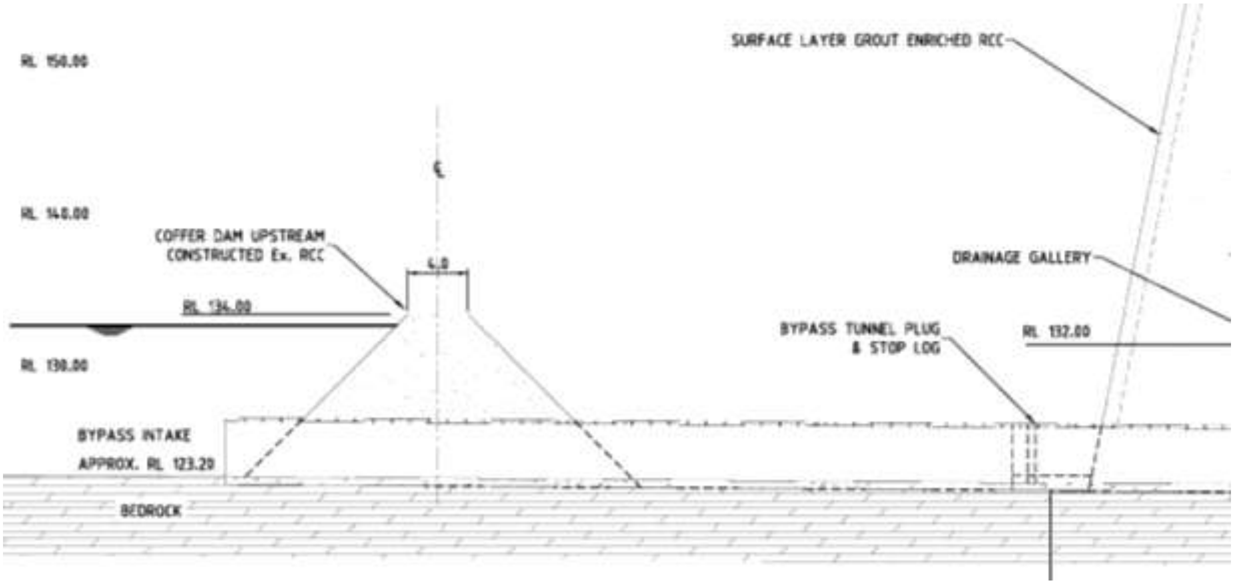
- Foundation grouting method: Jet grouting has been chosen on the basis of the geotechnical features (sand layer including gravels and boulders) in order to allow rapid construction and to minimize the loss of grouting materials.

The diversion will consist of three components: upstream cofferdam, diversion conduit to pass low level floods and downstream cofferdam. These elements will ensure protection from floods during dry-season construction. The RCC dam will tolerate over-topping during the wet-season provided the foundation excavations and high-risk activities have been completed in the dry season.

The diversion will be sized to pass the yearly or 1:2 annual exceedance probability (AEP) flood (up to 360m3/s). An AEP of 2 means that every two years this peak flow could occur, or that every year there is a 50% chance that this peak flow occurs.

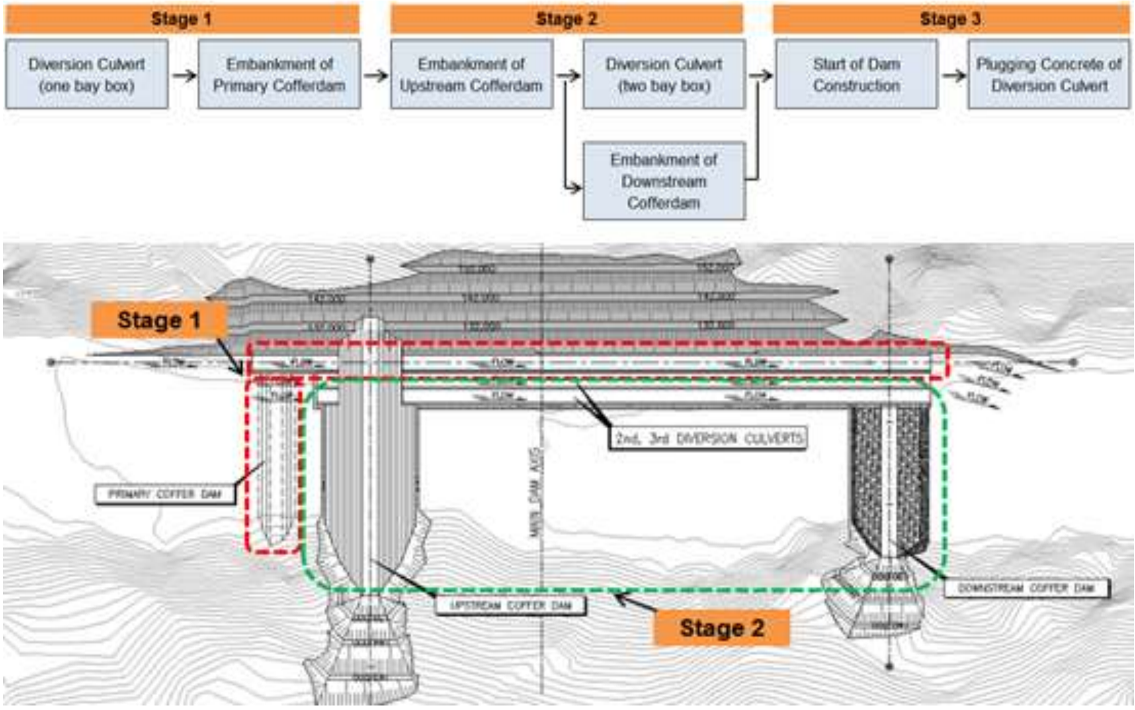
Diversion closure will take place once the dam, spillway and intake are completed and will involve installing a gate at the upstream entrance to the conduit. A diversion plug will be installed (as shown in the Figure 2-12) allowing for the installation of an outlet controlled by a valve to ensure 1 m3/s minimum river flow during initial reservoir filling (Note: this outlet is not shown on drawings).

Figure 2-12 Diversion by-pass intake and by-pass plug



Source: Entura (2014)

Figure 2-13 Sequence of River Division Works



Source: Technical Proposal (2017)

2.3.3 Power Intake Head Race Tunnel

According to Entura (2014) and Technical Proposal (2017), the underground head-race tunnel construction will be excavated using drill and blast techniques for hard rock, and using road-header equipment for softer and weathered rock. Shotcrete or concrete lining of the headrace will also be required for permanent tunnel support. Construction excavation will be done from both ends to expedite progress. Other temporary services will also be required. This will include power, tunnel ventilation, compressed air and facilities for shotcreting and concreting.

Spoils may be used for road construction, as aggregate base, or for river diversion works downstream of the dam and adjacent to the powerhouse tailrace. The feasibility study did not provide the quantity of spoil, but BRLi has estimated it to be approximately 24,300m^3, based on dimension of infrastructures.

The power intake will be located at 160.75 masl in the Technical Proposal (2017) and convey water to the power station. The specifications, the plan and the profile of the intake are shown below.

Table 2-3 Comparison of the specs of Intake

Item	F/S	Technical Proposal
Size	W3.3m×H3.3m	W3.5m×H3.5m
Gate bottom EL.	EL.162.5m	EL.160.75m
Trashrack size	W5.0m×H5.0m	W6.0m×H6.0m
Inlet tunnel length	17.8m	17.8m

The power intake will be located in the left abutment and will contain trash-racks, isolation gate and a mini-hydro pipe. A flushing outlet (scour outlet at 150 masl) will be located upstream of the trash-rack to enable flushing of sediments that have been deposited over time near the intake.

Trash-rack screens will facilitate excluding floating and submerged material from entering the power conduit.

Following the power intake, a 3.3km underground head-race tunnel will convey water to a vertical surge shaft and then via a short power tunnel to the power station. The head-race tunnel will have an internal diameter of 3.3m. The tunnel system will be designed for flow rate up to $24m^3/s$. The head-race tunnel will be built to ensure a minimum of 20m surficial material remains over the crown. Figure 2-14, 2-15 and 2-16 illustrates the tunnel system from Technical Proposal (2017).

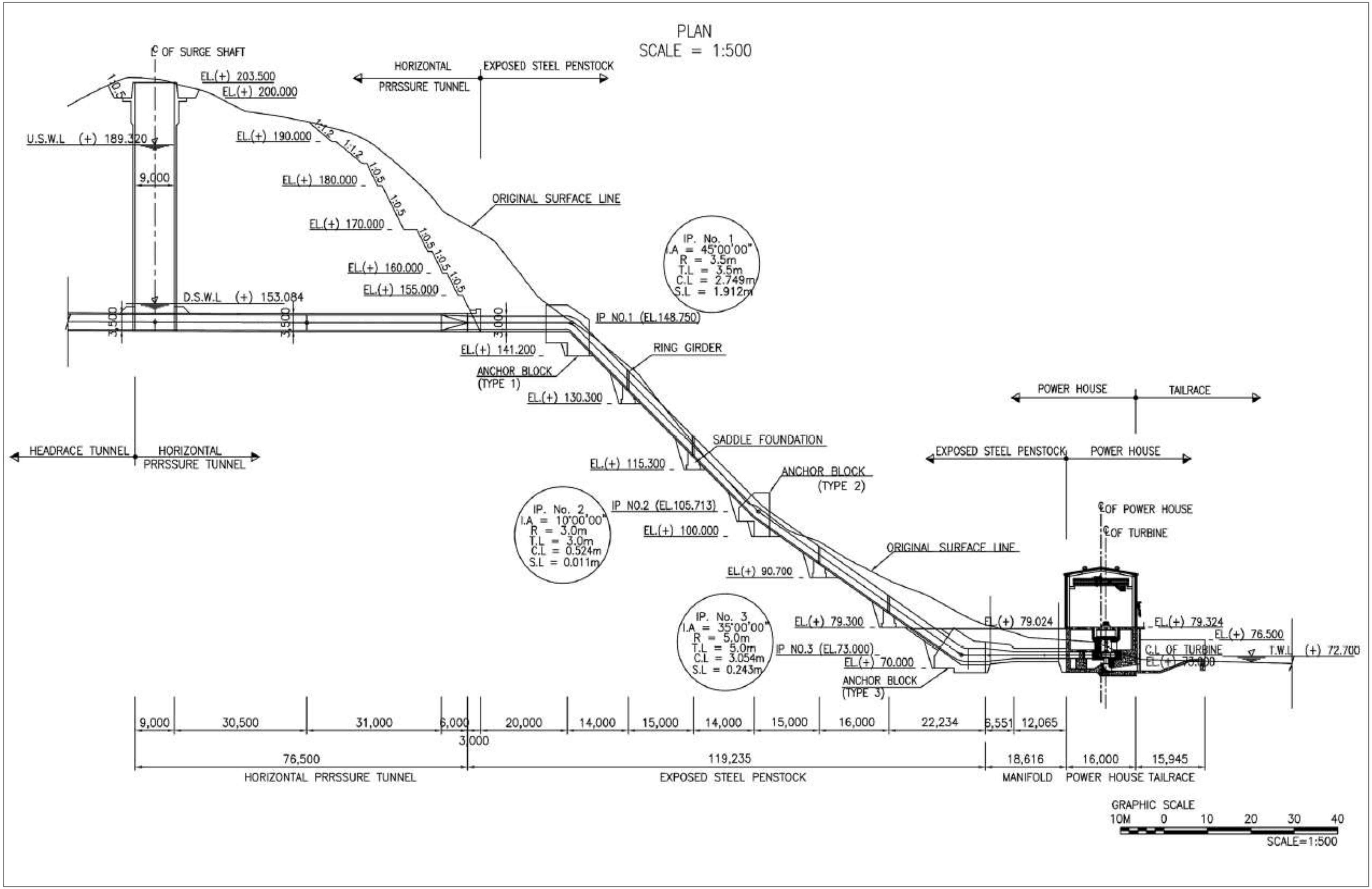


Figure 2-14 Tunnel longitudinal section

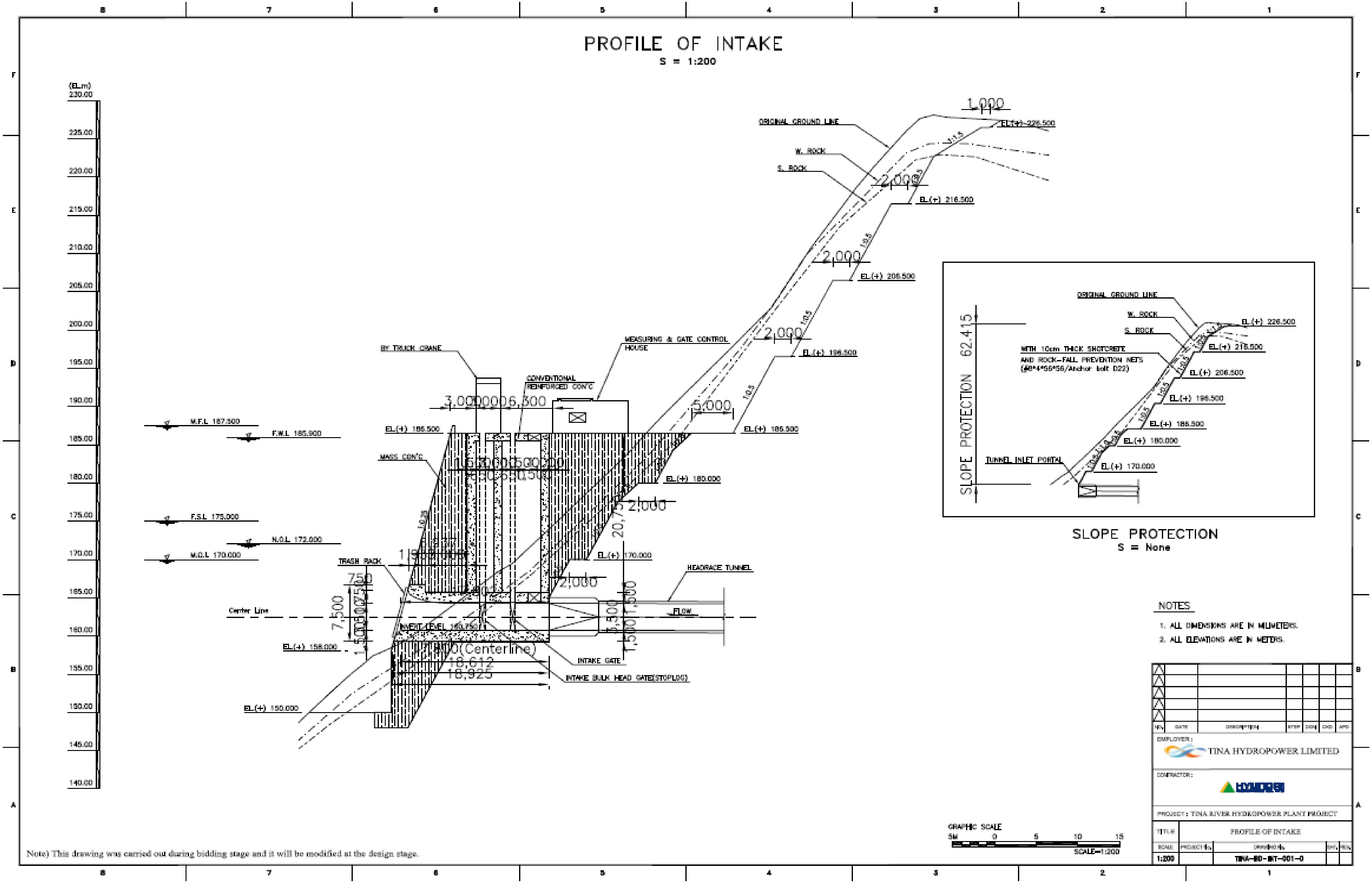


Figure 2-15 Profile of intak

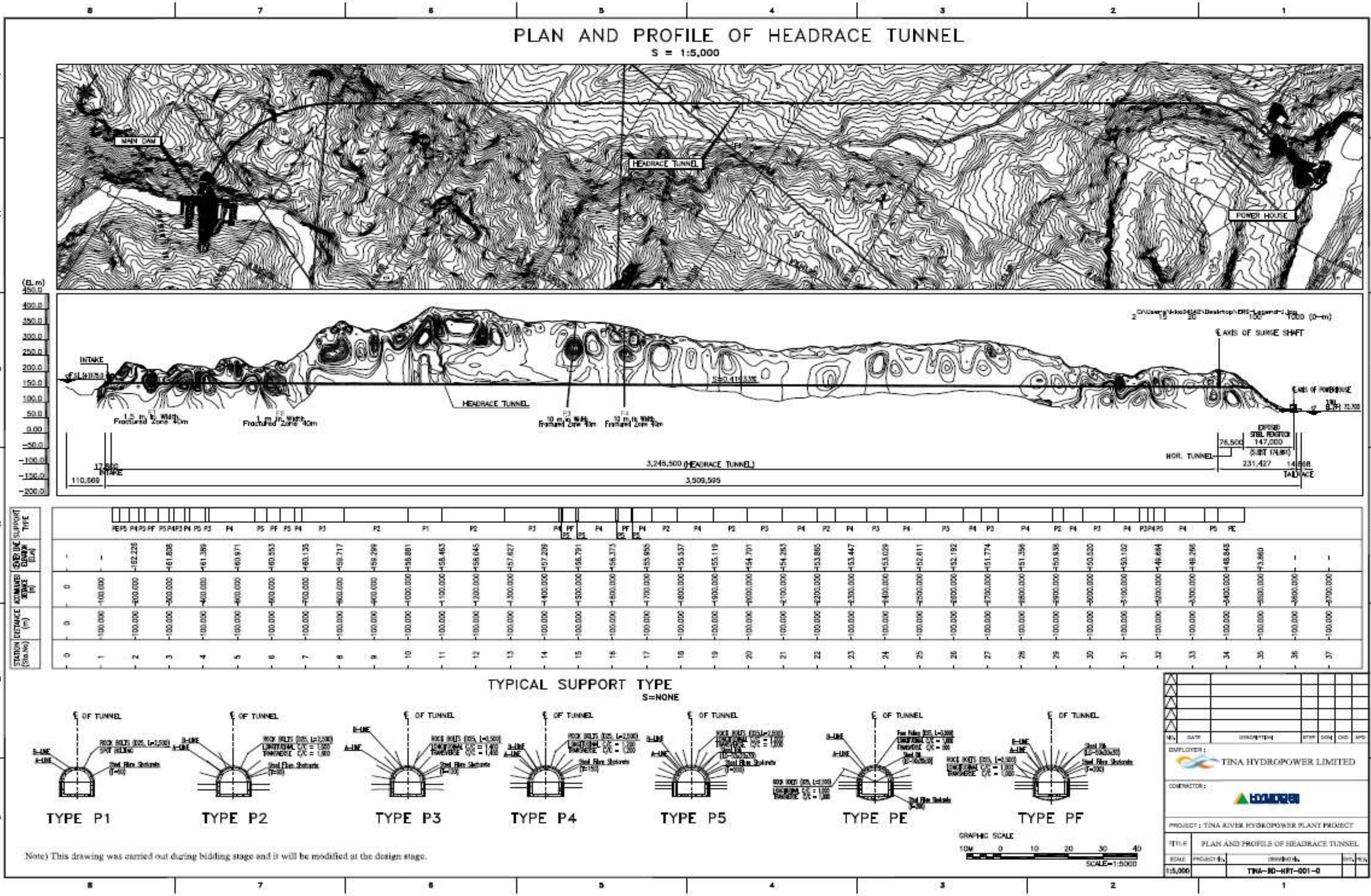


Figure 2-16 Plan and Profile of headrace tunnel

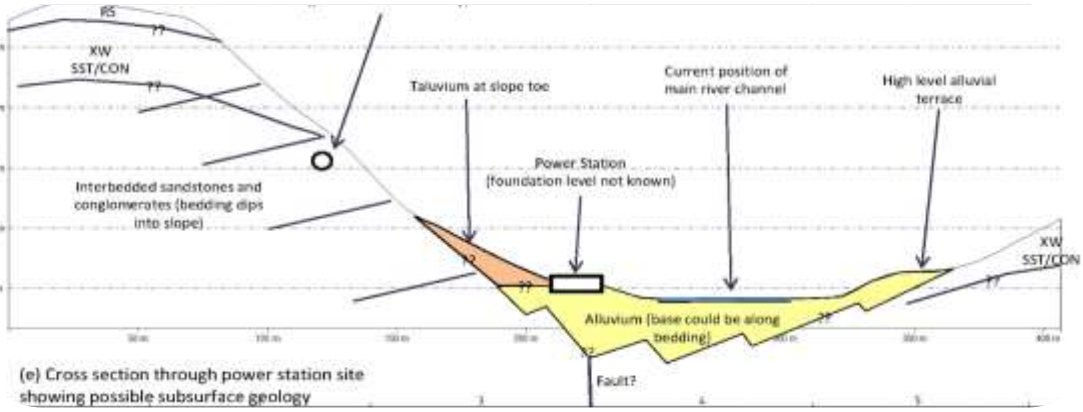
2.3.4 Powerhouse

The powerhouse will be built using conventional methods including:

- Foundation excavation and levelling
- Concrete foundations
- Steel superstructure erection
- Steel cladding
- Tailrace excavation

The construction of the power station will require significant site formation and foundation due to the presence of thick taluvial/ landslide debris underlain with alluvial material and due to the proximity of floods coming from the Tina River. Taluvial deposits are angular rocks blocks within fine-grained matrix typically in equal proportion. Figure 2-17 illustrates the geology at the power station site.

Figure 2-17 Geology at the Powerhouse site



Source: GeoRisk Solutions (2014)

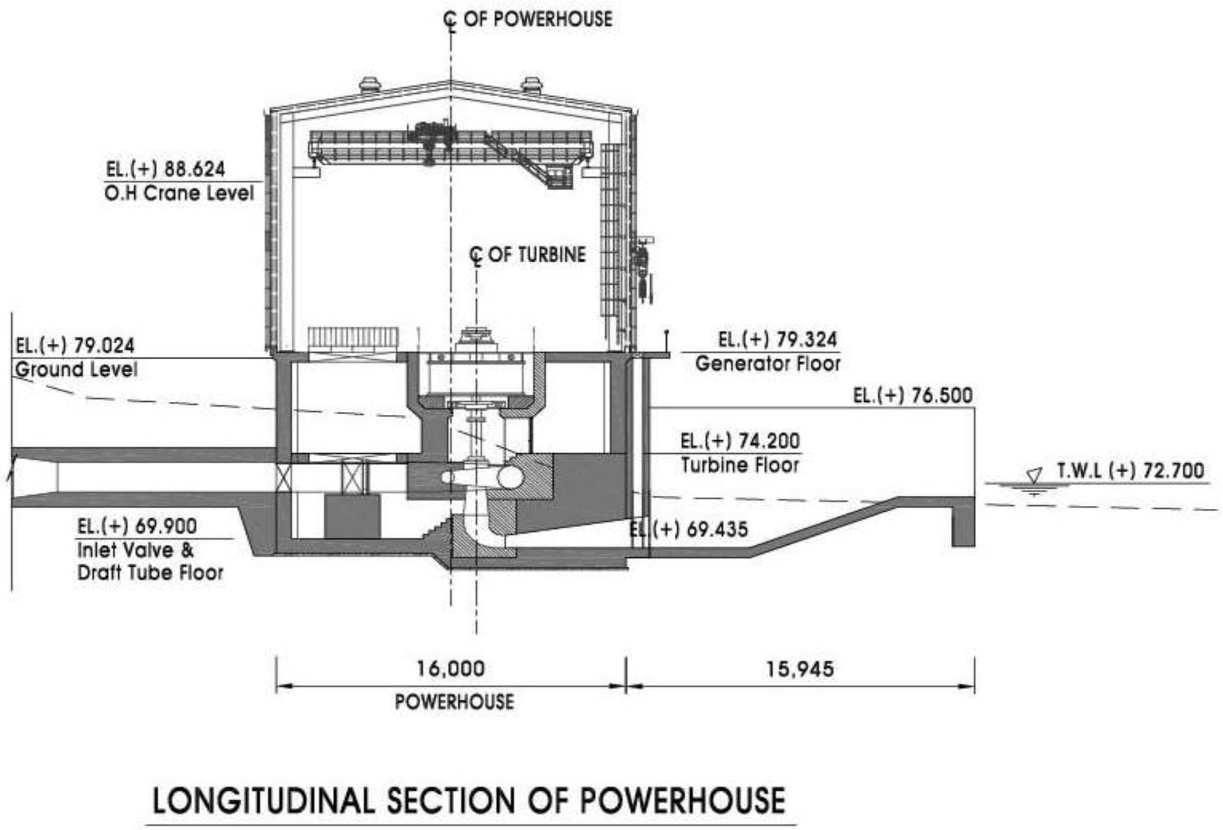
The powerhouse will have a concrete substructure and a steel portal frame, and will be protected from a flood event of 1:1000 AEP. The powerhouse will comprise 3 x 5MW Francis turbines. The powerhouse has been planned to be 16.0 m-wide, 24.583 m-high, and 48.05 m-long in size in Technical Proposal (2017).

The power station will be operated to maximise power generation, so that during periods of high flow the station will be at full generation for much of the time. However, during low flows in the dry season, the river flow will be considerably less than the maximum generating capacity. During these periods, the station will operate on a daily/weekly cycle, generally following the load demand with maximum generation up to 19.9 m^3/s on weekdays during working hours, then shutting down during the night, as shown in Fig. 9. From an environmental perspective, it would be preferable for the night generation to reduce to minimum machine discharge (2.4 m^3/s) rather than zero flow. This will reduce the magnitude of fluctuations in flows, and better meet environmental flow requirements in the Tina River between the tailrace and Toni River confluence.

The powerhouse tailrace will enter the Tina River perpendicular to the river and will be protected from large floods by a concrete wall. A transformer substation occupying 440 m^2 of land will be located adjacent to the powerhouse. Figure 2-18 illustrates plan, profile and section views of the powerhouse in Technical Proposal (2017).

Source: Technical Proposal (2017)

Figure 2-18 Power Station Arrangement



2.3.5 Riparian (Environmental Flow) Outlet

The Tina River gradually increases in gradient from its confluence with the Toni River to the head of the proposed reservoir. The average gradient between the Tina/Toni confluence and the power house site is 5.3 m/km, increasing to 9.3 m/km between the power house and dam. The morphology reflects the change in gradient with the substrate size and frequency of swift water habitat increasing with gradient. The river is characterised by runs and riffle, with relatively few rapids/torrents and pools.

Surveys of the river were carried out on 6-9 March 2016 and 11-15 July 2013. During the first survey, the proportion of the different habitat types was measured and cross-sections were identified in each of the habitat types. A large flood that occurred on the second day of the survey removed more than half of the temporary staff gauges that had been installed. This meant that only 3 cross-sections were surveyed in March, one pool, one run and one riffle. Water levels were measured at flows of 8.7 m^3/s and 19.7 m^3/s and these were used to develop rating curves at each cross-section. The second survey (11-12 July 2013) comprised cross-sections in 2 pools, 5 runs, 5 riffles and 2 rapids; a total of 14 cross-sections. The flow was 9.91 m^3/s on the 11 July and 9.66 m^3/s on the 12 July. Water level and flow measurements were taken on 15 July and 25 July for rating calibration when the flows were 8.28 m^3/s and 5.39 m^3/s, respectively.

The selection of an environmental flow depends on the balance between environmental effects and loss of generation and the relative values placed on the environment and generation. The assessment of environmental flow is set out in section 11.3.1.1. Provision of a 1 m^3/s environmental flow between the dam and powerhouse should maintain or improve fish and benthic invertebrate densities and total numbers for most species. An environmental flow of 1 m^3/s would maintain the riffle habitats that appear to be used by most fish species, although there would be a reduction in habitat for the *Sicyopterus* species, which can live in very swift water. Pools will also be maintained for *Kuhlia* and grunters. Moreover, trapping of sediment in the dam and subsequent coarsening of substrate in the river below the dam will improve habitat for all aquatic species and overall productivity and this improvement with an environmental flow of 1 m^3/s should result in fish densities that are similar to that in the Tina and Toni rivers at present.

The environmental flows will be released from the toe of the dam at the right abutment as shown in Figure 2-19.

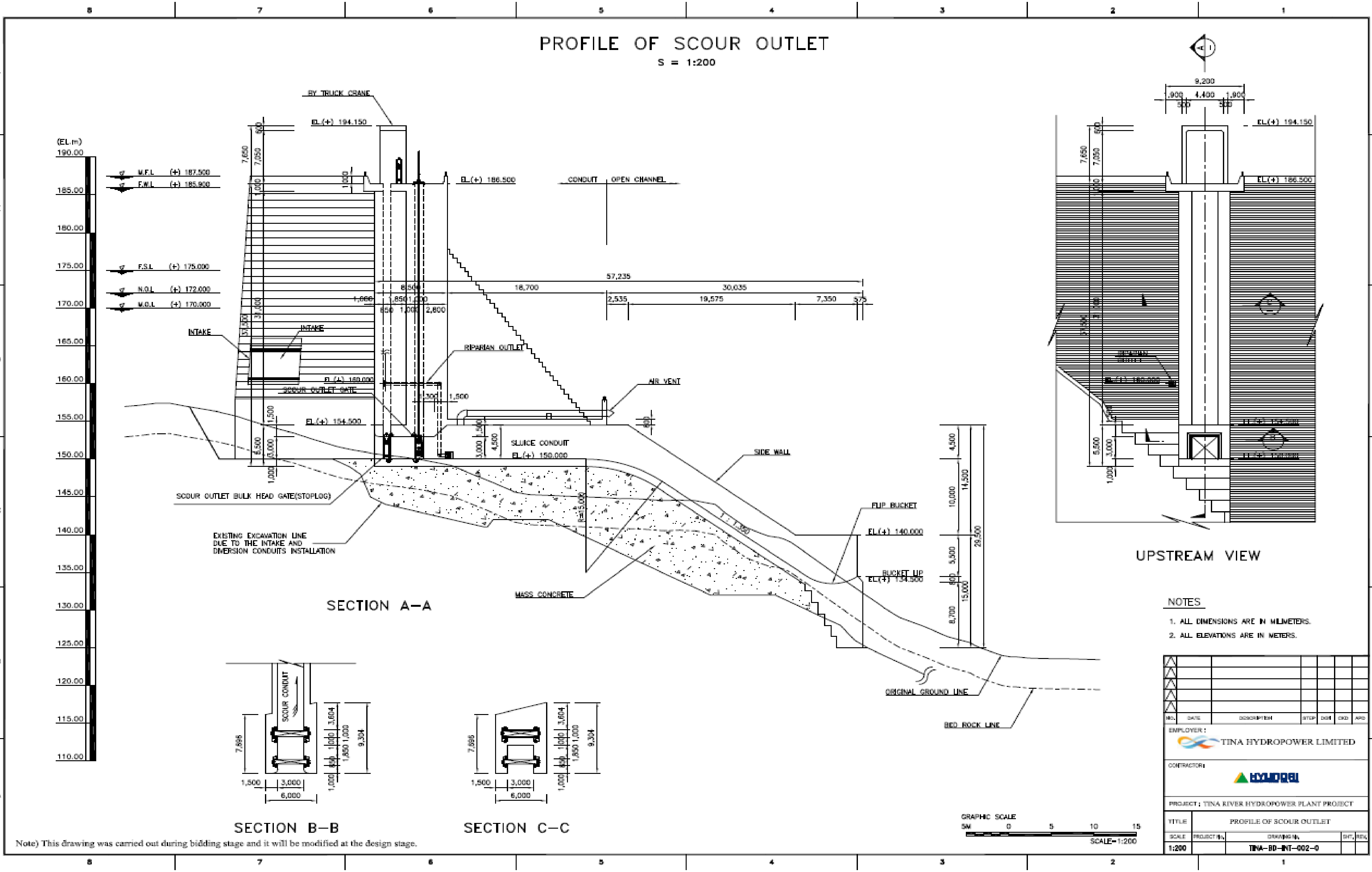


Figure 2-19 Dam arrangement (Technical Proposal, 2017)

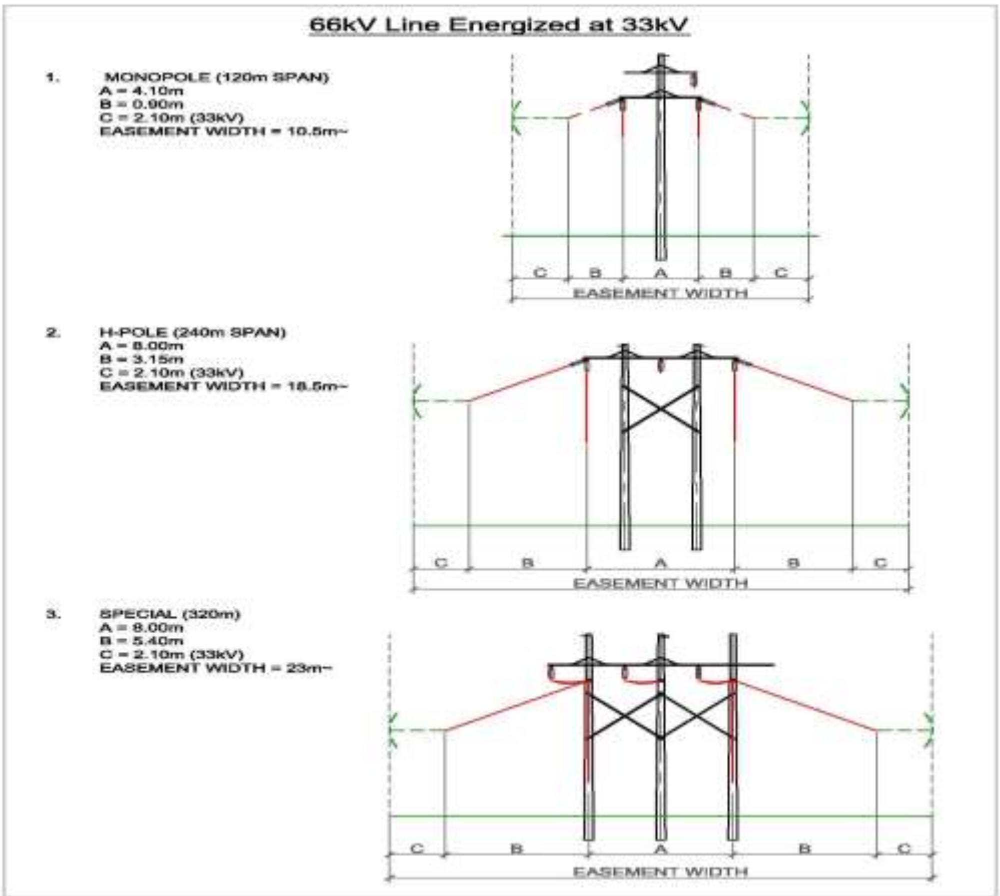
2.3.6 Transmission Line

Two 33kV, 22km long transmission lines, constructed on the access road are proposed to connect the TRHDP substation to the existing SIEA electrical grid at a substation located at the Kukum Highway junction, which in turn, will connect to the Lungga diesel power station. The transmission line will be designed to enable it to be upgraded to 66kV in the future.

The transmission line will be constructed within the purposely acquired road reserve from Black Post to the TRHDP substation above the Power station. The land through which the access road and transmission line are constructed is highly modified, by commercial and casual logging; Oil Palm plantations and relatively intensive settlement. Minor earthwork and complete forest clearing will be required along the right-of-way. The total width of right-of-way for the transmission lines and access road will be up to 50m. Vegetation clearing and control is included in the discussion on access road construction and operation (see Section 13 – ESMP).

Neon 19/3.75 Type AAAC 1120 aluminium alloy conductors will be used to transmit electrical energy. Entura (2014) provided specifications for pole-mounted step-down transformers of 33kV/415V to be located at each village along the access road, to distribute electricity to communities. Figure 2-20 provides examples of the types of transmission towers that may be installed.

Figure 2-20 Examples of transmission line pylons



Source: Entura, 2012

2.3.7 Project Support Facilities

2.3.7.1 Access Roads and Traffic

The main access road will start at the junction between Kukum highway and the existing Black Post gravel road. Black Post Road will provide access to the Project site on most of its current alignment (approximately 10km).

Figures 2-21 and 2-22 are photographs of Black Post Road.

Figure 2-21 Beginning of Black Post Road near Kukum Highway

Figure 2-22 Blackpost Road close to villages

The access road will bifurcate from the existing Black Post Road before reaching Marava. This segment of access road will necessitate about 1.5km of new road construction. Black Post Road stops at Mangakiki. Beyond this point, only an old timber harvesting road is still visible across remnant forests and secondary forests. The dam, powerstation and tunnel sites are currently inaccessible by vehicle. The new section of access road will follow this old timber harvesting road for about 2.6km and will be extended to the South through an area of secondary and primary forests (see Section 6 – Biological Environment Baseline - Terrestrial) to access the dam site on the left bank of the river.

All roads presented in Table 2-4 will require upgrade/refurbishment to accommodate the passage of construction traffic in both directions. This will involve widening, forest and vegetation clearing, and construction of road subgrade, road base, and roadside drainage (including installation of culverts).

Along the existing Black Post Road (up to Mangakiki), the access road will not require any forest clearing but will be widened. This widening will result in encroachment into disturbed habitat dominated by grassland (see Section 10 – Assessment of Impacts on the Biological (Terrestrial) Environment). Beyond Mangakiki, parts of the access road will be constructed along timber harvesting trails, where forest clearing and earth-work will be required. According to Entura (2014). The presence of steep slopes along this section of road alignment will require significant engineering, including high cuts, high fill embankments and retaining walls.

Figure 2-23 shows a photograph of a section of the timber harvesting trail, as it currently exists, beyond Mangakiki, This section of timber harvesting trail will become part of the right-of-way along which the access road will be constructed. The access road will be routed through areas of forest that will need to be cleared.

Figure 2-23 Timber harvesting trail beyond Mangakiki

Under contract to TRHDP, dam constructors will be responsible for subcontracting a local timber harvesting company to undertake forest-clearing activities if needed. Entura's Feasibility Study (2014) identified two quarry sites both in the reservoir area. However, no access roads were identified to connect to these quarries sites. For the purposes of the ESIA, it has been assumed that these access roads will follow topographic contour lines and use the same design specifications as the other access road(s).

The access road from Mangakiki to the dam site will follow the 160masl to 200masl topographic lines, and will enable traffic to pass in both directions. According to GeoRisk Solutions (2014), the access road at the dam site will follow a tortuous ascent in a tributary valley towards the left bank of the River. The main road (sealed road) to Honiara, also called Kukum Highway, will be used to transport material, equipment and pre-fabricated office trailers to the project site. Table 2-4 identifies the different roads that are required to support project construction and operation in Feasibility Study.

Table 2-4 Access roads (Feasibility Study, 2017)

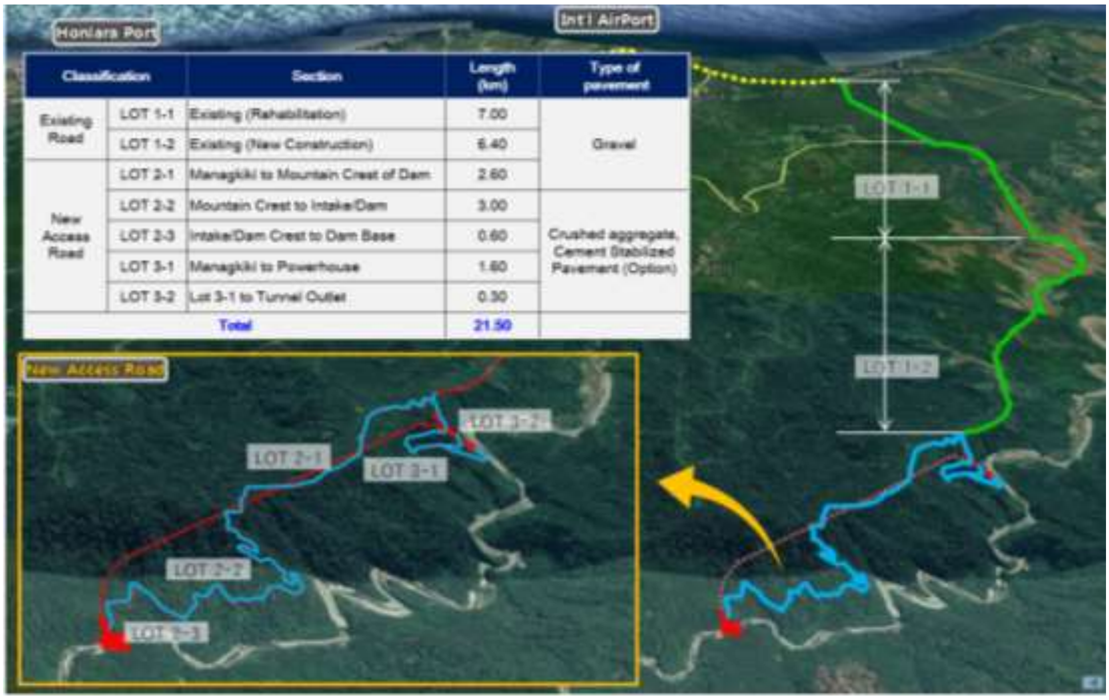
Road	**Type**	**Length (km)***	**Width (m)****
Permanent existing Black Post road	Unsealed	13.3	Approximately 15m (the total right of way is up to 50m to allow room for the two transmission lines)
Permanent access road to powerhouse (extension of Black Post road)	Sealed	1.45	
Permanent access road to dam (extension of Black Post road)	Sealed	4.7	
Temporary access road to intake portal	Unsealed	0.25	Unknown
Permanent road to dam base and mini-hydro	Sealed	0.66	Unknown
Temporary access road to quarries**	Unsealed	1.5	Approximately 15m

* This width includes the right-of-way for the transmission line. Lengths are subject to change when final design is completed.

** It is assumed that access roads will follow topographic contour lines and have the same width as the other access road. It is suggested not to seal this access road to allow vegetation to regrow once material extraction over.

According to the Technical Proposal, the plans for the permanent and temporary roads in main construction area can be summarized in Figure 2-24.

Figure 2-24 Access Road (Technical Report, 2017)



Classification		Section	Length (km)	Type of pavement
Existing Road	LOT 1-1	Existing (Rehabilitation)	7.00	Gravel
	LOT 1-2	Existing (New Construction)	6.40	
New Access Road	LOT 2-1	Managkiki to Mountain Crest of Dam	2.60	
	LOT 2-2	Mountain Crest to Intake/Dam	3.00	Crushed aggregate, Cement Stabilized Pavement (Option)
	LOT 2-3	Intake/Dam Crest to Dam Base	0.60	
	LOT 3-1	Managkiki to Powerhouse	1.60	
	LOT 3-2	Lot 3-1 to Tunnel Outlet	0.30	
Total			21.50	

Small landslides occasionally occur along steep sections and may be exacerbated by the construction of the road. Retaining structures, such as gabion walls, or the removal of upslope colluvium may be required to minimize the risk of landslides occurring during construction and operation of the access road. It is anticipated that daily traffic volumes will be comprised of light, medium and heavy vehicles. The anticipated traffic volume between the construction sites and Honiara is estimated to be in the order of 25 to 40 round trips per day. Additional trips for spoils disposal are expected to take place within the Core Area. Most of the heavy vehicles on the road are expected to be associated with the transport of cement, fly ash, rebar, substation transformers, transmission line towers, and electro-mechanical machinery for installation in the powerhouse.

2.3.7.2 Work Areas and Project Offices

The work area will require 130m x 90m (11,700m^2) of land. It will need to be cleared of vegetation and levelled. Soils will be removed and stockpiled.

The site for Project offices, stores, work areas such as batch plant, crushing areas and pugmill will be located close to the dam on an area of approximately 11,700m^2. The fly ash warehouse will be located in this work area. Other supporting infrastructures locations and characteristics were not defined at the time of ESIA writing.

According to Entura (2014), it is likely that explosives will be needed throughout the construction phase, especially during tunnel excavation, stripping of the dam's foundation and quarrying aggregate for concrete and road paving. Explosives will be handled and stored in accordance with local legislation and statutory requirements. Explosive storage facilities will be isolated from the project office and fabrication, equipment storage and maintenance areas, and will be secured within earth bunds and have sufficient security to prevent theft and misuse.

2.3.7.3 Staff and Workers' Accommodation

The maximum number of staff on site at any one time is estimated to be more than 300 at peak during the construction of the dam. During the first construction season, the maximum number of staff will in the order of 80. Staff will include experienced expat labour and locally sourced semi-skilled and unskilled labour. Accommodation for non- local workers will not be located on site to avoid the presence of non-local workers close to local communities. The housing of non-local workers in Honiara and Lungga will help mitigate adverse impacts on local communities. Employment preference is to be given to Malango and Bahomea communities. It is the responsibility of the Developer to explore accommodation options including in east Honiara, and at Lungga and Henderson, for workers living outside of Malango and Bahomea.

The provision of other utilities on site such as sewage treatment, potable water, electricity and telecommunications is expected to involve minor earthworks.

2.4 BOOT STRUCTURE

The Project aims to mobilize concessional financing which is expected to be one of the largest investments ever to be made in Solomon Islands.

It is expected that the Project will be developed as a build-own-operate-transfer (BOOT) scheme. The developer (Korea Water Resources Corporation and Hyundai Engineering consortium) [KW-HEC] has been selected competitively through an open and transparent tender process under the guidance of International Finance Corporation (IFC). K-Water is wholly owned by the Government of South Korea (an SOE) and has extensive experience of investing in, owning and operating Hydro power stations. Hyundai Engineering Company, a subsidiary of Hyundai Corporation, is one of the largest Engineering construction companies in the World. KW have invested in the successful construction and operation of Hydropower projects in Pakistan and Georgia.

Depending upon the structure and sources of project financing, costs of private financing would have added considerably to the construction costs. The high project cost will put an upward pressure on the power purchase agreement (PPA) tariff, and disincentives SIEA from switching to clean and renewable energy.

Therefore, the Solomon Islands Government (SIG), with the support of IFC and the International Development Association (IDA; World Bank) has sought concessional funds from the Green Climate Fund (GCF) and other sources in order to reduce the financing cost to strengthen the Project's economic viability and to support SIEA's transition from diesel power to renewable hydropower.

KW-HEC, has been granted an exclusive development right to prepare the project. Also, KW & HEC set up a project company, Tina Hydropower Limited, in Solomon Islands and has signed the PPA (Power Purchase Agreement) with Solomon Islands Electricity Authority (SIEA) at 06 Dec. 2018. HEC will be primarily responsible for the Engineering Procurement and Construction (EPC) development and THL will be responsible for the Operation and Maintenance contract during the BOOT period. The BOOT concession period is expected to be for a period of 30 years from commissioning, approximately 35 years from mobilisation. EPC budget includes environmental management and monitoring; Employment of local staff will be prioritised by THL and HEC according to IA. The number of local staff is anticipated as more than 300 . Plans include training for locally recruited staffs.

Kwater-HEC collectively hold 100% of the equity ($10.8 million, KW: HEC = 80:20). The equity investment will be through a Special Purpose Company (THL) which will hold the development licence; will lease the Core Land from the Tina Core Land Company (a SIG-Landowner JV) for the term of the BOOT; and transfer the project to the Government at the end of the BOOT period.

Concessional debt financing is anticipated from the Economic Development Cooperation Fund (EDCF) of the Korea Exim Bank; Green Climate Fund (GCF); Abu Dhabi Fund for Development and IDA. ADB's public sector financing window (Asian Development Fund [ADF]) and commercial window (Private Sector Operations Department [PSOD]) are also considering financing the Project.

2.5 ACTIVITIES ADJACENT TO AND WITHIN THE PROJECT AREA

This section of the ESIA outlines activities within the project area that have had, or continue to have, an influence on the environment and on the local population economy. This section helps to highlight any potential cumulative impacts of other existing or reasonably foreseeable projects or programs (see Section 13). Sources of information regarding the activities in the project area were derived from environmental and social baseline studies undertaken for preparing the initial ESIA, bibliographical sources, and previous project reports (pre-feasibility and feasibility studies). Additional information on each of the activities discussed in the following subsections is provided throughout the ESIA report.

Three main activities occur in areas surrounding the project area: timber harvesting, mining and palm oil extraction. These activities provide sources of income for many people in the area, from royalties, or through employment opportunities. In addition, people's life may be improved with the building of schools, clinics, houses and roads. Nevertheless, despite many benefits on livelihood, health and education, these activities may have caused adverse impacts to accrue to the natural habitat.

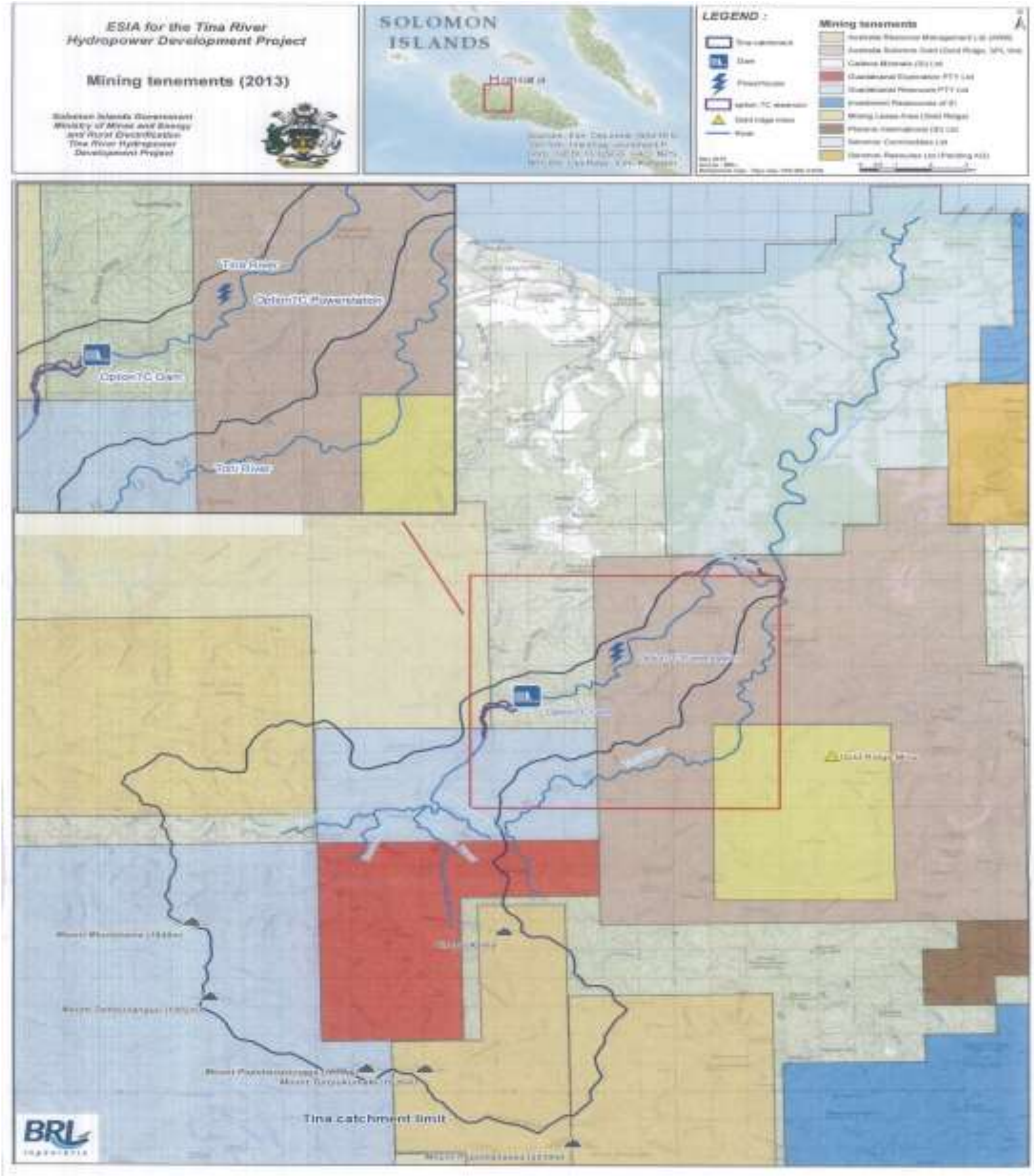
2.5.1 Mining in Adjacent Catchment

Even though mining activities are much localized, they often lead to groundwater and surface water contamination due to siltation and the release of chemicals used in drilling and mineral processing. There are no gold panning activities on the Tina River or within the Toni River catchment. Chupu Kama, in the Tina River catchment area was prospected in the late 1990s. However, gold assay results were sub-economic (Veronica Webster Pty. Limited, 2012). Prospecting has been carried out in the montane region of Tina River catchment. Today there are no mining activities in the Tina River catchment or in the Toni and Ngalimbiu river catchments. Gold Ridge Mining Limited (GRML) is located in the Tinahulu and Chovohoi catchments (both rivers are part of the Metapona River catchment). Prospecting tenements have been granted almost everywhere in central Guadalcanal including ten tenements in the Tina catchment as shown Figure 2-15 (obtained from MMERE).

Gold Ridge has been granted a Special Prospecting License (SPL 194 or Vunusa Tenement), which includes an area overlapping both the Toni and Tina river catchments. SPL 194 covers an area of 130km^2 that surrounds the 30km^2 Mining Lease (No 1/1997). Gold Ridge was negotiating with landowners for land access some of which are also landowners within the TRHDP area. This SPL covers both the Toni and Tina river catchments, as shown in Figure 2-25.

Gold Ridge operations were suspended in 2014, and the Mining Lease (No 1/1997) has now been cancelled. SPL 194 is expected to expire shortly. Today, local entrepreneurs are looking to reopen the mine. Whether SPL 194 will receive an extension or not is unknown. Notwithstanding, it is assumed that if SPL 194 could be renewed, it would represent a potential worst-case scenario for mining impacts within the catchment.

Figure 2-25 Map of mining tenements



2.5.2 Oil Palm Plantations in Lower Catchment

Oil palm industries can contribute to pollution of rivers and coastal areas from fertilizers (mainly nitrogen based) and pesticides. Pollution can also originate from overflowing mill effluent storage ponds. Surface water pollution is particularly aggravated during floods. Oil palm plantations are located downstream of the project site. However, no information regarding water quality was available at the time the initial ESIA was prepared. Mill storage ponds and nearby water courses are regularly sampled for Biochemical oxygen demand (BOD), pH, Total Suspended Solids (TSS), oil and grease. Some oil palm fields drain into the Ngalimbiu River and others drain into the Metapona River. GPPOL has implemented an Integrated Pest Management program that aims to make the use of pesticides more efficient and reduce pollution.

2.5.3 Timber Harvesting in Middle and Upper Catchment

According to WWF (2005) and Pikacha (2008), timber harvesting is the major threat to Solomon Islands forests, as they are exploited faster than their regeneration rates. Timber harvesting causes biodiversity loses, by either killing species or destroying their habitats. It also causes soil erosion, water quality impairment, and may facilitate the establishment of invasive species in remote areas. The opening of the canopy reduces humidity levels near the ground and increases insolation destroying the habitats of many amphibians. Timber harvesting also has adverse impacts on aquatic dependent wildlife. Increased sedimentation, tree felling and frequent collapsing of timber harvesting bridges may obstruct small channels and streams (Polhemus et al., 2008).

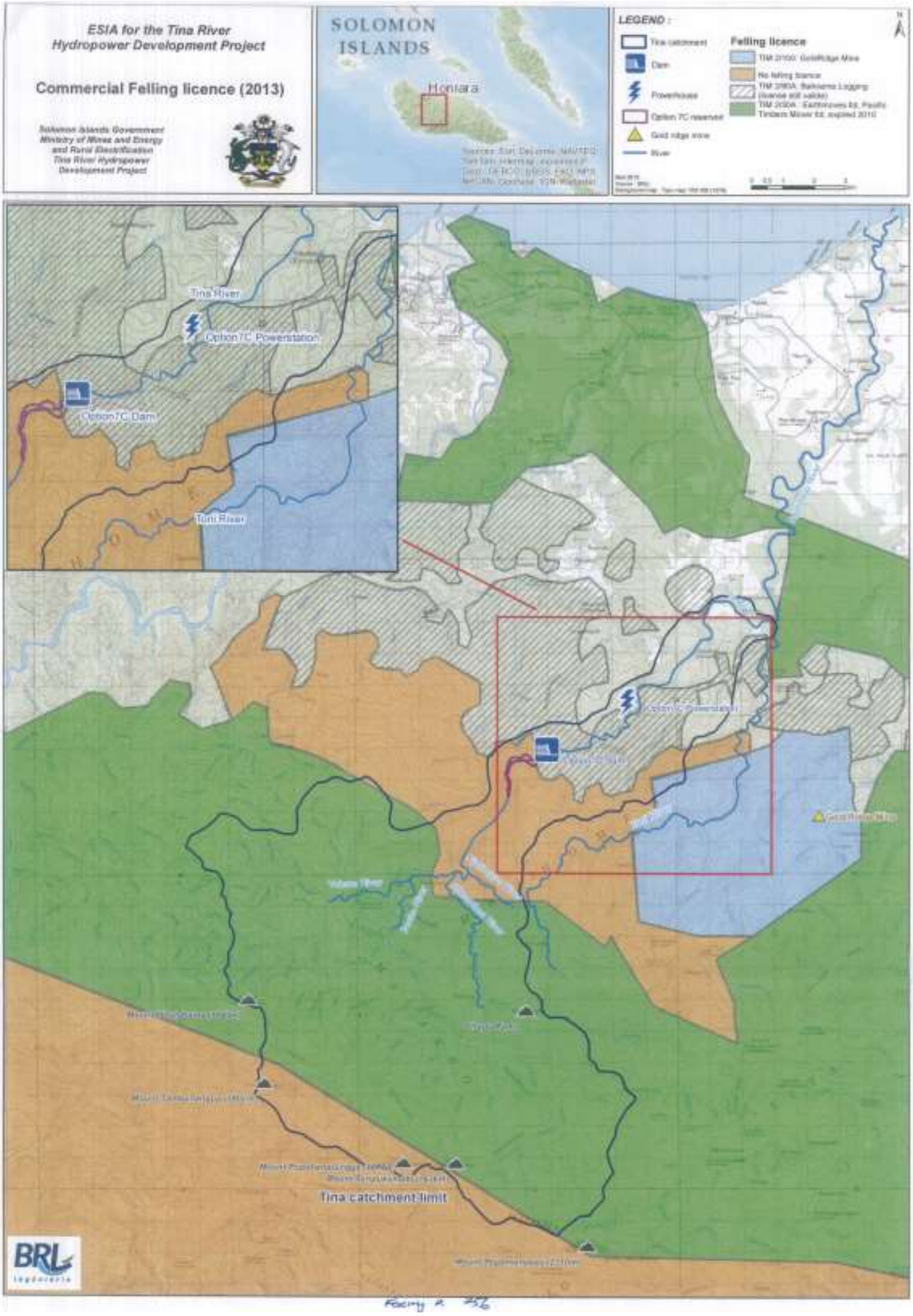
Many areas on the left bank of the Tina River are, or were, being exploited for timber harvesting either commercially (with a timber license) or privately by local villagers. According to national laws, timber harvesting activities are forbidden in areas above 400masl. Based on field visits and the use of Google Earth Imagery, it was possible to observe that most timber harvesting activities were selective timber harvesting, which only involved removing commercially valuable trees. Selective timber harvesting is less damaging to the environment than clear-cutting, since selective timber harvesting has less impact on topsoil erosion. During field visits in August 2013, the sound of chain saws could be heard from Senge to Mangakiki. However, no clear-cut areas were observed. Most timber harvesting activities represent a potential threat to water quality and could increase siltation processes in the reservoir as well as be an initiator of landslides if timber harvesting was to intensify upstream of the dam.

Another problem associated with timber harvesting activities is that no environmental or social impact assessment has been carried out on these activities. It is, therefore, difficult to determine the extent of such activities, or their impacts. License agreements between timber harvesting enterprises and the customary owners of lands are informal and the extent of the exploitation is not precisely known. Officially, according to the Ministry of Forest and Research (2013), there are (or were) three timber licenses within the Tina River catchment, as follows:

- TIM 2/30A: Earthmovers Ltd, Pacific Timber Movers Ltd (Expired in 2010);
- TIM 2/90A: Bahomea Timber harvesting (License is still valid).

Figure 2-26 is a map obtained from MFR that shows the timber harvest licenses recorded as of 2013. It reveals that the majority of the Tina River catchment is, or was, under a timber license.

Figure 2-26 Timber harvesting licenses (2013)



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2.5.4 Gravel Extraction in the Ngalimbiu River

Some private operators have permits to extract gravel from the Ngalimbiu River. Local communities also extract gravel along the Tina River on a much smaller scale (see Section 2.5.5 and Section 13 Cumulative Impact Assessment). Operators pay royalties to landowners of the downstream communities. During both baseline surveys (from July 2013 to September 2013) and mitigation workshops (February 2014), it was impossible to obtain information on the amount of gravel extracted. In theory, a list of the current permit holders should be available from the projects' parent government department but no records are available.

According to a report published by the Pacific Islands Applied Geoscience Commission (SOPAC)[1] Secretariat (2006), river aggregate deposits are composed largely of igneous rock fragments with lesser limestone constituents. Igneous rock fragments comprise plutonic rocks and slightly lower volcanic rocks. In 2005, extraction covered an estimated 10,000m^2 on Ngalimbiu River. According to the SOPAC report, there is a need to develop transparent and efficient mechanisms to manage gravel resources.

The main issue concerning gravel extraction associated with constructing the dam is the alteration of sediment continuity downstream and the progressive halt of gravel replenishment.

2.5.5 Local Population Pressures on Natural Resources

The population of the Solomon Islands has increased considerably over the past few decades (Solomon State of Environment, 2008). Increased population leads to increasing pressure on water usage and water pollution; increasing hunting and fishing; and habitat fragmentation due to timber harvesting. The water quality decreases when moving downstream along the Tina River due to sanitation problems (increase in coliform bacteria). Until recently, agricultural activities were limited to gardens that have had minimal impact on the water quality of the Tina River. More details on local population pressures on natural resources are provided in Section 12 – Assessment of Socio-community Impacts, and Section 14 Cumulative Impact Assessment.

2.6 PROJECT PLANNING AND INSTITUTIONAL REQUIREMENTS

2.6.1 Project Planning Impacts

Planning for a project of the scale of TRHDP in this context requires the establishment of constructive relationships with leaders and the project-affected communities. It is important that these relationships are developed and sustained over time. In this regard, consultation regarding plans for a hydro-electricity scheme on the Tina River began in 2009 and has continued since then.

[1] The Pacific Islands Applied Geoscience Commission (SOPAC) was an inter-governmental regional organisation dedicated to providing services to promote sustainable development in the countries it serves. In 2010, its functions had been transferred to the Secretariat of the Pacific Community (SPC) and the Pacific Regional Environment Programme (SPREP), thus ending SOPAC as a separate entity. Today, SOPAC is a division of the SPC with its main office in Suva, Fiji.

As outlined earlier, TRHDP planning activities have included community awareness raising and social networking, and consultation with tribal chiefs, local leaders, village communities, and organisations in Bahomea, Malango, and Ghaobata. Through such interactions, the PO has become an important organisation among local communities and is seen as having the power to shape their future economic and social lives. In terms of institutions, the PO appears to be closer to the Bahomea community and its leaders than any other government agency.

The TRHDP PO's growing involvement in local affairs, and its relationship with local communities, has been facilitated by the establishment of a network of part-time community liaison assistants (CLAs). These assistants provide information and news about the project to their villages, help organise events, and provide support to project planning activities. Furthermore, the project officers appear to make efforts to be accessible to the people of Bahomea, and the Honiara-based PO receives a steady stream of visitors from the area, often seeking assistance with problems. In the context of post-Tension relations with government, the PO and its network of liaison people appear to have been a positive development.

2.6.2 Institutions

As part of its planning, in 2009, the SIG created the Tina River Hydro Landowner Council (LC), an elected body of tribal representatives with which government could negotiate to obtain access to the area, so that project feasibility studies could be carried out. Government made a payment of an Access Fee of SBD 100,000 per member to the 27 clans and sub-clans making up the council, to assist in forging an access agreement. Working with the already established Bahomea HOC and the Malango HOC, the LC also began work on identifying the rightful landowners within the proposed project areas.

Due to representational issues, the apparent proliferation of stakeholders, politicisation of the process, and associated rent seeking, the PO reduced its support for the LC and started working instead with a community consultative group, referred to as the Bahomea Land Identification Committee (BLIC). This is a voluntary group of the most knowledgeable Bahomea elders who wanted the landowner identification process to progress without it becoming politicised or corrupted. There has since been dissatisfaction among some members of the (now defunct) LC, despite the Government's legal endorsement of the current land identification arrangements. At the same time, the HOC was initially supported by the TRHDP PO in resuming its traditional leadership role in customary land and cultural affairs. The TRHDP has, therefore, already had a mixed effect on the institutional situation in the project area[2].

During the construction, the developers and contractors will have a strong influence in local communities. Their activities are likely to affect all villages in the Tina area in some way, and there will be more contacts between the communities and the project than at present. The developer should continue to consult directly within affected peoples with the community via community liaison committees. The SIG will need to monitor the developer and the contractors in regard to their performance in this area.

Consultation and negotiation will place an increasing burden on community representatives. It is doubtful that the local communities and institutions have the capacity to cope with the amount

[2] Crucially, since the SIA fieldwork and associated consultations, the landowning tribes for the Option 7C Core Area have publicly asserted their rights over decision making over their land, rejected the institutional validity of the Landowner Council, and endorsed the alternative BLIC process (see, for example, Core Land Tribes press release, 24/6/2014)

of work and the complexity of issues arising from the project planning and implementation. Dealing with matters as diverse as compensation for damage to land owner property, cultural heritage protection, benefits sharing and river management, will require that local communities obtain additional capacity, such as affordable, honest, and independent legal advice. Legal advice to land owners is currently available from the Public Solicitor's Office.

2.6.3 Group Formation and Stability

There is no catchment-wide social or political organisation representing those most likely to be affected by the proposed development. The LALRP provides information on the co-operative societies formed to represent landowning groups who are resident of a number of different communities across Malango and Bahomea.

A number of villages want to be able to represent themselves in negotiations with the project and government over compensation and do not want this role to be captured by the HOC or the LC. Some villages have formed their own informal groupings such as the "Up Stream Community" (USC) – involving Valekocha, Komureo, Namopila, Pachuki, Senge and Koropa.

In the downstream Ghaobata villages, where a number of landowner and interest organisations were established to deal with the Gold Ridge mining companies, and the operators of the palm oil plantation, there is also a strong call to have their interests and concerns addressed in a separate organisation. The SIG and PO need to pay more attention to the involvement of the downstream Ghaobata communities in planning decisions.

The desire for separate representation by some communities is understandable, given that there is distrust of landowner trustees and other leaders, and people who have acted previously as agents for timber harvesting companies, etc. The proliferation of groups seeking direct and localised representation in dealings with the project has the potential to increase the risk of internal conflicts or require special attention by the PO and its advisers.

2.7 IMPLEMENTATION SCHEDULE

According to Technical Proposal (2017), the Project was estimated to take approximately 57 months to construct and commission and EPC contractor will start project activities from mobilization and access road. The detailed construction schedule is finally set out after a basic and detailed design.

2.8 PROJECT OPERATION

Details of power station operation, and utilisation of available water resources in wet and dry seasons will be determined as a result of complex computer modelling. However, the evaluation of available energy from the 29 years of simulated flows, compared with the normal patterns of demand in Honiara, and accepting Solomon Power assessment of load growth, has enabled some calculations to be made.

Wet year inflows will see the station able to operate at full capacity for most of the time – with unused water being spilled around 40% of the time. In the driest three years on record (i.e. an event with about 10% probability) the station will only rarely be able to utilise all three machines.

In those dry years it is expected that the hydropower station will be used to reduce the need for diesel capacity in the high demand times of the week – between 8 a.m. and 6 p.m. If diesel produced a steady 8MW for the whole of this period of the day, the hydro could produce all of demand which exceeded that base load, in any circumstances modelled. The hydro could also meet all demand above a 6 MW baseload, for all but 4 weeks in the driest year.

This modelling assumes that in these relatively rare, dry events, the inflows over-night (apart from the environmental flow) will be used to restore lake levels. Flows during these night time periods would be restricted to the environmental flow plus minimum machine outflow (2.4 m^3/s) above the Toni River.

2.9 PROJECT COST

The capital cost of the Project was estimated to be US$133.3million (Entura). Currently it is about US$213 million.

2.10 PROJECT DECOMMISSIONING

It is expected that the TRHDP would have an operating life of 80 to 100 years, and that at the end of this lifespan, it would probably be decommissioned. Decommissioning would involve draining the reservoir, excavating sediments from within the former reservoir, removing the dam, restoring former natural flow regime to the river channel, draining and blocking the power headrace tunnel, removing the penstocks and powerhouse, and removing the switchyard. The various impacts associated with decommissioning would be examined in a separate ESIA that would be prepared at that time.

3. INSTITUTIONAL AND LEGAL FRAMEWORK

3.1 INSTITUTIONAL FRAMEWORK

This section presents information on the government agencies and NGOs that will most likely play a role in the Project implementation and, where appropriate, discusses their policies, objectives and mission statements as they pertain to TRHDP.

3.1.1 Ministry of Mines, Energy and Rural Electrification (MMERE) and TRHDP Project Office (PO)

The Ministry of Mines, Energy and Rural Electrification (MMERE) is responsible for mining, energy and water resources in the country. It consists of a number of strategic divisions: mines, geology, water resources, and energy divisions, each headed by a director. MMERE's corporate division provides administrative logistical support to all other departments. The administrative head of MMERE is the Permanent Secretary, and the political lead is the Minister. MMERE plays a strategic role in the current development phases of Solomon Islands through the emerging mining sector, the focus on developing sustainable energy supply for the country, and the increasing pressure on water resources.

The Energy Division (ED) is the lead agency directly implementing the Project through the TRHDP PO. The TRHDP PO consists of approximately ten local and expatriate staff, supported by contractors, and includes expertise in engineering, project management, legal, customary land, community relations, public relations, biology and social sciences. As the key government agency responsible for the TRHDP, the PO provides overall coordination and support on matters relating to government policy, land and project implementation and is responsible for meeting the requirements of major donors, such as the World Bank. In the context of the ESIA, the PO plays a critical role in ensuring the information required for the ESIA is provided by other government agencies and stakeholders.

The ED plays an oversight role and ensures that the PO implements the Project according to the directions set by the government. A major constraint faced by the energy division is the limited number of officers available to manage quite a broad range of issues relating to energy in the country. In this context the PO provides dedicated personnel for the Project.

MMERE will also play a key role in overseeing the procurement, engineering design and construction of the access road from the Black Post turnoff to the dam site. Current indications are that the capacity of the MMERE is sufficient to respond to the large-scale TRHDP development with the support of the TRHDP PO and donor agencies. TRHDP PO has engaged an international road specialist to assist with this role.

Through its Policy Goal within MMERE, the Solomon Islands Government Translation and Implementation Framework states that:

> "The mineral and energy resources are used in a sustainable, innovative, environmentally conservative and socially acceptable manner that enhances the well being of people and helps toward making Solomon Islands energy efficient".[3]

[3]NCRA Government Policy Statement

The Solomon Islands National Energy Policy 2014 underpins the role of the ED and outlines the National Government's policies for the planning and management of the energy sector over the next 10 years (2014-2024). to the vision of the Policy is to unlock 'the development potential of Solomon Islands' economic base through a dynamic and effective energy sector'.[4]

The Policy's stated mission is that it:

> "Provides the base for appropriate coordination, planning, promotion, development and management, and efficient use of energy resources".[5]

The role of the MMERE and its Energy Division and PO in implementing these policies is, therefore, critical as preparations are made for the TRHDP development.

3.1.2 Solomon Islands Electricity Authority

The *Electricity Act* establishes the Solomon Islands Electricity Authority (SIEA), operating under the brand of Solomon Power, as the central entity to generate electricity in the Solomon Islands. SIEA is in charge of all matters related to electricity production and transmission/distribution, including ensuring standards of safety, efficiency and economy. It also advises the Government on matters related to electricity and can make recommendations as to regulatory instruments. The SIEA is set up as a "corporate body", with independent liability and the capacity to independently enter into contracts[6.]

SIEA consists of a Chairman and four members who, together, form its Board, as well as a general manager, who acts in an ex-officio capacity. The General Manager is appointed by SIEA, whereas, the five members of the Board are all appointed by the Minister of MMERE. SIEA is free to appoint any other members of staff and is largely self-regulated[7].

SIEA will play a critical role in the purchase and distribution of power from the Project. SIEA has entered into the Power Purchase Agreement (PPA) with THL and through this agreement SIEA has contractual rights to enforce the THL's obligations under the ESIA. SIEA are also responsible for submitting an EIS/PER for the construction and operation of the transmission line system for the project.

The organisation is going through an institutional reform with support from the World Bank to increase its revenue collection capacity and improve its services.

3.1.3 Ministry of Environment, Climate Change, Disaster Management and Meteorology (MECDM)

The Ministry of Environment, Climate Change, Disaster Management and Meteorology (MECDM), has four divisions, each with their own respective directors. The Meteorology division, the Climate Change Division, Disaster Management Division and Environment and Conservation Division.

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4 Solomon Islands National Energy Policy 2014

5 Solomon Islands National Energy Policy Framework

6 *Electricity Act*

7 Ibid.

The Environment and Conservation Division (ECD) is the key department responsible for assessing, monitoring and mitigating the environmental and social impacts of developments in Solomon Islands. The *Environment Act 1998*, *Wildlife Protection Act 1998*, and the *Protected Areas Act 2010,* together with their respective regulations, guide its mandate. MECDM's Strategic and Corporate Plan 2012-14 identifies five strategic areas (listed below) as core functions of the Ministry.[8] Within each of these strategic areas, target issues are also identified.

- Strategic Area 1 - Conservation and Management of SIs' Environment
    - Conservation and management of biodiversity
    - Protected areas network
    - Waste management and pollution control
    - Development control
    - Environment Training
- Strategic Area 2 - Climate Change
    - Policy and legislative framework
    - Mitigation strategies
    - Adaptation strategies
    - International representation
- Strategic Area 3 - Meteorology
    - Policy and Legislative review
    - Meteorological Forecasting, operations and monitoring
    - Early Warnings (tsunamis and extreme events)
    - Quality management systems
    - Data & Information management system
    - Research
- Strategic Area 4 - Disaster Management and Risk Reduction
    - Governance and Institutional Framework
    - Operational effectiveness and capacities
    - Public awareness and village disaster risk planning
    - National Disaster Management Office (NDMO) capacity and capability
- Strategic Area 5 - Corporate Services
    - Management Teamwork, direction and coordination
    - Performance management
    - Communication and information flows
    - Staff development and skills upgrading
    - Trainings, selection and recruitments
    - Logistics and asset management
    - Financial Planning and management
    - Corporate planning and reporting

The ECD will play an important role under the *Environment Act* in evaluating the environmental and social impact assessment for the Project, conducting community consultation and issuing

[8] MECDM Corporate Plan 2012-2014

the development consent for the Project. The ECD will also play a key role in monitoring the environmental impacts of the Project.

The increasing number of large-scale developments in the country has put a lot of pressure on the division, which has limited capacity in terms of staff and technical ability to assess and monitor environmental and social impacts. While ECD has developed considerable experience addressing the social and environmental issues facing the neighbouring Gold Ridge Mine, ECD would benefit from technical inputs and analysis of water quality and other parameters by third parties. Third party inputs will be incorporated in the final design of the ESMP where relevant.

3.1.4 Ministry of Lands, Housing and Survey (MLHS)

The complex task of administering land lies with the Ministry of Lands, Housing and Survey (MLHS). The key legislation governing the Ministry's mandate is the *Land and Titles Act.*

The Commissioner of Lands is empowered under the *Lands and Titles Act* with the administration of registered land in the country. While customary lands are beyond the Commissioner's jurisdiction, it is the Commissioner's role to acquire and oversee the registration of customary land for development.

With respect to the Project, the Commissioner of Lands had responsibility to oversee the acquisition of the customary land required for the Project under the *Land and Titles Act*. MLHS is also responsible for enacting the subdivisions and transfers of registered land required for the road and transmission line corridor. As the land access components of the Project are managed by SIG, the impact of land acquisition and safeguards relating to this are set out in the Land Acquisition and Livelihoods Restoration Plan.

The Registrar of Titles serves a core function in formally registering land transactions.

The Geographic Operations Group (GOP) provides technical support to other core functions within the MLHS. Surveyors are posted to provinces and are included in the Lands & Survey Provincial Operations Group. With the devolution of the Town & Country Planning Boards to Honiara City Council and the Provinces, physical planners have been re-tasked to provide professional advice and support to these Boards where operational.

The Policy, Management and Regulation Executive Committee provides policy direction to the Ministry and monitors the achievements of its programs[9]. The Administrative Support Services provides administrative services and support to the whole of MLHS. The Human Resource (HR) unit has responsibility for overseeing and supporting human resource development within the Ministry.

The land administration system was inherited from the colonial period, well before independence in 1980, and more than 20 years of poor governance and a lack of funds has diminished the Ministry's capacity. Efforts to support the development of the MLHS have been ongoing since 1999, with support from Ausaid's Solomon Islands Institutional Strengthening of Land Administration Project (SIISLAP), which ran from 1999 to 2007[10]. MLHS also receives some ongoing support from the Pacific Community (SPC).

9 Ministry of Lands, Housing and Survey Corporate Plan.

10 *Solomon Islands Institutional Strengthening of Land Administration Project (SIISLAP)*

3.1.5 Ministry of Forestry and Research (MFR)

The Ministry of Forestry and Research (MFR) was created by the Coalition for National Unity and Rural Advancement (CNURA) Government in January 2008.

The MFR undertakes its duties under the framework of the *Forest Resources and Timber Utilisation Act 1969* (FRTU Act).

The FRTU Act, as amended, is the main law governing the use and management of forests in Solomon Islands. Repeated efforts to revise the FRTU Act in recent years have failed to obtain Cabinet approval

The Act assigns responsibility for managing the felling and milling of trees for commercial use to the MFR's Commissioner of Forests.

Section 4 (1) of the FRTU Act establishes that it is an offence to fell trees or remove timber for sale except if it is:

- under and in accordance with the terms and conditions of a valid licence;
- for a purpose declared by notice of the Minister to be exempt from a valid licence; or
- other purposes not applicable to the Project such as use for firewood or under the authorisation granted to a licenced mill.

Section 4(2) of the FRTU Act provides that "any person who fells trees or removes timber from any land shall, until the contrary is proved, be presumed to have felled that tree or removed that timber for the purpose of sale". Whether a timber licence is required for TRHDP will likely depend on whether the timber felled is ultimately sold.

While eight amendments to the FRTU Act have occurred, along with a number of additional regulations, it remains out-dated and principally focused on the role of the MFR in licensing and monitoring the logging industry, including focusing on the allocation of rights and licenses to fell and mill trees. Even in this area, it has significant weaknesses. These include provisions for high levels of discretionary power by forest and tax officials, and limited guidance on levels of license allocation and best practices for timber harvesting.

The FRTU Act covers both forests on registered land and customary land, with any licensee required to have entered into an agreement with the landowner of the plot(s) on which the trees are situated. This requires an agreement of the allocation of timber rights to be obtained from all groups having rights over the land. This process is straightforward on registered lands, but becomes more complex on unregistered customary land where rights holders must first be identified, and then sufficient time allocated for rights to be contested.

With respect to the TRHDP, any trees felled will be within the area of land acquired and registered for the Project. This will reduce the complexity of the timber rights process. If a felling licence is required the registered owner of the land will sign the timber rights agreement for the land and a profit-a-prendre will be registered on the certificate of title. The land valuation conducted as part of the acquisition process outlined in the Land Acquisition and Livelihoods Restoration Plan (LALRP) included an assessment of the commercial timber value of the forests on the acquired land.

A Felling License does not involve any separate environmental permitting processes in addition to the development consent required from the Director of the ECD under the *Environment Act*. In practice many logging operations fail to obtain development consent.

3.1.6 Ministry of Culture and Tourism (MCT)

The primary role of the Ministry of Culture and Tourism (MCT) is to develop, protect and promote Solomon Islands' culture, art and heritage. MCT is an entity that hosts the national museum. Tabu sites and cultural heritage is the responsibility of the National Museum of Solomon Islands.

The National Museum will need to be consulted regarding valuing and undertaking on site assessments if there is proposed disturbance or removal of a tambu site for development purposes.

3.1.7 Ministry of Development Planning and Aid Coordination (MDPAC)

The Ministry of Development Planning and Aid Coordination (MDPAC) was created from the former Department of National Reform and Planning in the mid-2000s. MDPAC is responsible for:

- The preparation and subsequent monitoring of implementation of the National Development Plan. The current plan is the National Development Strategy 2011-20.
- The preparation and formulation of the annual Development Budget Estimates. The SIG prepares two budgets each year, the recurrent budget and the development budget.
- Aid coordination. MDPAC is responsible for coordinating development partner activities and for securing donor funding for new projects/programmes. This is a critical aspect of successful preparation of the annual Development Budget. Aid coordination also includes frequent liaison with aid donor representatives and for the organisation of high-level talks with some development partners.

MDPAC is the lead coordinating agency for donor-funded projects and, therefore, is a key stakeholder. The Ministry has shown considerable competence in managing and coordinating donors in the country and has been and will be involved in the TRHDP in this regard.

3.1.8 Ministry of Infrastructure and Development (MID)

The Ministry of Infrastructure and Development (MID), Department of Infrastructure (DI) plays a key role in the public administration of Solomon Islands, and is responsible for roads, wharves, airstrips and government workshop facilities. In the past twenty years, the government and donors have invested a little more than one billion Solomon dollars in transport infrastructure throughout the country. The country's internal problems, including inadequate funding, reduced DI's capacity for ongoing and systematic infrastructure maintenance. Consequently, much of that infrastructure is now in need of complete reconstruction. DI's mission is to enhance the prosperity, wellbeing and participation of the community by providing an integrated, efficient and affordable infrastructure and transport system; supported by ethical, professional, proficient and valued staff.[11]

The work of DI focuses on the sustainability of rural and urban livelihoods[12]. Its scope includes:

- Provide quality advice to support the Government's reforms and priority activities
- Implement major reforms in line with Government policy

[11] Ministry of Infrastructure and Development Corporate Plan

[12] ibid

- Offer individuals and industry in various parts of the country a satisfactory and safe transport system at affordable cost
- Ensure compliance and a regulatory framework that delivers safe, reliable and efficient transport services
- Ensure that financial resources are targeted to best achieve Solomon Island's transport system needs
- Communicate the benefits of transport reforms
- Effectively plan the upgrade and rehabilitation of infrastructure, government housing stock, fleet, plant and machinery
- Effectively provide transport planning that supports other sectors in the economy through an integrated approach, targeting Economic Growth Centers and vital social infrastructures
- Promote development of a professional, technical, proficient, able, capable and dedicated workforce
- Ensure and provide opportunities for more private sector participation.[13]

3.1.9 Guadalcanal Provincial Government

Guadalcanal Province is divided into 21 Electoral Wards. Elections are held every 4 years for the 21 Members of the Provincial Assembly. The Premier is the political head of the Province and also presides over the Provincial Executive. The Speaker presides over the Provincial Assembly meetings. The Provincial Assembly is the highest law-making body in the Province. It enacts and passes ordinances for the proper conduct, welfare and livelihood of Guadalcanal citizens.[14]

Currently, there are 10 Executive Members or Provincial Ministers including the Premier. Similar to the national government, each Minister is responsible for a certain portfolio. The portfolios are as follows:

1. Office of the Premier, including Finance & Education
2. Ministry of Planning and Economic Development/Deputy Premier
3. Ministry of Natural Resources
4. Ministry of Reconciliation and Rehabilitation
5. Ministry of Health, Medical and Social Services
6. Ministry of Agriculture & Lands
7. Ministry of Geana Regional Affairs
8. Ministry of Tasimauri Regional Affairs
9. Ministry of Tasimate Regional Affairs

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13 ibid

14 Guadalcanal Province - Reform and Rural Regional Development and Empowerment Policy Framework (2011-2015)

The administrative head of the Province is the Provincial Secretary who coordinates all administrative and management units in the Province. The incumbent is seconded from the Public Service on a fixed-term appointment. In this regard, the Provincial Secretary and other seconded officers have a dual responsibility. While they are responsible to their supervisor at the national level, they are also required to equally fulfil their duties to the Province.

Guadalcanal Province has been mandated by an Act of parliament to perform three different functions in the provision of services to the people, including “legislative matters, provincial services and statutory functions”. However, some of the statutory functions have not been transferred from the national to the provincial government at the time the ESIA was prepared.

Regarding legislative matters, Guadalcanal Province has been responsible for the following: facilitating the marketing of products; collecting land taxes to raise revenue; forming the Guadalcanal Town and Country Planning Board; providing water to some rural villages; and establishing corporate bodies for the provision of provincial services, including some economic activities. The provincial minister responsible for natural resources has been vested with certain powers to facilitate some forestry operations under the Devolution Order No. 1 of the *Forestry Resources and Timber Utilisation Act 1970.* As well, the police have been collecting revenues from commercial vehicles under the *Traffic Act*.

Provincial governments, under Schedule 3 of the *Provincial Government Act 1997* (PG Act), have been given responsibility for minor local matters such as the licensing of local businesses, bars, hotels, markets, fire protection and waste disposal. They have not been empowered with control over the delivery of services for the people.

With respect to the Project, the Guadalcanal Provincial Government’s newly constituted Town and Country Planning Board will have a role in granting planning consent for the Project under the *Town and Country Planning Act*. This consent is separate to the development consent to be issued by the ECD of MECDMM under the *Environment Act*.

The Province will also have a key role in issuing business licenses for the developer and other sub-contractors under the *Guadalcanal Province Business and Hawkers Licence Ordinance*.

The Provincial Government may also have a role in the application of ministerial powers under the *River Waters Act* under a devolution order. This will require confirmation in consultation with SIG.

3.1.10 Ministry of Agriculture and Livestock Development (MAL)

Established in the 1950’s the Ministry of Agriculture and Livestock Development (MAL) is one of the oldest ministries and has played a key role in the development of the country. Its levels of capacity have, however, shifted significantly over time, with staff numbers reducing from over 400 in the late 1990’s to 169 in 2007 (GoSI 2007, MAL 2007). Over 80% of the country’s population still relies on subsistence agriculture as a key element of its livelihood strategy. Improvement of small-scale agricultural production is a key goal for national growth.

The MAL is currently subdivided into four departments, each with its own director:

- The Livestock and Quarantine Department – Aim is to formulate and regulate policies; provide livestock development and extension services in the provinces; breed and distribute livestock and disseminate information; and conduct research into indigenous animal species.

- Extensions and Training Department - The department's staff is supposed to work directly with villagers in rural areas. Around 100 extension staff are planned for the provinces, mostly men, with up to 10 in each province, except Western Province and Malaita, which will have 20 each. In many cases, the majority of staff are based in the provincial capital.
- Research Department - In the past this department, which is based at Dodo Creek, played a major role in the delivery of services, both directly to farmers via on-farm field trials and demonstration plots at its field stations, and via technical support to the Extensions and Training Division. With the destruction of the research station and the displacement of research staff, the department is unable to function effectively.
- Planning and Management Department - This department includes the land use-planning unit. It had a general role in coordinating the activity and policy of the other MAL departments.

Whilst MAL has no direct inputs in the Project, development activities to compensate for impacts on livelihoods could be agriculturally based and therefore their inputs in any such initiatives will be important. Land based compensation measures are discussed in the Land Acquisition and Livelihood Restoration Plan.

3.1.11 Ministry of Finance and Treasury (MFT)

The Ministry of Finance and Treasury (MoFT) is responsible for facilitating the provision of sound advice on monetary, budget and fiscal policy to the Solomon Islands Government. The mission of the Ministry is to provide leadership to the Solomon Islands community in financial matters and deliver high quality, professional financial and economic services to the Minister of MFT, the SIG, other ministries, and the wider community.[15]

MoFT's services include statistics and economic management to support government decision-making processes and the implementation of good governance practice.[16] Core tasks of the Ministry include financial reporting, revenue collection, border protection, government payments, preparing and managing the annual recurrent budget and advising the Government on a range of financial policies including economic reforms.[17]

To achieve its mission, MoFT delivers services through its divisions and units:

- The Customs and Excise Division
- The Inland Revenue Division
- The Budget Unit
- The Economic Reform Unit
- The Debt Management Unit
- Statistics,
- Internal Audit,
- Corporate Services[18]

[15] Ministry of Finance Corporate Plan

[16] ibid

[17] ibid

[18] ibid

MoFT has been very active in structuring and sourcing consessional financing for the Project. MoFT will manage the on-lending of these funds to THL, and their repayment to concessional finance parties under an On-Lending Agreement to be entered into between THL and SIG.

3.1.12 Public Solicitors Office

The Public Solicitors Office provides legal assistance and representation and comprises of three key units:

- The Criminal Unit;
- The Family Protection Unit; and
- The Landowner's Advocacy and Legal Support Unit (LALSU).

LALSU provides free legal advice sessions and formal representation to landowners and communities across the country relating to land use and ownership, with an emphasis on logging, mining, protected areas and large-scale developments. LALSU also conducts regular legal awareness trips to each province, runs test cases and is active in advocating for policy and law reform impacting on customary land owners. LALSU works closely with NGOs in the environment space and has strong relationships with the Ministry of Environment, Climate Change and Disaster Management.

With respect to the Project, LALSU has provided a series of awareness sessions on legal rights to communities in the Project area. LALSU has also provided assistance to identified landowning owning tribes in the compulsory acquisition process. This is discussed in further detail in the Land Acquisition and Livelihood Restoration Plan.

3.1.13 Civil Society / Non-government Organisations (NGOs)

There is a range of civil society groups and non-government organisations (NGOs) that are likely to play important roles in the development of the TRHDP. The involvement of civil society groups will be important in the review of the ESIA, in particular, the implementation of mitigation measures adopted in the environment management plan. The role of many of the civil society groups in the country can be described as geographically constrained, or, on a national level, sporadic and reactive when issues arise. Often, this is the result of the perception that political interference dominates major development projects and programs in the country.

Table 3-1 includes a list of civil society groups / NGOs that may become involved in the project at some stage.

Table 3-1 Key NGOs

Civil Society/NGO	Focus area	Potential Involvement
Transparency Solomon Islands (TSI)	Transparency and Governance in Solomon Islands	Benefit distribution and the nature of agreements between communities, landowners and investor
Solomon Islands Development Trust (SIDT)	Rural development	Community projects and development

Civil Society/NGO	Focus area	Potential Involvement
The Nature Conservancy	Environmental conservation and promotion of protected areas	Advocacy with respect to environmental impacts
Live and Learn Environment Education (LLEE)	Environment Education	Education and awareness on the potential environmental impact on livelihoods for communities and on gender inclusion and leadership
Red Cross	Social and health issues and advocacy	Advocacy and training on health issues and opportunities from the Project
National Council of Women (NCW) and Guadalcanal Provincial Council of Women	Advocate women's rights and gender equality	Ensuring gender issues are fully addressed and that issues affecting women are taken into account.
World Wide Fund for Nature (WWF)	Environmental advocacy and promotion of protected areas	Environmental and conservation advocacy

3.1.14 Key Stakeholders

There are a number of other stakeholders that will play direct and indirect roles in the TRHDP. These stakeholders are important for the reasons indicated in Table 3-2 and are described throughout the report.

Table 3-2 Key stakeholders

Stakeholder/Organization	Importance to Project	Key focus areas/Lessons learned
Gold Ridge Mining Ltd (GRML)	Close proximity to the Tina Hydro Project. Many villagers worked or received royalties from GRML when operational.	▪ landownership issues ▪ benefit distribution ▪ lessons learned from addressing environment and social issues
Guadalcanal Plains Palm Oil Ltd (GPPOL)	Close proximity to the Tina Hydro Project. Many villagers work for GPPOL or receive royalties.	▪ land issues ▪ benefit distribution ▪ dispute settlement ▪ community engagement. ▪ addressing environment and social issues
World Bank /DFAT/Green Climate Fund/EDCF/IDA/ADB	Main or potential funding agencies	▪ World Bank Environment and Social Safeguards ▪ World Bank (WB) Performance Standards ▪ ADB Safeguard Policy Statement (2009)
Financial Institutions including Pan Oceanic Bank and ANZ	Management of financial benefits for landowners from the project including establishing bank accounts for individuals and trust accounts for minors	▪ financial services to landowning groups and compensation recipients ▪ financial literacy to communities

3.2 ACTS, REGULATIONS AND ORDINANCES

This section describes the acts, regulations and ordinances that are relevant to the Project and helps to describe what is required prior to the implementation of TRHDP. This section also presents requirements from national and provincial legislation to ensure the compliance and will assist in the development of mitigation measures in the course of the ESIA.

Table 3-3 presents a summary of the Solomon Islands regulatory regime (see Annex 10 for a more complete analysis).

Table 3-3 Solomon Islands Acts and Regulations

Name of Act or regulation	Implication for the Project
Constitution of Solomon Islands	The Constitution provides additional safeguards for the compulsory acquisition of customary land.
Solomon Islands National Energy Policy 2014	The Policy outlines the National Government's policies for the planning and management of the energy sector over the next 10 years.

Name of Act or regulation	Implication for the Project
Agriculture Quarantine Act 1982	An Order of the Minister may prohibit or regulate the importation or landing of: (a) animals and animal products; (b) plants; (c) earth; and (d) other things by, or by means of, which it appears to the Minister that any disease or pest might be introduced.
Environment Act 1998 and Environment Regulation 2008	The TRHDP is a prescribed development under schedule 2 (section 16) of the *Environment Act 1998* and, therefore, requires the preparation and submission of an Environment Impact Statement (EIS) through the Environment and Social Impact Assessment (ESIA) Process. The scope of the *Environment Act* and its Environment Regulations encompass a number of processes, and procedures, and the establishment of an institution, to regulate them. The following key issues are addressed by the legislation: ▪ Provides the guiding principles and definition for environmental management. ▪ Establishes the Environment and Conservation Division as a key institution responsible for managing environmental issues in the country. ▪ Sets out the procedures for undertaking and approving Environmental and Social Impact Assessments. ▪ Develops requirements for robust stakeholder engagement processes through public consultation as part of assessment and decision-making process. ▪ Requires the formulation of appropriate environmental and social safeguards as part of the environment and social impact assessment process (section 31) ▪ Requires environmental monitoring of the development (section 31) ▪ Establishes the Environment Advisory Committee as the appeal body where the Developer or any person may, within 30 days of the publication of the Director's decision, appeal against the Director's decision concerning the issuing of development consent.
Fisheries Management Act 2015	The Act is concerned with the conservation, management and development of fisheries and marine resources. The Act provides a regime for licensing commercial fishing as well as for establishing fisheries management plans that can cover commercial and non commercial fishing. The Act may become relevant to any future use of the reservoir for commercial fishing, whether as a livelihood development project for communities or otherwise. It would also be relevant if any fisheries management plan were applied to the Tina River.

Name of Act or regulation	Implication for the Project
Forest Resources and Timber Utilization Act 1969	The Act requires a felling licence to be obtained to fell any trees for the purposes of sale. Whilst the intention of law is not to cover vegetation removal for construction or other purposes, there is a possibility that a "felling license" could be required for the project if any commercially valuable trees felled are later sold, whether by the developer or landowners. Further consultations will be undertaken with the Ministry of Forestry based on the amount of vegetation to be removed during the construction phase of the Project.
Labour Act 1996	This Act makes provisions for the protection of workers and their rights. It establishes the Office of the Commissioner of Labour to address all labour related issues. The legislation broadly covers the roles and powers of the office, identifies the commissioner as the relevant administrative body, and outlines specific guidance on minimum wages and hours of work for all workers in the country. It also makes provision for the manner in which contracts for employment are made for both national and foreign workers. The provisions of both the *Labour Act* and the *Immigration Act* will be important during the construction phase.
Land and Titles Act	The *Land and Titles Act* establishes the procedure for the registration and acquisition of customary land. The Project's Core Land was acquired through the compulsorily acquisition process set out in Division 2, Part V of the Act. The acquisition included all of the customary land needed for the construction and operation of the project including part of the access road. The process used was a 'compulsory' process under the legislation, with acquisition contingent on first obtaining the consent of all identified landowning tribes. This consent was obtained through the negotiation of a written 'process agreement'. The *Land and Titles Act* also establishes the procedure for the subdivision and voluntary sale of registered land, relevant to the Project's acquisition of the registered land required for the access road and transmission line corridors. The *Lands and Titles Act* also made provision for preservation orders to be applied to land of "historic, architectural, traditional, artistic, archaeological, botanical or religious interest", and permits the establishment of nature reserves.

Name of Act or regulation	Implication for the Project
Customary Land Records Act	The Act provides a process for the formal identification and recording of customary land ownership and boundaries. Although the *Customary Land Records Act* is technically in force, the administrative bodies required to administer the Act have not been established. The Act has been piloted informally but never technically used. For this reason, the Project cannot make use of the Act. However, an informal process for recording customary land was undertaken by a land identification committee. The provisions of the *Land and Titles Act* were used to formally register the land required for the Project.
Mines and Minerals Act	The Act sets out procedures the licence prospecting for, and the extraction of, minerals. The Act will be relevant to the extraction of building materials from the site for use in project construction. The Act requires that the extraction of gravel for use as a building material must have a “Building Materials Permit” (BMP). The BMP is not transferable, and royalties must be paid at the prescribed rate per cubic meter for all building materials extracted. However, similar to many of the laws in the Solomon Islands, the Minister can issue an exemption to the building materials permit: building materials for building or road construction for the personal use of the landowner or occupier, or for sale not exceeding a prescribed amount, may be mined without a “Building Materials Permit". The extraction of materials for the TRHDP could require seeking an appropriate permit from MMERE for quarry development to occur. However, the Minister has powers to issue exemptions where a national project, such as TRHDP, is involved.
National Parks 1954	The Minister can make a proclamation declaring certain areas to be a National Park and purchase or acquire any land for such purpose. This Act is outdated and lacks provisions to empower customary landowners to make decisions about their resources. In practice, the Act has been replaced by the *Protected Areas Act* although not formally repealed.

Name of Act or regulation	Implication for the Project
Protected Areas Act 2010	The Act sets out the process for landowners to formally protect their land. Once protected, land cannot be used for commercial logging or mining, and other uses of the land will be subject to the terms of the management plan established for the land. For an area to become a Protected Area (PA), a community or organization shall prepare an application to the Director of Environment for their site to be declared. The application shall include a PA management plan and scientific studies to show that the areas is of significance to biological diversity and to the community in terms of natural resources. The application will also include an estimated budget for the PA, and evidence of agreement by all customary landowners, as well as a map showing the boundary and size of the site. The director, upon receiving the application, will review the application and make recommendations to the Minister. The Minister shall consider whether: (a) Conservation objectives of the proposed PA are identified and are in accordance with sound conservation practices; (b) Boundaries of the area are accurately identified, or otherwise demarcated and surveyed; (c) Consent and approval are obtained from persons having rights or interests in the area; (d) Appropriate conservation, protection or management plan is developed for the area, to ensure that the conservation objectives of the protected area will be achieved. The Protected Areas Committee has been established and the country’s first Protected Area was declared in 2016.

Name of Act or regulation	Implication for the Project
Provincial Government Act 1997	Schedule 3 of the *Provincial Government Act 1997* provides a list of activities for which the provinces have responsibility, and have the power to pass ordinances; ▪ Trade and Industry - Local licensing of professions, trades and businesses, local marketing. ▪ Cultural and Environment Matters - Protection of wildlife, coastal and lagoon shipping, ▪ Agriculture and Fishing - Protection, improvement and maintenance of fresh-water and reef fisheries. ▪ Land and Land Use - Codification and amendment of existing customary law about land. Registration of customary rights in respect of land including customary fishing rights. Physical planning except within a local planning area ▪ Local Matters - Waste disposal ▪ Rivers and Water - Control and use of river waters, pollution of water ▪ Corporate or Statutory Bodies - Establishment of corporate or statutory bodies for provincial services including economic activity. (Provincial services include "Conservation of the Environment" and "Fishing"). The Guadalcanal Province Wildlife Management Area Ordinance 1990 (GPWMAO) applies to the protection of wildlife. This ordinance applies to TRHDP to ensure that wildlife impacts are understood. Other requirements include a business license during construction and approval under the provincial Town and Country Planning Board.
River Waters Act 1964	The *River Waters Act 1964* states that it is an offence to interfere with a river, except in accordance with the terms and conditions of a permit. The Act applies to the section of the river called Ngalibiu (referred to as part of the Ngalimbiu River). A permit will, therefore, be sought from the Minister for MMERE before constructions works proceed. The process for applying for a permit involves submitting details of the proposed construction and diversion that will occur, including maps of the location in which construction will occur. The conditions for issuing a permit include a study of the current use of the river and the potential impact of the proposed interference on the river. In granting any permit, the Minister shall have regard to the existing use of water and shall safeguard such existing use of water as far as it appears to be practicable and consistent with the provisions and purposes of this Act. A practical application would be to submit the ESIA and proposed development plan for a permit to be issued. The law does not provide a timeframe for the permit to be issued.

Name of Act or regulation	Implication for the Project
River Waters Ordinance 1969	Provides measures for watershed control in relation to rivers and regulates the use of designated river water through permit applications.
Public Health Ordinance 1970	This Ordinance authorises inspections to be conducted for the regulation of water pollution.
Solomon Islands Water Authority Act 1992	The Solomon Islands Water Authority (SIWA) is established under this Act and is currently charged with providing the proper management and development of urban water resources and services, and sewerage services in the Solomon Islands.
Safety at Work Act 1982	The legislation codifies the duties of employers to their employees and others responsible for ensuring the safety of workers in various work environments, in particular, safety of workers in dangerous and risky conditions. It provides for the civil and criminal liability of employers who are negligent regarding the safety of their workers.
Town and Country Planning Act 1980	The Act requires developments on registered land to obtain planning consent from the relevant provincial Town and Country Planning Board. The Guadalcanal Board has recently been re-established. The TRHDP will require consent under this Act.
Wild Birds Protection Act 1914	This Act was repealed by the *Wildlife Protection and Management Act.*
Wildlife Protection and Management Act 1998	The legislation primarily protects wildlife by limiting the import of potentially harmful species, preventing the export of listed protected species and requiring a permit (for scientific research) for others. Schedule I lists the species that are prohibited to export, and Schedule II lists the regulated and controlled species for which a valid permit to export such specimen is required. The Act also empowers the Minister to make an order to approve a management programme which can include measures for the breeding or study of certain species, and the setting aside of reserved areas for their protection. There are no known orders currently in place.

Name of Act or regulation	Implication for the Project
Environmental Health Act 1980 and *Environmental Health (Public Health Act 1970) Regulations*	In the case of the TRHDP, the Guadalcanal provincial health authority has a duty to take necessary and reasonably practicable measures to enforce the law and request that, at all time, the Project site be in a clean and sanitary condition.
Electricity Act	The *Electricity Act* sets out in very wide terms the functions and duties of the Solomon Islands Electricity Authority (SIEA). The SIEA (trading as Solomon Power) is generally in charge of all matters related to electricity production and transmission/distribution in Solomon Islands, including ensuring standards of safety, efficiency and economy. It also advises the Government on matters related to electricity and can make recommendations as to regulatory instruments. Relevant to the Project, the Electricity Act empowers SIEA to enter into contracts for the purposes of signing the Power Purchase Agreement. The Act also establishes a licencing regime for an electricity producer and the developer will require a licence under this Act.
Guadalcanal Historic Places Ordinance 1985	This Ordinance provides a means of legally protecting sacred, traditional and archaeological sites. No such sites are present in the Project study areas.

3.3 INTERNATIONAL ENVIRONMENTAL AND SOCIAL TREATIES

Table 3-4 presents and describes international environmental and social treaties signed and ratified by the Solomon Islands, and the relationship between the Project and these treaties is analysed.

Table 3-4 Treaties observed by the Solomon Islands

Multilateral Environment Agreement	Status	Purpose/Aim	Agency Responsible	Relevance to TRHDP
Regional Multilateral Environment Agreements				
Pollution Protocol for Dumping	Ratified 10/9/98	Prevention of pollution of the South Pacific region by dumping.	Marine Div/MECDM	NA

Multilateral Environment Agreement	Status	Purpose/Aim	Agency Responsible	Relevance to TRHDP
Pollution Protocol for Emergencies	Ratified 10/9/98	Cooperation in combating pollution emergencies in the South Pacific region.	Marine Div/MECDM Project: National Pollution Prevention Plan	NA
Natural Resources & Environment of South Pacific Region (SPREP Convention)	Ratified 10/9/98	Protection of natural resources and environment of the South Pacific Region in terms of management and development of the marine and coastal environment in the South Pacific Region.	MECDM	This is relevant for the Project and the ESIA should address the related issues. This a pacific agreement for the management of natural resources and biodiversity
Waigani Convention on Hazardous & Radioactive Wastes 1995	Ratified 7/10/1998	Bans the importation of hazardous and radioactive wastes into Forum Island countries and to control the trans-boundary movement and management of hazardous wastes within the South Pacific region.	MECDM	Any import of hazardous material will require permits to be issued by MECDM. This is a regional version of the Basel Convention.
International Multilateral Environment Agreements				
Chemicals, Wastes and Pollution				
Liability for Oil Pollution Damage	Ratified	Strict liability of ship owner for pollution damage to a coastal state within a certain amount.	Marine Div	NA
Marine Pollution Convention (London)	Ratified	Prevention of marine pollution by dumping of wastes and other matter.	MECDM/Foreign Affairs	NA

Multilateral Environment Agreement	Status	Purpose/Aim	Agency Responsible	Relevance to TRHDP
United Nations Convention to Combat Desertification (UNCCD)	Acceded 16/4/1999	Agreement to combat desertification and mitigate the effects of drought in countries experiencing drought or desertification.	MAL/MECDM Project: National Action Plan on Land Degradation and Drought	NA
POPs Convention (Stockholm)	Acceded 28.7/2004	Protection of human health and environment from persistent organic pollutants (POPs).	MECDM/Environmental Health Div. Project: National Implementation Plan	NA as no POP chemicals will be used during construction.
Biodiversity				
CITES	Instrument of ratification being prepared	Regulations and restriction of trade in wild animals and plants through a certification system of imports and exports.	MECDM	Unlikely to be applicable as applies to import or export of relevant species
World Heritage Convention (UNESCO)	Acceded 10/6/1992	Protection of sites of Outstanding Universal Values. Solomon Islands currently has East Rennell Island as a World Heritage site.[19] Mt. Popomanaseu is on the Tentative list of the UNESCO	National Museum/ MECDM	NA, however, Mount Popomanaseu is at the upper reaches of the Tina Catchment
UN Convention on Biological Diversity (UNCBD)	Ratified 3/10/1995	Conserve biological diversity through the sustainable use of its components and the fair and equitable sharing of the benefits arising out of utilizing genetic resources.	MECDM Project: NCSA; National Biodiversity Strategy and Action Plan;	Relevant since the ESIA also aims at protecting species

[19] World Heritage Convention

Multilateral Environment Agreement	Status	Purpose/Aim	Agency Responsible	Relevance to TRHDP
			International Waters Program; 3rd National Report	
Cartegena Protocol to the UNCBD	Acceded – 26/10/2004	Protection of human health and the genetic diversity.[20]	MECDM	NA
Coral Triangle Initiative (CTI) Agreement		Protection and conservation of marine resources within the coral triangle region.		NA
Cultural and Natural Heritage				
World Cultural and Natural Heritage Convention	Acceded in 1992	Protection and management of cultural and natural heritage	National Museum under the Ministry of Home Affairs	Applicable since cultural heritage is valued by local communities
Climate Change Related				
United Nations Framework Convention on Climate Change (UNFCCC)	Ratified – 28/12/1994	Set an overall framework for intergovernmental efforts to tackle the challenges posed by climate change.	MECDM	This is relevant since the Project will reduce the use of fossil fuel for electricity production.
Kyoto Protocol	Ratified – 13/03/2003	Reduce greenhouse gases especially carbon dioxide for the 39 industrial/ developed countries by an average pf 5.2% by 2012.	MECDM	NA- emissions from the construction of the Project are limited in time
Montreal Protocol	Acceded - 17/06/1993	Allows phase out of substances that deplete the ozone layer according to a fixed schedule.	Energy Division	NA

20 artegena Protocol to the UNCBD

Multilateral Environment Agreement	Status	Purpose/Aim	Agency Responsible	Relevance to TRHDP
Vienna Convention for the Protection of the Ozone Layer	Acceded – 17/06/1993	-Protection of the ozone layer through intergovernmental cooperation on research. -observation of ozone layer - monitoring of CFC		NA

3.4 WORLD BANK GROUP REQUIREMENTS

To date, the World Bank has provided significant project funds to the Project. The Bank has also proposed that it may provide a partial risk guarantee, as well as concessional and grant financing, towards construction costs. Therefore, the Project must comply with several social and environmental principles. These principles are reflected in the WB Operational Policies, and the WB Performance Standards.

The WB Operational Policies apply to public sector projects and will apply to the land acquisition and livelihood restoration undertaken by the SIG.

The eight Performance Standards, initially developed by the IFC in 2006 and amended in 2012, were adopted by the World Bank in 2013 as the World Bank *Performance Standards for Projects Supported by the Private Sector* ("*WB Performance Standards*"). They are to be applied where the Bank provides support for projects (or components thereof) that are designed, owned, constructed and/or operated by a Private Entity, in lieu of the World Bank's Operational Policies. The developer, the Special Purpose Company (SPC) managed by K-Water as a private sector entity, will abide by WB Performance Standards, all of which, except for PS5 on land acquisition and resettlement, apply to the dam and power plant.

The following sections identify the World Bank Operational Policies and World Bank Performance Standards that will apply to the Project.

The developer/contractor will be responsible for developing an environmental and social management system (ESMS) and for identifying, assessing and managing environmental and social risks and impacts associated with the Private Sector Activity, all in accordance with the WB Performance Standards.

3.4.1 WB Operational Policies

While a private sector agent is taking the lead role in management of environmental and most social impacts, TRHDP-PO, within MMERE, retains the responsibility for land acquisition, livelihood restoration, and benefit sharing, all of which have particular significance to indigenous communities.

World Bank OP 4.12 and OP 4.10 thus apply as safeguards relating to Indigenous Peoples (IP) that are managed in the land acquisition plan (LALRP). WB PS 7 is applicable to the dam and power plant because the Developer must abide by any IP-related mitigation, monitoring, hiring, community engagement, etc. all of which involve IPs.

It is proposed that Solomon Power will construct the transmission line between the powerhouse / switchyard and the main tie-in point at Lungga Generating Station for which WB Operational Policies will apply. Solomon Power as a state-owned enterprise is classified as a public sector agency according to OP 4.03 criteria.

3.4.1.1 Applicable Operational Policies

Those components of the Project relating to the transmission line will be undertaken in accordance with the following applicable World Bank Environmental and Social Safeguard Policies:

- OP4.01 – Environmental Assessment
- OP4.04 – Natural Habitats
- OP4.36 – Forests
- OP4.10 – Indigenous Peoples
- OP4.11 – Physical Cultural Resources

OP 4.01: Environmental Assessment

OP 4.01 (Environment Assessment) sets out the general policies and principles for environmental and social protection and requirements for assessment of impacts and implementation plans and measures to mitigate or manage impacts.

OP 4.01 requires that an assessment evaluate a project's potential environmental risks and impacts in its area of influence; examine project alternatives; identify ways of improving project selection, siting, planning, design, and implementation by preventing, minimizing, mitigating, or compensating for adverse environmental impacts and enhancing positive impacts; and include the process of mitigating and managing adverse environmental impacts throughout project implementation.

The requirements of OP 4.01 for the access road are addressed as part of this ESIA.

OP 4.04: Natural Habitats

OP 4.04 supports the protection, maintenance, and rehabilitation of natural habitats, and a precautionary approach to natural resource management. It provides that the Bank does not support projects that involve the significant conversion or degradation of critical natural habitats unless there are no feasible alternatives for the project and its siting, and comprehensive analysis demonstrates that overall benefits from the project substantially outweigh the environmental costs.

The requirements of OP 4.04 for the access road and transmission line are incorporated into this ESIA. No critical natural habitats are identified as affected by the access road.

OP4.10: Indigenous Peoples

OP 4.10 Indigenous Peoples (Amended 2013) is triggered where a project affects Indigenous Peoples. The vast majority of the people benefiting from and affected by the Project are assessed to be Indigenous Peoples. The Policy will apply to the SIG’s acquisition of land for the Project, as well as the SIG’s upgrade and construction of the access road and Solomon

Power's construction of the transmission line. The Policy requires that SIG engage in free, prior and informed consultation resulting in broad community support. It also requires that SIG avoid potentially adverse effects on Indigenous People and where avoidance is not feasible, minimize, mitigate or compensate such effects. Compensation and benefits must be culturally appropriate and gender and inter-generationally inclusive.

Clause 12 of the Policy indicates that "when Indigenous Peoples are the sole or the overwhelming majority of direct project beneficiaries, the elements of an Indigenous Peoples Plan (IPP) should be included in the overall project design, and a separate IPP is not required." Based on this clause, since the vast majority of citizens of the Solomon Islands are members of one or more Indigenous Peoples, and the entirety of the communities in the project Area of Influence are comprised of members of one or more Indigenous Peoples. Rather, the Social Impact Assessment prepared for the whole project, as part of the overall ESIA, fulfills the needs of what would otherwise be an IPP, and the project design fully accounts for the interest of Indigenous Peoples within the project-affected area. Measures to minimize, mitigate and compensate for land acquisition impacts, and the SIG's process of free, prior and informed consent, are set out in the Land Acquisition and Livelihood Restoration Plan.

OP4.12: Involuntary Resettlement

The World Bank's policy on involuntary resettlement "is triggered" in situations involving involuntary taking of land and involuntary restrictions of access to legally designated parks and protected areas. The policy aims to avoid involuntary resettlement to the extent feasible, or to minimize and mitigate its adverse social and economic impacts. The policy prescribes compensation and other resettlement measures to achieve its objectives and requires that borrowers prepare adequate resettlement planning instruments prior to Bank appraisal of proposed projects (World Bank, 2014).

In the case of the TRHDP as it is currently conceived, the Policy is triggered because:

- the proposed project will require the taking of customarily owned land for the dam site, hydro storage reservoir, power station, access roads, quarries and borrow sites, and for power transmission infrastructure, and;
- the taking of such land implies a loss of assets for some, and/or a loss of income sources or means of livelihood.

It is not anticipated that the construction or operation of the TRHDP will result in the loss of residence or shelter of any members of local communities or require any of them to move to another location. While there have been calls during community consultations by some people for their villages to relocate, the project is being designed to avoid relocating and resettling any existing households or communities and, accordingly, will not require any relocations for it to proceed safely.

Avoidance of displacement is consistent with the Bank's polices on the protection of indigenous peoples; nevertheless, compliance with OP 4.12 requires the preparation of a Resettlement Action Plan or a Livelihood Restoration Plan for loss of livelihood.

This plan has been prepared as a separate document, the Land Acquisition and Livelihood Restoration Plan. As the SIG is responsible for land acquisition, the plan is prepared with respect to World Bank OP 4.12.

3.4.1.2 OP4.37: Dam Safety

WB Performance Standard 4 will apply to the Project with respect to dam safety. However, OP 4.37 has been used to guide the actions necessary for Performance Standard compliance.

The World Bank's policy on dam safety "is triggered" when the construction of a new dam is proposed. The policy prescribes that the dam be designed and its construction supervised by experienced and competent professionals. It also requires that project adopt and implement certain dam safety measures for the design, bid tendering, construction, operation, and maintenance of the dam and associated works. (World Bank, 2013).

If TRHDP were a Government project, the Policy would be triggered because the proposed TRHDP dam at a height of 53m qualifies as a large (>15m high) dam.

Under the Policy the project proponent is required to engage technical specialists to investigate the site and design the dam, supervise new or remedial construction, advise on initial reservoir filling and start-up operations, and perform inspections and safety assessments. The qualifications of the professionals (e.g., engineers, geologists, or hydrologists) employed by the borrower must be adequate to the complexity of the particular dam.

Project information relevant to dam safety, including: cost estimates; construction schedules; procurement procedures; technical assistance arrangements; environmental assessments; plans for construction supervision and quality assurance, instrumentation, operation and maintenance, and emergency preparedness are to be prepared, along with any other action plans relating to dam safety.

3.4.2 WB Performance Standards

WB Performance Standards (PS) will guide all actions and activities of the Project from design and construction through operations and maintenance, to decommissioning and rehabilitation / restoration of the site. The PS will guide the Project to identify impacts and to avoid, mitigate and manage them in an environmentally and socially acceptable way.

The term "client" is used throughout the Performance Standards broadly to refer to the party responsible for implementing and operating the Project that is being financed, or the recipient of the financing, depending on the project structure and type of financing. In the case of TRHDP, the client is the developer of TRHDP.

The term "consultant" refers to the company that is responsible for preparing the ESIA.

TRHDP has delegated the consultant to prepare the ESIA to describe the baseline environmental and social conditions, identify impacts, and propose mitigation measures in accordance with national, World Bank and other IFI standards.

The following sub-sections present the WB PS that apply to the ESIA and highlight what needs to be implemented to comply with the PS.

3.4.2.1 Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts

The requirements of PS1 are presented in Table 3-5

Table 3-5 PS 1 requirements

#	Requirements	How will the Project implementation process comply with requirements
R.1	To conduct a process of Environmental and Social Impact Assessment (ESIA) and maintain an effective Environmental and Social Management System (ESMS).	This ESIA includes an Environmental and Social Management Plan
R.2	The client will establish an overarching policy defining the environmental and social objectives and principles that guide the project to achieve sound environmental and social performance	The client will implement such policy based on the ESIA
R.3	The client will establish and maintain a process for identifying the environmental and social risks and impacts of the project	ESIA identifies and describes risks and impacts. As required, the ESIA studies the areas likely to be affected directly or indirectly by the Project, studies associated facilities (access roads, camps, quarries, etc.) and cumulative impacts. Monitoring measures will be implemented to enable verification of impact predictions and mitigation measures.
R.4	The client will establish management programs (such as environmental and social action plans) to describe mitigation and performance improvement measures and actions that address the identified environmental and social risks and impacts of the project	The ESIA includes a list of action plans annexed in the ESMP. These plans will be further developed by the developer as it finalises the detailed design.
R.5	The client, in collaboration with appropriate and relevant third parties, will establish, maintain, and strengthen as necessary an organizational structure that defines roles, responsibilities, and authority to implement the ESMS.	The final ESMP will assess the responsible actor's capacity to implement environmental and social measures. Capacity building measures to strengthen staff are proposed. The ESMP also assesses the need for external experts to assist the responsible actor in implementing measures.

#	Requirements	How will the Project implementation process comply with requirements
R.6	The ESMS will establish and maintain an emergency preparedness and response system so that the client, in collaboration with appropriate and relevant third parties, will be prepared to respond to accidental and emergency situations associated with the project in a manner appropriate to prevent and mitigate any harm to people and/or the environment.	To respond to accidents and emergency situations, and to comply with World Bank Operational Policy OP 4.37 Safety of Dams, several reports will be produced that address seismic monitoring of the dam, instrumentation, construction supervision, reservoir loading and flood prediction, emergency preparedness and response, etc., prior to commencement of construction. In addition, the ESMP outlines some safety measures.
R.7	The client will establish procedures to monitor and measure the effectiveness of the management program, as well as compliance with any related legal and/or contractual obligations and regulatory requirements.	The ESMS defines a monitoring program for the developer to implement, identifying all monitoring activities, and roles and responsibilities for monitoring and reporting. The developer will also conduct internal audits to ensure measures are implemented. Results will be documented and the monitoring program will be part of the review cycle. The monitoring program will define corrective measures in situations where goals are not achieved.
R.8	The client will develop and implement a Stakeholder Engagement Plan that is scaled to the project risks and impacts and development stage and tailored to the characteristics and interests of the Affected Communities.	A final Stakeholder Engagement Plan (SEP) will be developed. Some amendments are proposed in the ESMP.

3.4.2.2 Performance Standard 2: Labour and Working Conditions

The scope of application of this Performance Standard depends on the type of employment relationship between the client and workers. It applies to workers directly engaged by the client (direct workers), workers engaged through third parties to perform work related to core business processes of the project for a substantial duration (contracted workers), as well as workers engaged by the client’s primary suppliers (supply chain workers).

Since the need for human resources will be concentrated in the construction phase, most employment will be temporary and, therefore, some requirements of PS2 do not apply. In the case of the Project construction, workers will be contracted. Even though only part of PS2 applies for contracted workers, all requirements are presented for the construction contractor to implement. The client, in turn, will have to audit the construction contractor for compliance and will have to ensure that specific requirements are part of tender documents.

The requirements of PS2 are presented in Table 3-6.

Table 3-6 PS 2 Requirements

#	Requirements	How will the Project implementation process comply with requirements
R.1	The construction contractor/client will adopt and implement human resources policies and procedures appropriate to its size and workforce that set out its approach to managing workers. The construction contractor/client will provide workers with documented information regarding working conditions and a written contract.	Through call for tender process, the TRHDP PO will ensure that the developer has a written human resources policy.
R.2	The construction contractor will provide reasonable working conditions and terms of employment.	The developer shall develop a health and safety plan, which will be audited by TRHDP PO.
R.3	In countries where national law recognizes workers' rights to form and to join workers' organizations of their choosing, without interference, and to bargain collectively, the construction contractor will comply with national law.	This measure will be presented in the ESMP and will be included in any contracts between the developer and its contractor(s).
R.4	The construction contractor will not make employment decisions on the basis of personal characteristics unrelated to inherent job requirements. The construction contractor will base the employment relationship on the principle of equal opportunity and fair treatment and will not discriminate with respect to any aspects of the employment relationship.	This measure will be presented in the ESMP and will be included in any contracts between the developer and its contractor(s).
R.5	The construction contractor will provide a grievance mechanism for workers (and their organizations, where they exist) to raise workplace concerns.	The Stakeholder Engagement Plan applies to the developer. Its contract will include specific measures regarding workers' conditions.
R.6	The construction contractor will not employ children in any manner that is economically exploitative or is likely to be hazardous or to interfere with them.	This measure is presented in the ESMP and will be included in any contracts between the developer and its contractor(s).
R.7	The construction contractor will not employ forced labor.	This measure is presented in the ESMP and will be included in any contracts between the developer and its contractor(s).

#	Requirements	How will the Project implementation process comply with requirements
R.8	The developer will provide a safe and healthy work environment, taking into account inherent risks in its particular sector and specific classes of hazards in the client's work areas, including physical, chemical, biological, and radiological hazards, and specific threats to women.	The developer will develop a health and safety plan, which will be audited by TRHDP PO
R.9	With respect to contracted workers, the developer will take commercially reasonable efforts to ascertain that the third parties who engage these workers are reputable and legitimate enterprises and have an appropriate ESMS.	Through the call for tender process, the developer will ensure that construction contractors put the ESMP into effect.

3.4.2.3 Performance Standard 3: Resource Efficiency and Pollution Prevention

The requirements of PS3 are presented in Table 3-7.

Table 3-7 PS 3 Requirements

#	Requirements	How will the Project implementation process comply with requirements
R.1	During the project life-cycle, the client will consider ambient conditions and apply technically and financially feasible resource efficiency and pollution prevention principles and techniques that are best suited to avoid, or where avoidance is not possible, minimize adverse impacts on human health and the environment.	The ESIA and ESMP address all impacts and define pollution prevention measures.
R.2	The client will implement technically and financially feasible and cost effective measures for improving efficiency in its consumption of energy, water, as well as other resources and material inputs, with a focus on areas that are considered core business activities.	The ESIA/ESMP addresses water quality impairment issues during construction activities and proposes efficiency measures. The ESIA/ESMP ensures that specific measures are developed to help the client integrate them in the call for tender documents. The client will include an environmental expert on its staff to ensure that processes are efficient (water, energy, etc.)
R.3	The client will avoid the release of pollutants or, when avoidance is not feasible, minimize and/or control the intensity and mass flow of their release.	The ESIA/ESMP addresses pollutant release issues during construction activities and proposes measures to avoid, mitigate, and control release of pollutants.
R.4	The client will avoid the generation of hazardous and non-hazardous waste materials. Where waste generation cannot be avoided, the client will reduce the generation of waste, and recover and reuse waste, in a manner that is safe for human health and the environment.	The ESIA/ESMP addresses waste issues during construction activities and proposes measures to avoid release, and reduce, reuse, and recover all types of waste. The construction contractor will use subcontractors that are reputable and legitimate enterprises licensed by the relevant government regulatory agencies and obtain chain of custody documentation for wastes transferred to the final destination. This condition will be included in contracts between the client and its contractor(s).

#	Requirements	How will the Project implementation process comply with requirements
R.5	Hazardous materials are sometimes used as raw material, or produced as product, by the project. The client will avoid or, when avoidance is not possible, minimize and control the release of hazardous materials.	The client will include conditions regarding use of hazardous materials in call for tender and in contracts. This measure will be presented in the ESMP and will be included in contracts between the client and its contractor(s).

3.4.2.4 Performance Standard 4: Community Health, Safety, and Security

The requirements of PS4 are presented in Table 3-8.

Table 3-8 PS 4 Requirements

#	Requirements	How will the Project implementation process comply with requirements
R.1	The client will evaluate the risks and impacts to the health and safety of the Affected Communities during the project life-cycle and will establish preventive and control measures consistent with Good International Industry Practice (GIIP).	The developer will develop a health and safety plan. A warning system will be developed as part of the Operations Plan to address the peak hour water releases (i.e., sudden releases from 2m^3/s to flow of 24m^3/s).
R.2	The client will design, construct, operate, and decommission the structural elements or components of the project in accordance with GIIP, taking into consideration safety risks to third parties or Affected Communities.	The developer will engage one or more external experts with relevant and recognized experience in similar projects, separate from those responsible for the design and construction, to conduct a review as early as possible in project development and throughout the stages of project design, construction, operation, and decommissioning
R.3	The client will avoid or minimize the potential for community exposure to hazardous materials and substances that may be released by the project.	The developer will develop a health and safety plan, and hazardous materials management plan as part of the developer's final ESMP.
R.4	The project's direct impacts on priority ecosystem services may result in adverse health and safety risks and impacts to Affected Communities, the client will identify those risks and potential impacts on priority ecosystem services that may be exacerbated by climate change.	The ESIA identifies the extent to which the Project affects ecosystem services that contribute to impacts on the health of local communities.

#	Requirements	How will the Project implementation process comply with requirements
R.5	The client will avoid or minimize the potential for community exposure to water-borne, water-based, water-related, and vector-borne diseases, and communicable diseases that could result from project activities, taking into consideration differentiated exposure to, and higher sensitivity of, vulnerable groups.	The ESIA identifies the extent to which Project construction and operation impact the health of local communities.
R.6	The client will assist and collaborate with the Affected Communities, local government agencies, and other relevant parties, in their preparations to respond effectively to emergency situations, especially when their participation and collaboration is necessary to respond to such emergency situations.	To respond to accident and emergency situations, and to comply with World Bank Operational Policy OP 4.37 Safety of Dams, several reports shall be produced to address seismic monitoring of the dam, construction supervision, reservoir loading and flood prediction, emergency preparedness and response, etc., prior to commencement of construction. These studies will be carried out in close collaboration with project affected communities
R.7	When the client retains direct or contracted workers to provide security to safeguard its personnel and property, it will assess risks posed by its security arrangements to those within and outside the project site. The client will make reasonable inquiries to ensure that those providing security are not implicated in past abuses; will train them adequately in the use of force, and appropriate conduct toward workers and Affected Communities; and require them to act within the applicable law.	The ESMP addresses such issues to ensure that local communities are safe.

3.4.2.5 Performance Standard 5: Land Acquisition and Involuntary Resettlement

Option 7C will not necessitate any physical resettlement. It will, however, necessitate land acquisition for the construction area. Land acquisition will be done in compliance with World Bank safeguard policies OP 4.12 on Involuntary Resettlement rather than PS5 since the process is carried out by SIG, which is a public agency.

A land acquisition process was carried out by the TRHDP PO to secure land from its customary tenure. The customary land acquired is referred to as the Core Land (also the Core Area). A memo summarizing the land acquisition process that was prepared at the time the ESIA was being developed, is included as Annex 20 in the Annex Report.

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3.4.2.6 Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources

The requirements of PS6 are presented in Table 3-9.

Table 3-9 PS 6 Requirements

#	Requirements	How will the Project implementation process comply with requirements
R.1	The risks and impacts identification process should consider direct and indirect project-related impacts on biodiversity and ecosystem services and identify any significant residual impacts. The client should seek to avoid impacts on biodiversity and ecosystem services. When avoidance of impacts is not possible, measures to minimize impacts and restore biodiversity and ecosystem services should be implemented.	The ESIA/ESMP addresses such issues. When avoidance of impacts is not possible, measures to minimize impacts and restore biodiversity and ecosystem services will be implemented. The ESIA presents the baseline conditions of natural habitats within the Project areas and describes their services.
R.2	For the protection and conservation of biodiversity, the mitigation hierarchy includes biodiversity offsets, which may be considered only after appropriate avoidance, minimization, and restoration measures have been applied.	The ESIA/ESMP has studied possible ways to offset impacts on natural habitats.
R.3	The client will conduct a systematic review to identify priority ecosystem services: (i) those services on which project operations are most likely to have an impact and, therefore, which result in adverse impacts to Affected Communities; and/or (ii) those services on which the project is directly dependent for its operations	The ESIA/ESMP addresses such issues. Section 4.2 identifies and describes environmental components that play a role for local population (sources of livelihood), Tambu sites, etc.
R.4	Where a client is purchasing primary production, systems, verification practices will be adopted as part of the client's ESMS to evaluate its primary suppliers	The ESMP develops measures to ensure that suppliers of natural resources (quarry, etc.) will be evaluated regarding their compliance with measures.

3.4.2.7 Performance Standard 7: Indigenous Peoples

The WB Performance Standard (and accompanying procedure) on indigenous peoples is triggered because the peoples and communities likely to be directly or indirectly affected by the construction, and/or operation of TRHDP, can be considered indigenous people according to the Standard. Performance Standard 7 uses the term indigenous people in a generic sense to refer to 'a distinct, social and cultural group possessing the following characteristics in varying degrees:

- Self-identification as members of a distinct indigenous cultural group and recognition of this identity by others;
- Collective attachment to geographically distinct habitats or ancestral territories in the project area and to the natural resources in these habitats and territories;
- Customary cultural, economic, social, or political institutions that are separate from those of the mainstream society or culture; or
- A distinct language or dialect, often different from the official language or languages of the country or region in which they reside (WB, 2012).'

The baseline sections of the ESIA identify several groups or communities resident within, or in close proximity to, the proposed project area that could be potentially affected by the project, including:

- Indigenous Teha/Malango-speaking people of the Bahomea district who customarily own and occupy the 'Core Area' for the project;
- Indigenous Malango people of Malango district, some of whom are customary 'shareholders' or users of the Core Area;
- 'Settler' Guale people in the Bahomea district, who are largely indigenous *Talise*-speaking people from the Weather Coast of Guadalcanal and do not have customary ownership rights in the project area, though have been granted usufruct rights to certain areas by Bahomea customary owners;
- Indigenous coastal *Lengo*-speaking Ghaobata people of the Guadalcanal Plains who have ownership rights over the land and resources of the lower part of the Ngalimbiu catchment, and the adjacent coastal area, and;
- 'Squatter' peoples of various origins and language groups, who are living on 'unoccupied' government/alienated land in the northern part of the project area, without the formal approval of the local indigenous customary tribes, and people who are living and working on the LQQ and GPPOL agricultural estates on the Guadalcanal Plains. These people are Indigenous to other parts of the Solomon Islands or other islands of the Pacific, such as the Gilbertese from Kiribati.

Based on the interpretation of the World Bank (World Bank's Lead Social Development Specialist, and the World Bank's Lead Safeguards Specialist for the project), for the purposes of the social impacts assessment and social standard compliance, all the groups resident in the project area are considered Indigenous Solomon Islanders since they all have the defining characteristics mentioned above.

As noted elsewhere in the ESIA, compliance with this policy requires that TRHDP preparation include a social impact assessment (see Section 12), the scale of which needs to be proportional to "the nature and scale of the proposed project's potential effects on the indigenous peoples and a process of free, prior, and informed consent (FPIC) with the affected indigenous communities, to ascertain whether there is 'broad community support' for the Project, or not.

This means that the project must also: involve the development of measures to avoid, minimise and/or mitigate adverse impacts; that the design and provision of benefits and mitigation measures include the consideration of options preferred by the affected indigenous peoples; and that the social and economic benefits for indigenous people are culturally appropriate and gender and generationally inclusive.

Other requirements of WB PS 7 mean that the ESIA must also review the extent to which the project planning has considered:

- Free, prior and informed consent;
- Achievement of broad community support;
- Actions that are taken to achieve the legal recognition of customary rights to lands that are traditionally owned, or customarily used or occupied, and for such land acquisition; and
- Management of the commercial development, if any, of cultural resources.

The requirements of PS7 are presented in Table 3-10.

Table 3-10 PS 7 Requirements

#	Requirements	How will the Project implementation process comply with requirements
R.1	The client will identify, through an environmental and social risks and impacts assessment process, all communities of Indigenous Peoples within the project area of influence who may be affected by the project, as well as the nature and degree of the expected direct and indirect economic, social, cultural (including cultural heritage), and environmental impacts on them.	The ESIA achieves this requirement.
R.2	Adverse impacts on Affected Communities of Indigenous Peoples should be avoided where possible. Where alternatives have been explored and adverse impacts are unavoidable, the client will minimize, restore, and/or compensate for these impacts in a culturally appropriate manner commensurate with the nature and scale of such impacts and the vulnerability of the Affected Communities of Indigenous Peoples.	Development of measures is carried out during the ESIA with the full participation of indigenous population to ensure that their opinions are taken into account and to minimize impacts on them.
R.3	The client will undertake an engagement process with the Affected Communities of Indigenous Peoples	The client's stakeholder engagement plan will be a dynamic document. Local population concerns and grievances will be gathered throughout the lifespan of the Project. Answers will be formulated to ensure ongoing communication.

#	Requirements	How will the Project implementation process comply with requirements
R.4	The client will obtain the Free, Prior, and Informed Consent (FPIC) of the Affected Communities of Indigenous Peoples in the circumstances.	Mitigation Workshops prepared the way for the FPIC by presenting local populations with information on the various components and impacts of the Project. Social Surveys has also prepared the way for FPIC and results are presented in Section 7 and annexes included in the Annex Report. The assessment of FPIC is presented in the social baseline section
R.5	The client will consider feasible alternative project designs to avoid the relocation of Indigenous Peoples from communally held lands	The new Project layout, based on Option 7C, avoids any relocation of people. Section 4 (Analysis of Alternatives) of the ESIA studies alternatives, presents each alternative, its strengths and weaknesses, and the reasons for the selection of the preferred option.
R.6	Where a project may significantly impact on critical cultural heritage that is essential to the identity and/or cultural, ceremonial, or spiritual aspects of Indigenous Peoples lives, priority will be given to the avoidance of such impacts. Where significant project impacts on critical cultural heritage are unavoidable, the client will obtain the FPIC of the Affected Communities of Indigenous Peoples.	Section 7.2 focuses on gathering information on cultural heritage in the Project areas from interviews with the local population. It identifies cultural sites that will be affected by the reservoir impoundment or road upgrades. During the mitigation workshops, measures were discussed with local populations, to ensure that their opinions regarding the fate of cultural sites, were taken into account and that compensation will be paid for any losses incurred. The ESMP includes a Cultural Heritage Management Plan.
R.7	The client and the Affected Communities of Indigenous Peoples will identify mitigation measures in alignment with the mitigation hierarchy as well as opportunities for culturally appropriate and sustainable development benefits.	Development of measures are carried out during the ESIA with the full participation of local populations to ensure that their opinions are taken into account (during mitigation workshops).

#	Requirements	How will the Project implementation process comply with requirements
R.8	The nature of the project, the project context and the vulnerability of the Affected Communities of Indigenous Peoples will determine how these communities should benefit from the project. Identified opportunities should aim to address the goals and preferences of the Indigenous Peoples, including improving their standard of living and livelihoods in a culturally appropriate manner, and to foster the long-term sustainability of the natural resources on which they depend.	Development of measures, including measures to ensure safeguarding of livelihoods, are carried out in the ESIA and Land Acquisition and Livelihood Restoration Plan with the full participation of local population. Measures to ensure long-term benefits for local population were proposed.
R.9	The client will prepare a plan that, together with the documents prepared by the responsible government agency, will address the relevant requirements of this Performance Standard	Requirements for an IPP incorporated into Social Impact Assessment of overall ESIA. Specific measures for restoring the livelihoods of indigenous peoples with respect to land acquisition are covered in the Land Acquisition and Livelihood Restoration Plan. This plan is prepared under OP4.12 but has also been drafted to meet FPIC requirements of PS7.

3.4.2.8 Performance Standard 8: Cultural Heritage

The requirements for PS8 are presented in Table 3-11

Table 3-11 PS 8 Requirements

#	Requirements	How will the Project implementation process comply with requirements
R.1	In addition to complying with applicable law on the protection of cultural heritage, including national law implementing the host country's obligations under the Convention Concerning the Protection of the World Cultural and Natural Heritage, the client will identify and protect cultural heritage by ensuring that internationally recognized practices for the protection, field-based study, and documentation of cultural heritage are implemented.	Chapter 8 presents information on cultural heritage in the Project areas from interviews with local population.

#	Requirements	How will the Project implementation process comply with requirements
R.2	The environmental and social risks and impacts identification process should determine whether the proposed location of a project is in areas where cultural heritage is expected to be found, either during construction or operations. In such cases, as part of the client's ESMS, the client will develop provisions for managing chance finds through a chance find procedure.	Chapter 8 presents information on cultural heritage in the Project areas from interviews with local population. Cultural sites that will be impacted by the reservoir impoundment have been identified. During the mitigation workshops, measures were discussed with local populations to ensure that their opinions regarding the fate of cultural sites were taken into account. The ESMP includes measures regarding chance find procedures.
R.3	The client will consult with the Affected Communities to identify cultural heritage of importance, and to incorporate into the client's decision-making process the views of the Affected Communities on such cultural heritage.	The Cultural heritage protocol of the ESMP details this requirement.
R.4	Where the client's project site contains cultural heritage or prevents access to previously accessible cultural heritage sites, the client will, based on consultations, allow continued access to the cultural site, or will provide an alternative access route.	The ESIA has studied project alternatives to ensure minimization of impacts on cultural sites
R.5	Where the client has encountered tangible cultural heritage that is replicable, where avoidance is not feasible, the client will implement restoration measures. Where restoration in situ is not possible, restore the functionality of the cultural heritage, in a different location.	As presented in Chapter 8, no replicable cultural heritage sites were identified. Mainly "non-physical" cultural heritage sites (Tambu sites) may be potentially affected.
R.6	Removal of non-replicable cultural heritage is subject to conditions: there are no technically or financially feasible alternatives to removal; The overall benefits of the project conclusively outweigh the anticipated cultural heritage loss from removal; and any removal of cultural heritage is conducted using the best available technique.	As presented in Chapter 8, no replicable cultural heritage sites were identified. Mainly non-removable "non physical" cultural heritage sites may be potentially affected. Compensation for losses of cultural heritage sites are described in the ESMP and Land Acquisition and Livelihood Restoration Plan.

#	Requirements	How will the Project implementation process comply with requirements
R.7	The client should not remove, significantly alter, or damage critical cultural heritage. In exceptional circumstances when impacts on critical cultural heritage are unavoidable, the client will use a process of Informed Consultation and Participation (ICP) of the Affected Communities.	As presented in Chapter 8, no critical cultural heritage sites were identified. Most sites are locally valued by population. Consultation with population regarding cultural places (Tambu sites) has been an ongoing process.

3.5 ASIAN DEVELOPMENT BANK REQUIREMENTS

3.5.1 Safeguard Policy Overview

The Asian Development Bank (ADB) is one of the development partners for this project and therefore the requirements set out in the Safeguard Policy Statement 2009 (SPS) also apply.[21] The goal of the SPS is to promote the sustainability of project outcomes by protecting the environment and people from any potential adverse impacts of the project.

The objectives of the SPS are to: (i) avoid adverse impacts of projects on the environment and affected people, where possible; (ii) minimize, mitigate, and/or compensate for adverse project impacts on the environment and affected people when avoidance is not possible; (iii) help borrowers/clients to strengthen their safeguard systems and develop the capacity to manage environmental and social risks.

The SPS contains three safeguard requirements; SR1: environment, SR2: involuntary resettlement, and, SR3: indigenous peoples. Each of the safeguard requirements comprises an objective, scope and triggers, and a set of policy principles that must be met. Each of the safeguard requirements follows a due diligence process of screening, categorization, scoping, consultation, impact assessment, management, and monitoring and reporting. Documentation of the due diligence is subject to disclosure as per the requirements of the Public Communications Policy 2011.

ADB will not finance projects that do not comply with the SPS and the host country's social and environmental laws and regulations, including those laws implementing host country obligations under international law. The SPS also contains a prohibited activities list identifying specific activities that ADB will not finance.

As per SR1, the project has been screened as category A i.e. its potential adverse environmental impacts are likely to be significant, irreversible, diverse, or unprecedented. These impacts may affect an area larger than the sites or facilities subject to physical works. In terms of level of environmental assessment, for category A projects, an environmental impact assessment is required. This ESIA has been prepared to meet the requirements of World Bank and ADB as per their respective safeguard policies, as well as national laws of Solomon Islands. The ESIA identifies the various components of the project, makes an assessment of the potential adverse environmental impacts and identifies the measures required to mitigate or minimise them and summarises these in the environmental and social management plan

[21] ADB 2009, Safeguard Policy Statement (Manila, Philippines)

(ESMP). As per the requirements of World Bank and ADB, the draft ESIA has been formally disclosed at least 120 days before consideration of their respective Boards.[22]

A separate report, the Land Acquisition and Livelihood Restoration Plan, identifies and addresses social safeguard impacts and how the project meets the requirements of SR2 and SR3.

3.5.2 Requirements for Natural and Critical Habitat

Policy principle 8 of SR1 requires that the borrower/client assesses the significance of project impacts and risks on biodiversity and natural resources as an integral part of the environmental assessment process. The assessment is required to focus on the major threats to biodiversity, which include destruction of habitat and introduction of invasive alien species, and on the use of natural resources in an unsustainable manner. The borrower/client needs to identify in the ESIA the measures required to avoid, minimize, or mitigate potentially adverse impacts and risks and, as a last resort, propose compensatory measures, such as biodiversity offsets, to achieve no net loss or a net gain of the affected biodiversity.

Natural Habitat

The SPS specification is that areas of natural habitat will not be converted or degraded unless all of a number of conditions are met (see below), and the key requirement for mitigation measures is they are to be designed to achieve no net loss of biodiversity.

The three conditions are: (i) no alternatives are available; (ii) a comprehensive analysis demonstrates that the overall benefits from the project will substantially outweigh the project costs, including environmental costs; and (iii) any conversion or degradation is appropriately mitigated.

Critical Habitat

Critical habitat includes areas with high biodiversity value and require special attention. Critical habitat is defined as comprising several characteristics including: (i) habitat of significance to critically endangered or endangered species; (ii) habitat of significance to endemic and/or restricted range species; (iii) habitat supporting globally significant numbers of migratory species or congregatory species; (iv) areas associated with key evolutionary processes; and (v) areas with unique assemblages of species or that provide key ecosystem services, and areas having biodiversity of significant social, economic or cultural importance to local communities in its definition. Endangered and critically endangered species are as defined in IUCN Red List or any national legislation.

Projects will not be implemented in areas of critical habitat unless additional thresholds are met. It is incumbent on the borrower/client to demonstrate the conditions can be met. Three thresholds that must be met include:

(i) there are no measurable adverse impacts, or likelihood of such, on the critical habitat which could impair its high biodiversity value or the ability to function;

[22] Disclosure for the World Bank was August 2016 and January 2017 and disclosure for the ADB was June 2017.

(ii) the project is not anticipated to lead to a reduction in the population of any recognized endangered or critically endangered species or a loss in area of the habitat concerned such that the persistence of a viable and representative host ecosystem is compromised; and

(iii) any lesser impacts are mitigated in accordance with SPS para. 27 (i.e. mitigation measures will be designed to achieve at least no net loss of biodiversity).

When a project involves activities in a critical habitat, the borrower/client must retain qualified and experienced external consultants to assist in conducting the assessment.

4. ANALYSIS OF ALTERNATIVES

4.1 Background

This section examines alternative ways that the objective of providing a more reliable source of electricity to Guadalcanal can be met, including potential alternative technologies to hydropower, and alternative ways of delivering a hydropower scheme. This section is based on the feasibility reports prepared by Entura for various phases of project development, between 2010 and 2014, as well as supplementary investigations undertaken since then.

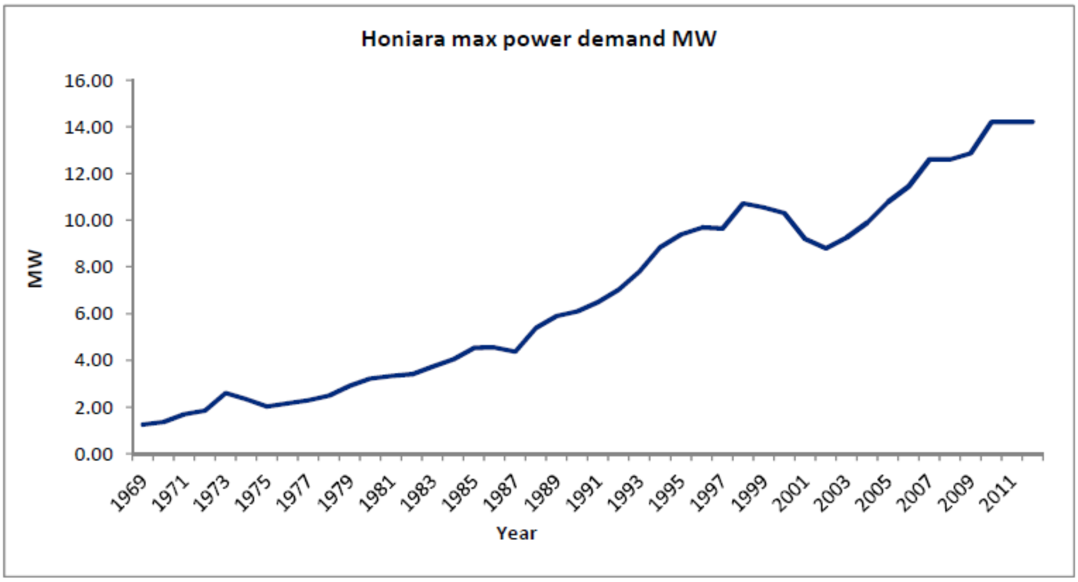
4.2 Energy Demand and Supply

4.2.1 Current and Future Energy Demand

Demand growth forecast studies have recently been undertaken by Deb Chattopadhyay for "Solomon Islands Sustainable Energy Project (SISEP)", commissioned by the World Bank as well as part of the "Energy Contract Modelling" (2014 JACOBS). The figure below is taken from the SISEP report showing demand growth for low, medium and high demand growth scenarios.

According to JACOBS, the historical annual maximum power demand for the Honiara electricity network dating from 1969 to 2012 is shown in Figure 4-1. The stagnation of demand growth since 2009 in thought to be a consequence of load shedding due to insufficient generation capacity (i.e. consumers are less inclined to buy and use electrical apparatus / appliances when the supply of electricity is unreliable).

Figure 4-1 Honiara historical maximum power demand

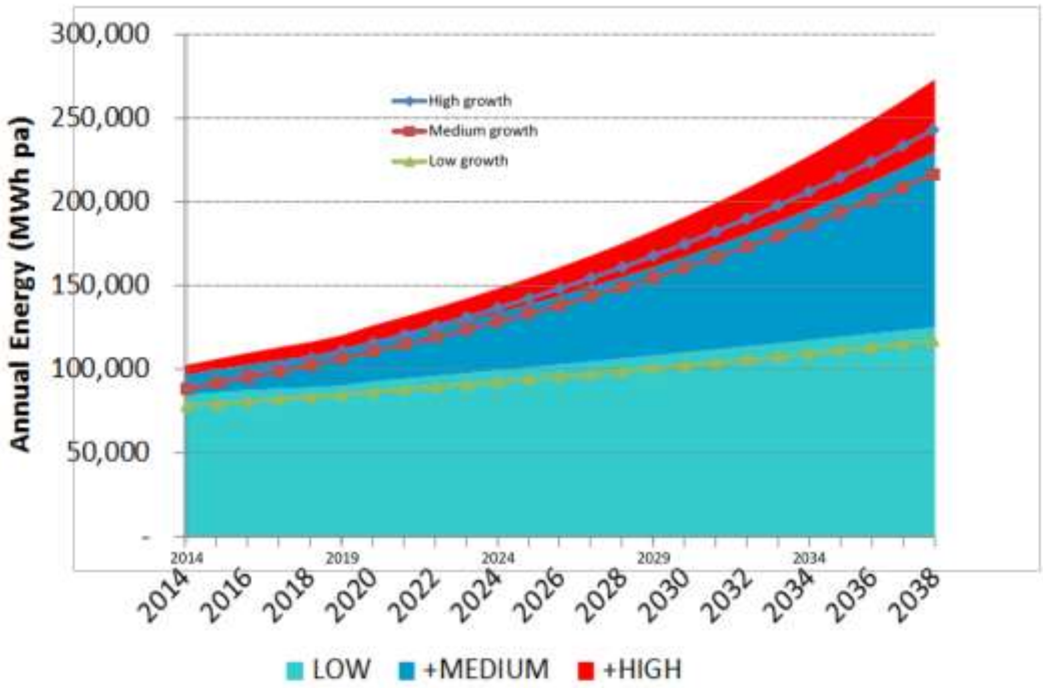


SISEP estimated new generation capacity requirements as 7 MW over the 25 next years for the Low demand growth scenario and an additional requirement for the High demand growth scenario as 25 MW.

The realization of High Demand growth scenario for the Honiara grid here depends on major new and uncertain loads coming on board — Gold Ridge, Tenaru, Mamara, Doma. If these loads do not eventuate the least cost generation plan changes (see Figure 4-2).

The SISEP assumed growth rates for the Honiara grid are conservative in that they do not envisage a significant expansion of the grid's geographic reach along the north coast of Guadalcanal. If such an expansion were to take place, as part of a national electrification strategy, demand would be higher, possibly requiring additional generation capacity.

Figure 4-2 Honiara Energy Growth Scenarios

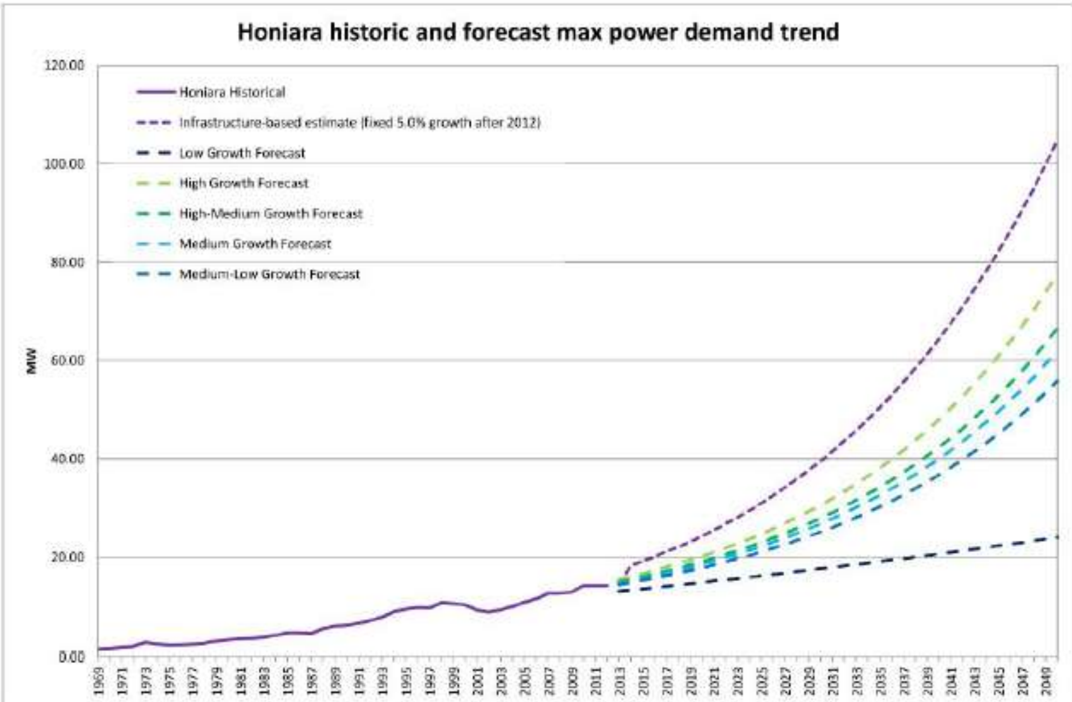


Solomon Power in 2015 predicts the annual growth in demand for energy from the Honiara grid to be 2.5% (compounding on the 2014 base year energy production of 77.6 GWh). This is similar to the SISEP report Low-Growth scenario shown in the figure above.

Solomon Power developed a 5 year demand forecast as part of the recently completed planning study.

Figure 4-3 below shows the extrapolated to demand forecast to 2050 combined with the historical demand records.

Figure 4-3 Combined Historical and Demand forecast to 2050 based on extrapolation of the 5 year forecast



4.2.2 Energy Supply

The Lungga diesel power plant is the main provider of electricity in Guadalcanal. The capital city and key population centre, Honiara, suffers from power shortages, especially during peak demand periods.

4.3 Identification of Potential Alternatives to the Project

4.3.1 Screening of Alternatives

Alternatives to the project were divided into four categories for the purpose of initial screening. These include:

1. Energy resources barred from development;

2. Emerging energy resources;
3. Demand side management (DSM); and
4. Available Energy Resources.

Alternatives to the Project were screened to determine their respective regulatory, technical and financial viability. Only those technologies that made it through the initial screening were further assessed against economic, environmental and social criteria.

4.3.2 Energy Resources Barred from Development

No legislation is barring energy resources from development in Solomon Islands.

4.3.3 Emerging Energy Resources

Wave power is the transport of energy by wind waves, and the capture of that energy to do useful work – for example, electricity generation, water desalination, or the pumping of water (into reservoirs). A machine able to exploit wave power is generally known as a wave energy converter (WEC). Wave power is distinct from the diurnal flux of tidal power and the steady gyre of ocean currents. Wave-power generation is not currently a widely employed commercial technology (the first experimental wave farm was opened in Portugal in 2008).

Tidal power, also called tidal energy, is a form of hydropower that converts the energy obtained from tides into useful forms of power, mainly electricity. Tidal power has potential for future electricity generation but is currently not widely used. Among sources of renewable energy, tidal power has traditionally suffered from relatively high cost and limited availability of sites with sufficiently high tidal ranges or flow velocities, thus constricting its total availability. However, recent technological developments and improvements in design and turbine technology indicate that the total availability of tidal power may be much higher than previously assumed, and that economic and environmental costs may be brought down to competitive levels in the future.

Because the technologies for producing power from these resources are still in their early stages and not sufficiently well developed to be employed in the Solomon Islands environment and, therefore, would not provide a reliable source of energy for Guadalcanal, they have been ruled out as alternatives to the Project.

4.3.4 Demand Side Management (DSM)

According to Wikipedia[23], Demand Side Management, or DSM "is the modification of consumer demand for energy through various methods such as financial incentives and behavioural change through education." DSM was considered, but quickly ruled out for Guadalcanal. This is because electricity costs are already very high and most consumers, having relatively low incomes and, therefore, being price sensitive, are already limiting their use of electricity. Most rural areas are not provided with electricity from the grid, so DSM has no bearing on their use, or not, of electricity produced by Solomon Power.

4.3.5 Available Energy Resources

Available energy resources include those for which technologies are sufficiently evolved to provide reasonably reliable generation and transmission and which might be available to Guadalcanal. They include: hydropower, pumped storage, solar, wind, geothermal, gas fired thermal, and transmission of electricity from adjacent islands, where surplus electricity might be available. A portfolio of different energy resources (e.g., combination of solar, wind, geothermal resources) was also considered, as was the status quo diesel generation.

4.3.5.1 Status Quo – Diesel Generator at Lungga

Sticking with the status quo is effectively choosing the "No Project" alternative.

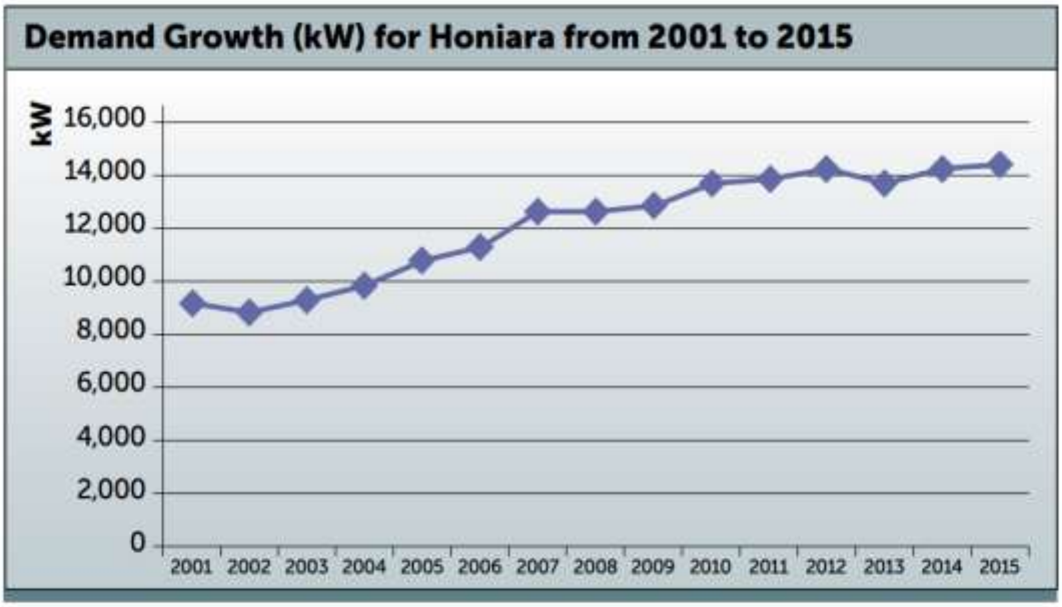
Grid-connected electricity is generated and supplied in Solomon Islands by Solomon Power (SolPower) which is a state-owned electricity utility. SolPower provides electricity to the national capital (Honiara) and eight provincial centres (Auki, Buala, Gizo, Kirakira, Lata, Malu'u, Noro-Munda, and Tulagi). Installed generation capacity in Honiara is 26 megawatts (MW) with a peak load of 14.3 MW and combined installed capacity in the provincial centres is 4 MW.

The demand for electricity in 2015 in Honiara peaked at 14,425 Kilowatts compared with a figure of 14,100 Kilowatts in 2014.

Figure 4-4 below shows the demand growth for Honiara from 2001 to 2015 (Source: Solomon Power annual Report 2015)

[23] https://en.wikipedia.org/wiki/Energy_demand_management

Figure 4-4 Honiara Electricity Demand Growth Solomon Power Annual Report 2015



Lungga and Honiara Solomon Power operations produced a total of 77.91Gwh (89.70%) whilst Solomon Power's provincial outstations (Buala, Taro, Auki, Gizo, Noro, Kirakira, Lata, Munda, and Tulagi), Solomon Tropical Products as an Independent Power Producer (IPP) (coconut oil) at Ranadi, and the Ranadi Solar Plant at Solomon Power head office together produced 8.91Gwh (10.3%). There was no energy bought by Solomon Power from its PPA with Soltuna in Noro during the year.

Diesel generation consume fossil fuels and in the long term are not considered a sustainable form of electricity generation. Diesel fuel is a relatively expensive, non-renewable energy source and highly dependent on market price and price changes.

Disadvantages of Diesel power generation:

- High operational cost
- High maintenance and lubrication cost
- Diesel unit capacity is limited
- Diesel generation is a net producer of the greenhouse gas carbon dioxide
- Air pollutant emissions
- Noise emissions
- Diesel plants are limited when it comes to supplying overloads continuously
- Diesel power plants are not economical where diesel has to be imported
- Limited life of a diesel power plant (usually 2 to 5 years)

4.3.5.2 Hydropower

Prior to identifying the Tina River as the site of a potential hydropower project, two hydropower schemes were studied for other sites in Guadalcanal. These were the Lungga Hydroelectric Project, and the Komarindi hydropower Project. Little is known about the characteristics of the Lungga Hydroelectric Project.

The Komarindi hydropower project was studied by Tonkin and Taylor (1993), who completed prefeasibility and feasibility studies, geotechnical investigations, detailed design, and an Environmental and Social Impact Assessment. If constructed, the project would have included a river intake, a tunnel to a penstock connecting to a powerhouse, and a tailrace / outlet back into the river.

The map in Figure 6-1 identifies the respective project areas for the proposed Komarindi, Lungga and Tina hydropower project.

- Komarindi hydro potential was identified “G-SI-7 Komarindi” with a hydro potential of 6.6MW.
- Lungga hydro potential was identified “G-SI-4 Lungga” with a hydro potential of 21MW.
- Tina hydro potential was identified “G-SI-21 Ngalimbiu” with a hydro potential of 17.7MW.

According to the World Bank, “the previous studies highlighted the unsuitability of the Lungga and Komarindi sites. The Lungga and Komarindi schemes failed to proceed for a variety of reasons, including inappropriate scale (both schemes) and poor site selection for the dam wall (Lungga)“. Investigations of the Lungga Gorge, as a site for potential Hydro development, were carried out in the 1980s. After initial optimism and development of a costly road to the proposed construction site, the project was abandoned because of the presence of geological conditions which made the site unsafe for development.

In addition, ‘The Solomon Islands, Guadalcanal Renewable Development Concept Study’ (World Bank Project Power Mission, February 2006) studied the hydropower potential of three catchments on Guadalcanal: the Ngalimbiu site on the Tina River; the Nuhu site on the Mbalasuna River; and the Choha site on the Ngheunaha and Kolokumaha Rivers. The study concluded the Ngalimbui site on the Tina River as having the greatest hydropower potential, and the other sites were dropped (Entura, 2012). The present TRHDP is located upstream of the Ngalimbui Site, and has a hydropower potential of 20MW.

Figure 4-5 shows all catchments and rivers that were, at one point, studied for potential hydropower development in Guadalcanal.

As with other forms of economic activity, hydropower projects can have both a positive and a negative environmental and social impact, because the construction of a dam and power plant, along with the impounding of a reservoir, creates certain social and physical changes.

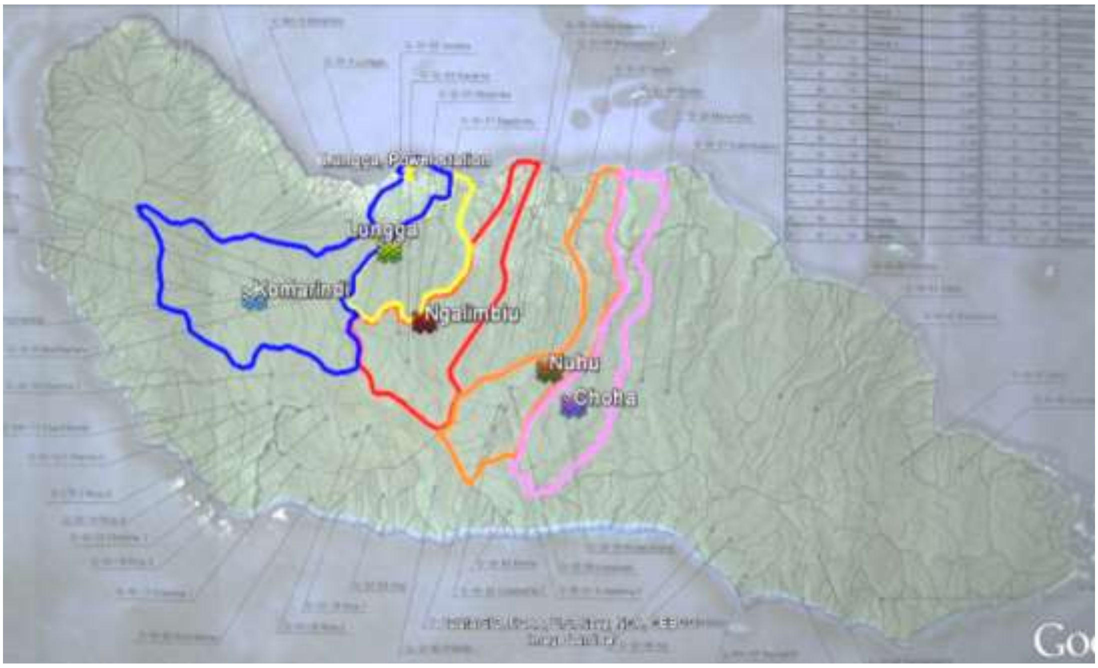
Advantages of hydropower

- Elimination of fuel costs;
- Comparably higher economic lifetime (than diesel generators, for instance);
- Low operation and maintenance (O&M) cost due to a high degree of automation;
- No direct emission of greenhouse gases or air pollutants.
- Potential for multipurpose usage (i.e. irrigation and water supply, fishery);
- River flow and flood regulation;
- Generation of renewable energy.

Disadvantages of Hydropower

- Construction of hydropower projects could introduce local imbalances to ecosystems, landscapes and river flow;
- Impoundment can potentially lead to thermal and chemical changes within the immediate reservoir areas, with possible downstream impacts.
- Sedimentation, deposition, and nutrient enrichment in the reservoir can lead to increased development of aquatic flora (plankton, benthic algae, rooted and floating macrophytes) which in turn, under certain conditions, can reduce the dissolved oxygen content in the water and cause mortality of fish and other aquatic life;
- Construction of hydropower plants in general is expensive (although having low operation & maintenance costs).

Figure 4-5 Studied catchments for hydropower development in Guadalcanal



Source: Photograph provided by MMERE offices and adapted with Google Earth

4.3.5.3 Pumped Storage

Pumped storage facilities use the height difference between two natural bodies of water or artificial reservoirs. At times of low electrical demand (night times), excess generation capacity is used to pump water into a higher reservoir. During times of higher demand (morning, mid-day and late afternoon), water is released back into the lower reservoir through a turbine, generating electricity. Reversible turbine/generator installations can be utilized to act as pump and turbine (usually a Francis turbine design).

A pumped storage system can be economical because it flattens out load variations on the power grid. Capital costs for purpose-built pumped storage are relatively high.

In summary, pumped storage depends on either:

1. Having a “must run” source of energy such as nuclear or geothermal which has excess capacity at low demand periods and can therefore pump the water to storage at little or no additional cost (other than the capital to establish the storage and hydro facility).; or
2. At least a peak demand price which greatly exceeds the off peak price (I.e. an essential part of the peak generation mix that has a variable cost which exceeds the cost of the pumped storage.

In Honiara, neither of these conditions applies. The pumped facility would cost more than Tina River Hydro per MW to build and more than the diesel generation cost to operate. In addition, there are no identified areas where any suitable hydro storage can be established.

4.3.5.4 Solar

A photovoltaic power station, also known as a solar park, is a large-scale photovoltaic system (PV system) designed for the supply of power into the electricity grid. They are differentiated from most building-mounted and other decentralised solar power applications because they supply power at the utility level, rather than to a local user or users. They are sometimes also referred to as solar farms or solar ranches, especially when sited in agricultural areas. The generic expression utility-scale solar is sometimes used to describe this type of project.

The land area required for a desired power output, varies depending on the location and on the efficiency of the solar modules, the slope of the site and the type of mounting used. Fixed tilt solar arrays using typical modules of about 15% efficiency on horizontal sites, need about 1 hectare/MW in the tropics and this figure rises to over 2 hectares in northern Europe.

Grid connection

The availability, locality and capacity of the connection to the grid is a major consideration in planning a new solar park, and can be a significant contributor to the cost. Most stations are sited within a few kilometres of a suitable grid connection point. This network needs to be capable of absorbing the output of the solar park when operating at its maximum capacity. The project developer will normally have to absorb the cost of providing power lines to this point and making the connection, often also any costs associated with upgrading the grid so it can accommodate the output from the plant.

Operation and maintenance

Once the solar park has been commissioned, the owner usually enters into a contract with a suitable third party to undertake operation and maintenance (O&M). In many cases this may be fulfilled by the original EPC contractor.

Solar plants' reliable solid-state systems require minimal maintenance, compared to rotating machinery for example. A major aspect of the O&M contract will be continuous monitoring of the performance of the plant and all of its primary subsystems, which is normally undertaken remotely. This enables performance to be compared with the anticipated output under the climatic conditions actually experienced. It also provides data to enable the scheduling of both corrective and preventive maintenance. A small number of large solar farms use a separate inverter or maximizer for each solar panel, which provide individual performance data that can be monitored. For other solar farms, thermal imaging is a tool that is used to identify non-performing panels for replacement.

Power delivery

A solar park's income derives from the sales of electricity to the grid, and so its output is metered in real-time with readings of its energy output provided, typically on a half-hourly basis, for balancing and settlement within the electricity market. Income is affected by the reliability of equipment within the plant and also by the availability of the grid network to which it is exporting. Some connection contracts allow the transmission system operator to constrain the output of a solar park, for example at times of low demand or high availability of other generators. Some countries make statutory provision for priority access to the grid for renewable generators

Advantages of Solar Power

Solar energy is a resource that is not only sustainable for energy consumption, it is indefinitely renewable. Solar power can be used to generate electricity, it is also used in relatively simple technology to heat water (solar water heaters).

Solar panels usually require little maintenance. After installation and optimization they are very reliable due to the fact that they actively create electricity in just a few milimetres of material and, unless installed with variable tilt mountings, do not require any type of mechanical parts that can fail. Solar panels are also a silent producer of energy, a necessity if dealing with sensitive neighbourhoods.

Disadvantages of Solar Power

The primary disadvantage of solar power is that it cannot be generated during the night. The power generated is also reduced during times of cloud cover (although energy is still produced on a cloudy day). Advances are being made in battery technology to permit overnight storage, but utility-scale applications are still rare.

Solar panel energy output is maximized when the panel is directly facing the sun. This means that panels in a fixed location will see a reduced energy production when the sun is not at an optimal angle. Many large scale solar "farms" combat this problem by having the panels on towers (above left) that can track the sun to keep the panel at optimal angles throughout the day.

A further disadvantage is the relatively large area required to develop commercial solar farms. For instance, Royalla Solar Farm (Canberra AU) comprises of 83,000 PV panels which are occupying 50 hectares at 20 MW installed capacity. The Royalla Solar Farm is a solar only facility and therefore generating power only during daytime hours.

Even today's most efficient solar cells only convert just over 20% of the sun's rays to electricity. Besides their low conversion efficiency, solar panels can be a substantial initial investment.

4.3.5.5 Wind

Economic wind generators require wind speed of 16 km/h (10 mph) or greater. An ideal location would have a near constant flow of non-turbulent wind throughout the year, with a minimum likelihood of sudden powerful bursts of wind. An important factor of turbine siting is also access to local demand or transmission capacity.

Advantages

- Aclean fuel source. Wind energy doesn't pollute the air like power plants that rely on combustion of fossil fuels, such as coal or natural gas. Wind turbines don't produce atmospheric emissions that cause acid rain or greenhouse gases.
- Wind is a domestic source of energy.
- It's sustainable. Wind is actually a form of solar energy. Winds are caused by the heating of the atmosphere by the sun, the rotation of the Earth, and the Earth's surface irregularities. For as long as the sun shines and the wind blows, the energy produced can be harnessed to send power across the grid.
- Wind power is cost-effective. It is one of the lowest-priced renewable energy technologies available today, costing between four and six cents per kilowatt-hour, depending upon the wind resource and the particular project's financing.
- Wind turbines can be built on existing farms or ranches. This greatly benefits the economy in rural areas, where most of the best wind sites are found.

Disadvantages

- Wind power must still compete with conventional generation sources on a cost basis. Depending on how energetic a wind site is, the wind farm might not be cost competitive. Even though the cost of wind power has decreased dramatically in the past 10 years, the technology requires usually higher initial investments.
- Good wind sites are often located in remote locations, far from cities where the electricity is needed. Transmission lines must be built to bring the electricity from the wind farm to the city.
- Wind resource development might not be the most profitable use of the land. Wind farms on land suitable for wind-turbine generation must compete with alternative forms of development for the land that might be more highly valued by the owners.
- Turbines cause noise and aesthetic impact. Although wind power plants have relatively little impact on the environment compared to conventional power plants, concern exists over the noise produced by the turbine blades and visual impacts to the landscape.
- Turbine blades can harm local wildlife. Birds and bats have been killed by flying into spinning turbine blades. These problems can be somewhat reduced through technological development and proper site selection.

To ascertain whether there is a commercial wind resource in useable locations within Solomon Islands would require at least 2 years of meteorological data monitoring prior to construction of a wind farm. A previous attempt to carry out such monitoring with meteorological measuring masts provided by donor funding failed to capture data from the installed equipment due to inadequate funding, and eventually the installed equipment was adapted for other purposes by the local communities.

4.3.5.6 Geothermal

Initial investigations were conducted into a possible geothermal resource on Savo Island, 40 km from Honiara. However, due to financial constraints, no drilling has been undertaken and the potential resource remains unproven. In 2015, Geodynamics, the majority shareholder of the geothermal venture, announced that it did not intend to incur any further significant expenditure on the project due to 'market conditions'.[24] No further activities have been undertaken. High transmission costs from Savo Island to Honiara are a disadvantage of the site, with 16 km of undersea cabling required to the closest point on Guadalcanal, some 60 km from Honiara, depths of Iron Bottom Sound near Savo of 600-1350 metres, and Solomon Power's preference for dual transmission lines to provide for n-1 redundancy.

4.3.5.7 Gas Fired Thermal

A gas fired power station is a power station which burns fossil fuel to produce electricity. Central station fossil-fuel power plants are designed on a large scale for continuous operation. In many countries, such plants provide most of the electrical energy used. Fossil-fuel power stations have machinery to convert the heat energy of combustion into mechanical energy, which then operates an electrical generator. The prime mover may be a steam turbine, a gas turbine or, in small plants, a reciprocating internal combustion engine. All plants use the energy extracted from expanding gas, either steam or combustion gases. Heavy fuel oil and other liquid fuels besides diesel could also be used in a thermal plant, but because any fossil fuels would have to be imported and gas is less expensive, only gas is being considered here.

Advantages

- Economy: Natural gas is cheaper compared to other fossil fuels and cheaper than electricity when used for supplying home appliances. Natural gas appliances are also cheaper compared to electrical ones.
- Environment: It does not pollute the ground or the underground water because its by-products are in gaseous form. Another important fact is that natural gas burns without releasing any particulate material or sulphur dioxide. It also emits 45% less carbon dioxide than coal and 30% less than oil per unit of electricity produced.
- Transportation: Transportation is made via sea (tankers) and land (pipelines and small tanks). This fact allows natural gas to be easily transferred from power plants to residential areas surrounding residential areas.

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[24] Geodynamics Annual Report 2015. See also 'Geodynamics puts expenditure on hold for Pacific Geothermal Projects', *Think Geoenergy*, 16 October 2015: http://www.thinkgeoenergy.com/geodynamics-puts-expenditure-on-hold-for-pacific-geothermal-projects/. Accessed 10 December 2016.

- Multi-uses: Natural gas is a multi-use fuel. It is used inside the house for cooking, heating, drying, etc. It can be used for generating electric power, powering vehicles (by substituting for diesel and gasoline), producing plastics, paints, fertilizers, and many more uses.
- Availability: It is abundant and almost worldwide available.
- Conversion to Hydrogen Fuel: It is currently the cheapest fossil fuel source for producing hydrogen.

Disadvantages

- Flammable: Natural gas leaks can be proven to be extremely dangerous. Such leaks may be the cause of fire or explosions. The gas itself is an asphyxiant. The main risk comes from the fact that it is naturally odourless and cannot be detected by smell, unless an odorant has been added to the gas mixture. In the case of an underground leak, the odorant may gradually become weaker and the gas may go undetected.
- Environmental Impact: When natural gas burns, carbon dioxide, monoxide, and oxides of nitrogen s are emitted in the atmosphere contributing to air pollution and the greenhouse effect. Although it is cleaner than other fossil fuels (oil, coal, etc.) as far as combustion by-products are concerned, natural gas leaks are significant contributors to climate change since methane, its main constituent, has 21 times the global warming potential of carbon dioxide.
- Processing: In order to use it as a fuel, constituents other than methane have to be extracted. The processing results in several by-products: hydrocarbons (ethane, propane, etc.), sulphur, water vapour, carbon dioxide, and even helium and nitrogen.
- Non-Renewable: It is a finite source of energy and cannot be considered a long-term solution to our energy supply problem.
- Installation: The whole pipe installation may be very expensive to construct since long pipes, specialized tanks, and separate plumbing systems need to be used. Pipe leakage may also be very expensive to detect and fix.
- Efficiency in Transportation: When natural gas is used as a fuel in cars, the mileage is lower than gasoline.
- Economics: In addition to the gas fired thermal generating station itself, an onshore compressed gas storage facility and dedicated deep sea terminal to receive LNG or CPG shipments site infrastructure are required.

- Conversion to Hydrogen Fuel: A drawback in producing hydrogen from natural gas is that efficiency drops to almost 50% compared to the original chemical energy.

4.3.5.8 Transmission of Electricity from Other Islands

Transmission of electricity from one of the other islands within the Solomon Islands archipelago, and from neighbouring island countries like Papua New Guinea (e.g., Bougainville) and Vanuatu, were quickly dismissed on the basis that all of these islands are currently in short supply of cheap electricity and, therefore, do not have surplus energy to sell. More importantly, even if surplus electricity were available for purchase, the great distances involved to connect Guadalcanal using an undersea transmission cable of sufficient capacity to overcome line losses, would cost orders of magnitude more than the next best alternative. Therefore, this option was given no further consideration.

4.3.5.9 Portfolio of Available Energy Resources

Consideration was given to combining the most promising available energy resources – solar, wind and geothermal – into a portfolio of energy generation against which the hydropower option was compared.

A significant percentage of total capacity being provided by hydropower would be favourable to the potential to add other more intermittent energy sources (such as solar, wind or tidal) to provide a portfolio of available energy sources because of the particular characteristics of hydropower generation. The hydro generators are able to provide ancillary services (frequency control, voltage control), spinning reserve and maintenance capacity to the networked generators.

The hydro turbines are able to start or increase output virtually instantaneously, and to maintain the key power quality characteristics of the network (voltage and frequency) even as other elements of the network fluctuate in their production.

A certain percentage of hydropower in the network is an essential feature that will allow for significant penetration to the network of either wind or solar generation. Thus a station like Tina Hydro could be a catalyst to support further construction of solar farms.

4.3.5.10 Preferred Project Alternative

Table 4-1 compares the various available energy project alternatives on the basis of: energy production; economics; reliability and limitations; and environmental and social benefits and constraints Based on a comparative review of the various available energy resources, the best alternative was determined to be that of a hydropower project located on the Tina River. The rationale for this selection is as follows:

- Hydropower is a reliable and proven source of renewable energy within local environments such as Solomon Islands
- Suitable hydrological conditions
- Project locations with minimal social and manageable environmental impact
- Availability of natural resource (water)
- Relatively long economic lifetime
- Low maintenance cost
- Reliable base load power supply

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When compared with the status quo or no-project alternative, if the hydropower alternative is not constructed, Honiara would probably continue to experience frequent power outages, as is the case today. Lungga power station would need to be upgraded, or additional diesel plants would need to be constructed to provide electricity during peak hours. Unlike electricity generated from hydro, electricity generated from diesel can contribute to environmental impacts in the form of greenhouse gas emissions, air pollution, risks of oil spills during production, sea transport and transfer. Another advantage of hydropower over diesel is that it allows the Solomon Islands to move toward energy self-reliance, using its own renewable resources, rather than importing non-renewable sources of energy. From an economic perspective, the unit cost of hydro is significantly lower than the unit cost of diesel. As diesel prices increase, this gap will become more significant. Therefore, not implementing the hydropower alternative would have economic consequences for SIG.

According to the TRHDP PO, there is provision in the transmission design for rural electrification, which will include 33kV/415V pole mounted transformers at each of the villages situated along the Tina Village road. Therefore, not implementing the hydropower project would potentially result in the loss of opportunity for rural electrification.

From an employment perspective, more jobs will be created during construction than for any other alternative energy project. Therefore, not developing the hydropower project would eliminate the opportunity for local communities to earn salaries, and gain experience and skills in construction work. Wages paid to construction workers typically represent the single largest social benefit during the construction phase of a dam. In the case of the TRHDP, it is the intention of the PO to engage as many workers as possible from the local communities during the construction phase.

Table 4-1 Comparative summary of energy resource projects

#	Status Quo (Lungga Diesel)/No Project	Hydro Project on Tina River	Solar	Wind	Geothermal	Gas Fired Thermal	Transmission from Another Island	Portfolio of Energy Resource Alternatives
Energy Production	71.91 GWh (2015)	78.35 GWh pa	Dependent on size (range 1 to 2.5 ha/MW)	1 average onshore wind turbine (2.5–3 MW capacity) can produce more than 6 GWh pa given suitable average wind speeds	Depending on available energy stored within geological unit	Approx. 8,000,000 m^3 gas / 81 GWh pa	Not feasible due to lack of suitable energy production facility on other islands	Combination of Hydro + Solar considered feasible to meeting increasing future demand (refer to hydro and solar columns)
Reliability & Limitations	Frequent outages experienced during times of peak energy demand	Reliable power generation option, immediately available energy, long project lifetime	Generation mainly during sunshine hours, difficult to store energy on large scale, suitable in combination with other power generation sources	Dependent on site selection, high initial investment cost	Low operation and maintenance cost once established, potential to run out of steam thus high initial investigation costs, extremely long lead time to install/repair undersea cables	Reliable technology, high efficiency (up to 60%),		
Economics	High cost due to import of diesel and lubricants, high operation and maintenance cost	High initial investment, low operation and maintenance cost	Medium to high initial investment, low operation and maintenance cost, current technology warranty of 25 years, average of 1% per annum of reduction in output	Due to storage limitations for energy, wind farms typically complement hydro power very well. Suitable sites for wind farms are required to operate economically, which may result in high transmission costs	Potentially available geothermal energy at Savo island (unproven), approx. 11MW, thus additional energy source required to meet demand; High initial investment, high transmission cost (undersea cable + transmission line), finite energy source	High cost due to import of natural gas and lubricants, high operation and maintenance cost, added cost for site and storage handling and infrastructure (storage, port facility, etc.)		
Environmental Benefits / Constraints	Fossil fuel, noise, priority air contaminants and GHG emissions, dependency on imported fossil fuels, potential spills	Inundation of land due to reservoir impoundment, requirement to manage reduced river flows between dam and powerhouse tailrace; potential barrier to migration of some fish species; lower net GHG emissions; no air pollutant emissions from operations	Relative large areas of land required for establishment (approx. 1 MW/2.5ha, depending on angle to sun), operation of solar plants has low environmental impacts	Large site required for establishment of wind park, but land can continue to be used for some agricultural purposes. Noise and aesthetic pollution. Bird and bat mortality.	Potential to release poisonous or otherwise harmful gases such as hydrogen sulphide. Potential water pollution from brines,	Fossil fuel, noise, priority air contaminants and GHG emissions, dependency on imported fossil fuels		
Social Benefits / Constraints	Local employment opportunities, constraints on locally available skilled maintenance/engineering	Local employment opportunities, constraints on locally available skilled maintenance/engineering	Local employment opportunities, constraints on locally available skilled maintenance/engineering	Local employment opportunities, constraints on locally available skilled maintenance/engineering	Local employment opportunities, constraints on locally available skilled maintenance/engineering	Local employment opportunities, constraints on locally available skilled maintenance/engineering		

4.4 ALTERNATIVE LOCATIONS AND CONFIGURATIONS FOR THE PREFERRED PROJECT - THRDP

4.4.1 History of Project Refinement

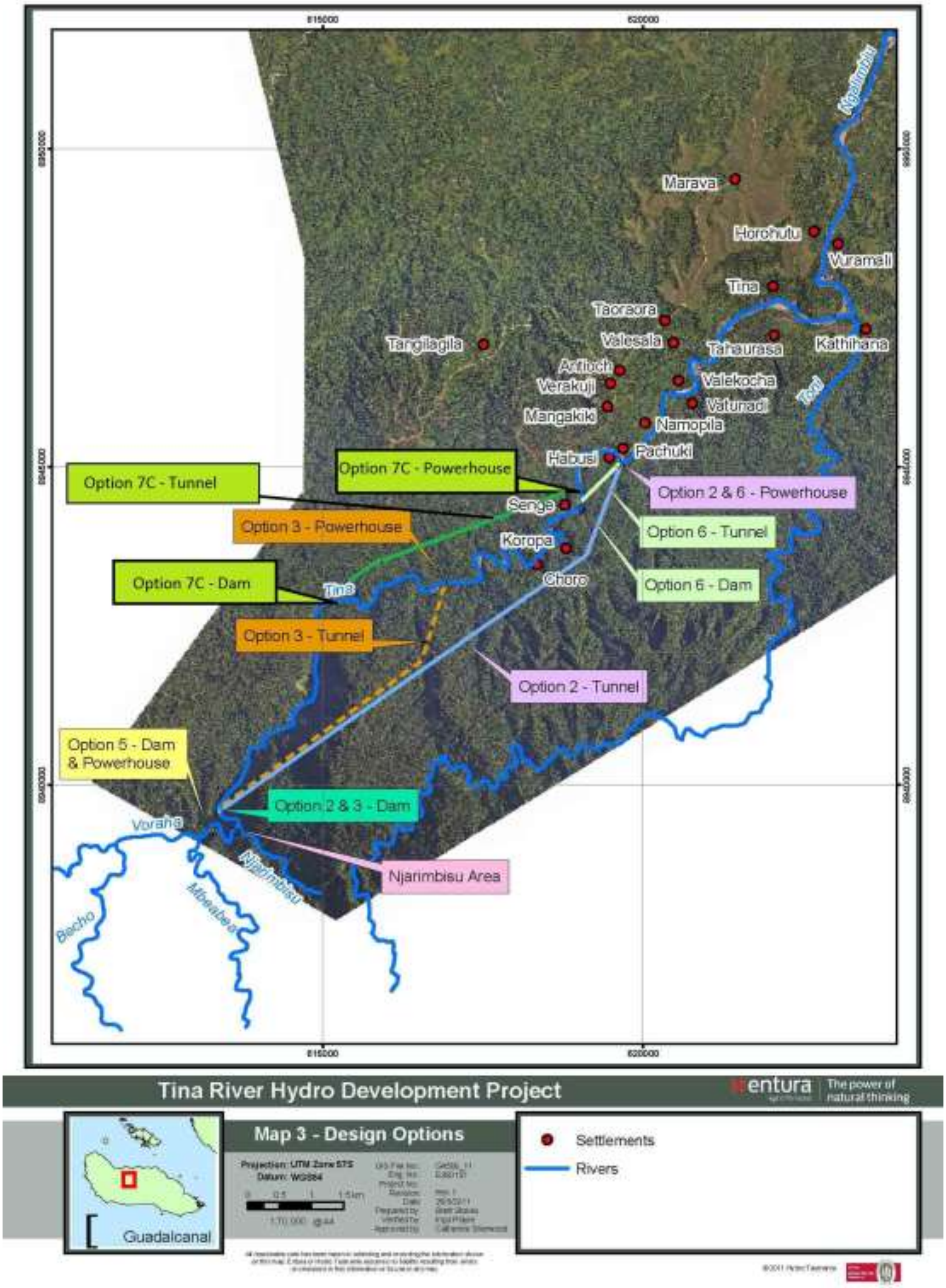
Entura (2010 to 2014) studied several options along the Tina River with the objective of locating the best site to optimize power generation capacity. Options were evaluated based on economic, technical and environmental and social criteria. The key criteria used to select the single best option were financial / economic viability and geological integrity.

Entura carried out a three-phased program to select the preferred site for a hydropower project, as follows (see Figure 4-6):

Phase 1 report studied a series of dams along the stretch of river from the Mbeambea River / Tina River confluence (upstream catchment) to the Toni River / Tina River confluence (Entura, 2010):

- Site 1: Dam located on the Tina River upstream of Njarimbisu and upstream of Mbeambea geological fault, and a powerhouse located upstream of Habusi village. Option 1 was considered not technically viable because of the high geological risk associated with the long tunnel. Option 1 was eventually dropped due to high environmental sensitivities of the upper catchment region.
- Site 2: Dam located on the Tina River downstream of Njarimbisu tributary and upstream of the Mbeambea geological fault, and a powerhouse located upstream of Pachuki, connected by a tunnel of approximately 8.6 km. Option 2 was eventually dropped due to high environmental sensitivities of the upper catchment region.
- Site 3: Dam located on the Tina River downstream of Njarimbisu tributary. Power station located upstream of Koropa, connected by a tunnel of approximately 5.5 km. Option 3 was eventually dropped due to high environmental sensitivities of the upper catchment region.
- Site 4: Dam located on the Tina River upstream of Njarimbisu tributary at the Mbeambea geological fault, and a powerhouse located at the downstream end of Njarimbisu. Option 4 was considered not technically viable because of extremely difficult access and unsuitable geology at the dam site.
- Site 5: Dam located on the Tina River upstream of Njarimbisu tributary and Mbeambea geological fault, and a powerhouse located at the toe-of-dam. Option 5 was eventually dropped due to high environmental sensitivities of the upper catchment region.
- Site 6: Dam located on the Tina River downstream of Senghe, and a powerhouse located upstream of Pachuki connected by a short tunnel. This option was selected for phase 2 report.

Figure 4-6 Sites investigated for the TRHDP



Phase 2 report (Entura, 2012) dropped the Site 6 (also called 6a) option, due to geological risks, and studied several further locations for siting a dam-powerhouse, from Site 6a to Site 6f. Two options were retained for further evaluation (Sites 6e and 6f) by GeoRisk Solutions (2012). The other options were eventually dropped due to potential adverse geological conditions. At the time the ESIA commenced, the Site 6e option was favoured.

Phase 3 report by Entura (2014) evaluated two sub-options for Site 6e, as well as a new site, referred to as Site 7c, for which three sub-options were evaluated.

- Site 6e: Option 1: RCC dam at chainage 11.3km, left bank pipeline to powerhouse at ch11.5km, dam height ranges from 35m to 75m above existing riverbed level (toe of dam solution)
- Site 6e: Option 2: RCC dam at chainage 11.3km, right bank tunnel to powerhouse at ch13.3km, dam height ranges from 35m to 75m above existing riverbed level (mid tunnel solution).
- Site 7c: Option 1: RCC dam at chainage 7km, left bank tunnel to powerhouse at ch12.7km, dam height ranges from 35m to 65m above existing riverbed level (long tunnel solution).
- Site 7c: Option 2: RCC dam at chainage 7km, right bank pipeline to powerhouse at ch7.3km, dam height ranges from 45m to 85m above existing riverbed level (toe of dam solution)
- Site 7c: Option 3: RCC dam at chainage 7km, left bank tunnel to powerhouse at ch8.9km, dam height ranges from 35m to 75m above existing riverbed level (mid tunnel solution)

In its Phase 3 report, Entura (2014) concluded that Site 7c Option 1 had superior economic, social and technical value when compared to Site 6e. A comparative environmental and social alternative analysis was made of Site 6e and Site 7c, the results of which are provided in the following subsection. Site 7c Option 1 is the Project assessed by this ESIA.

4.4.2 Final Selection of the Preferred Project Site and Layout

Table 4-2 presents an analysis of alternatives from Entura's 2014 Phase 3 report, based on social, environmental, technical and economic criteria.

The Phase 2 and Phase 3 feasibility studies by Entura (2014), had selected several options along Tina River, the selection of options was mainly based on geophysical criteria used to select a site that offers stable geological conditions, as well as economic performance in terms of return on investment, and electricity production. In the following analysis, emphasis was placed on environmental and social criteria to complement the technical analysis done by Entura.

Options that were favoured, were those that were best able to address environmental, social or technical/financial criteria, or combination of criteria.

Criteria were selected based on their relevance, and do not necessarily reflect the various existing baseline sections. For example, criteria such as "reptiles and amphibians" or "birds" are not dealt with since they represent a level of detail that was not available at the time the overview level of analysis of alternatives was undertaken.

Table 4-2 summarises the results of the evaluation of the two Site 6e and three Site 7c alternatives for the Project. Chainage distances are based on Entura (2010) Phase 1 work, with CH 0km being the confluence of the Mbeambea and the Voraha, and CH 18.7km being the downstream Tina River / Toni River confluence.

Table 4-2 Comparison of siting options

Criteria	Site 6e- Option 1	Site 6e- Option 2	Site 7c- Option 1	Site 7c- Option 2	Site 7c- Option 3
Location (Chainage in km)	Dam: 11.3 Powerhouse: 11.5 Reservoir: 11.3 - 7 Toe of dam option (no by-passed river reach)	Dam: 11.3 Powerhouse: 13.3 Reservoir: 11.3 - 7 Mid tunnel option (mid by-passed river reach)	Dam: 7 Powerhouse: 12.7 Reservoir: 7 – 4.5 Long tunnel option (long by-passed river reach)	Dam: 7 Powerhouse: 7.3 Reservoir: 7 – 4.5 Toe of dam option (no by-passed river reach)	Dam: 7 Powerhouse: 8.9 Reservoir: 7 – 4.5 Mid tunnel option (mid by-passed river reach)
Catchment size (150 km^2)	Upstream of dam: 135 km^2 Downstream of dam: 15 km^2		Upstream of dam: 125 km^2 Downstream of dam: 25 km^2		
Social and cultural					
Number of people/villages to relocate and land acquisition	For this criteria, the best option would be the one that involves the least number of inhabitants to resettle and the smallest Core Area to acquire (to alienate from customary land ownership)				
	Choro (CH 9km), ~4 inhabitants to be resettled due to the reservoir Senghe (CH 11.5km), ~16 inhabitants to be resettled due to the powerstation Koropa (CH 11 km), ~19 inhabitants to be resettled due to quarries Habuchi (CH 13.3 km), ~33 inhabitants, no foreseen physical resettlement		Choro (CH 9km): no foreseen physical resettlement Senghe (CH 11.5km): no foreseen physical resettlement Koropa (CH 11 km): no foreseen physical resettlement Habuchi (CH 13.3 km): no foreseen physical resettlement Pachuki (CH 13.8 km): no foreseen physical resettlement Villages along the access road: no foreseen physical resettlement		

Criteria	Site 6e- Option 1	Site 6e- Option 2	Site 7c- Option 1	Site 7c- Option 2	Site 7c- Option 3
	Pachuki (CH 13.8 km), ~65 inhabitants, no foreseen physical resettlement Villages along the access road: no foreseen physical resettlement				
	Since this option will physically relocate people, some of their sources of livelihood will also be affected such as garden and river uses. However, this option would require a relatively small Core Area because the powerhouse would be at the toe of the dam	Since this option will physically relocate people, some of their sources of livelihood will also be affected such as garden and river uses. In addition, the Core Area to be acquired would include the powerhouse 2 Km downstream of the dam	Although this option does not necessitate relocation of people, the Core Area to be acquired would be relatively large to include the powerhouse 5.7 Km downstream	In terms of livelihood, this option would probably be the best since it would not require any resettlement of people and it would require a relatively small Core Area because the powerhouse would be at the toe of the dam	Although this option does not necessitate relocation of people, the Core Area to be acquired would need to include the powerhouse 1.9 Km downstream
				Best Options	
Sacred sites and cultural heritage	For this criterion, the best option would be the one that would affect the least number of sacred sites or safeguards the most important ones.				
	Each community has numbers of cultural heritage sites (tambu site); most of their localizations are unknown to outsiders, therefore all options have to be considered equally good for this criteria. However, the sacred site identified as “Tulahi” would be unaffected by 7c and it has been excluded from Land Acquisition				
			Best option		

Criteria	Site 6e- Option 1	Site 6e- Option 2	Site 7c- Option 1	Site 7c- Option 2	Site 7c- Option 3
Infrastructure, school, clinic, churches to displace	None of the options affect infrastructure or buildings				
River uses	For this criterion, the best option would be the one that would affect the fewest villages along the Tina River (and the fewest river users), and affect the shortest river section.				
	Fishing is carried out along the length of the Tina River, though nowadays it is focused on the river holes and pools in the upper catchment, upstream of Choro and as far as the Mbicho and Mbeambea rivers. All options will modify river use around Choro-Koropa because of the presence of either the reservoir or the by-passed river reach. River uses will evolve due to the presence of a reservoir creating new opportunities such as sustainable, non-commercial fisheries. At the reservoir location, local topography and distance from villages will determine whether the reservoir will be easily accessible for new uses or not.				
	This option will modify river use due to the presence of a reservoir	This option will modify river use due to the presence of a reservoir, in addition to the 2 km affected river reach with modified flow between the dam and powerhouse that would potentially affect Koropa, Senghe, Habusi and Pachuki villages.	The 5.7 km affected river reach with modified flow will pass through Choro, Koropa and Senghe potentially affecting river uses.	This option will not affect river uses outside of the infrastructure rights-of-way since it is located outside any human settlement and has no by-passed river reach with modified flow.	The 1.9 km affected river reach, with modified flow, will not pass through any villages.

Criteria	Site 6e- Option 1	Site 6e- Option 2	Site 7c- Option 1	Site 7c- Option 2	Site 7c- Option 3
	Local topography around Site 6e is less steep, and the reservoir will be easily accessible for pedestrians, access to the reservoir will, therefore, most likely be easier, allowing for local people to develop new uses of the reservoir		Steep gorge around site 7c will restrain access to the reservoir (especially during day-time low water level). In addition, being located approximately 5 km upstream from Mangakiki, access for pedestrians will be more difficult.		
	Best option in terms of potential for developing new opportunities around the reservoir			Best option in terms of limitation of actual river uses	
Natural resources use (on a livelihood perspective)	For this criterion, the best option would be the one that would be located the farthest away from villages and valuable natural resources, thereby limiting impacts on natural resources (timber, game wildlife, etc.)				
	These options will affect natural resource uses by the local population since they are close to Choro, Senghe and Koropa. Hunting and timber products will be affected locally.		Natural resources close to Option 7C dam and the reservoir are poorly utilized by local population as the site is difficult to access and is located upstream from villages. Regardless of the location of the powerhouse, any of Options 1, 2, 3 have the same low impact on actual natural resources use.		
			Best option		
Local population wellbeing and safety	For this criteria, the best option would be the one that would be located the farthest away from villages (including access road).				
	Regardless of the option, the access road through villages would be the same, according to TRHDP PO, the final road alignment is being designed to limit disturbances and ensure the safety of villagers.				
	All options will necessitate heavy machinery and truck traffic during construction, so villages nearby the access road will be disturbed. Villagers will be at risk of collisions with trucks and will be subjected to noise and vibration from passing trucks. Health and safety precaution will be developed.				

Criteria	Site 6e- Option 1	Site 6e- Option 2	Site 7c- Option 1	Site 7c- Option 2	Site 7c- Option 3
	Noises and vibration from dam construction could affect some nearby villages		Noise and vibration from dam construction will probably not affect villagers thanks to the site's remote location		
	The powerhouse is relatively far from settlements. This helps reducing flow related safety hazards (since the powerhouse outlets release flows after a night's storage (sudden flows))	The powerhouse is the closest of all options to settlements, this could lead to flow related safety hazards (since the powerhouse outlets release flows after a night's storage (sudden flows))	The powerhouse is close to settlements, this could lead to flow related safety hazards (since the powerhouse outlets release flows after a night's storage (sudden flows))	The powerhouse is the farthest of all, this significantly reduces flow related safety hazards (since the powerhouse outlets release flows after a night's storage (sudden flows))	The powerhouse is relatively far from some settlements, this helps reducing flow related safety hazards (since the powerhouse outlets release flows after a night's storage (sudden flows))
				Best option	
Effect on downstream communities due to modified flow and water quality	Regarding water quality impairment during construction and modified flow, any options will have the same effects on communities downstream of the dam. There is a slight difference between Sites 6e and 7c, that benefits 7c: the size of the reservoir and the volume of usable storage is less for 7c than with 6e, thus limiting the ability to hold back and manage flows. Regardless of the option, supply of potable water to affected communities will be necessary during construction, and during the first years of post-impoundment reservoir filling.				
Gender aspects	There is no difference between options regarding gender aspects.				
Best option based on socio cultural criteria				Site 7c- Option 2 is the best option based on social criteria	
Environment					

Criteria	Site 6e- Option 1	Site 6e- Option 2	Site 7c- Option 1	Site 7c- Option 2	Site 7c- Option 3
Plant and wildlife habitat during construction	For this criteria, the best option would be the one that would necessitate the smallest surface of natural habitat to be cleared and the option that is located the farthest away from primary forests, as upstream area are more intact and would require longer access roads				
	With a toe-of-dam powerhouse and a location closer to the existing access road (Black Post Road), the access road will encroach on limited area of habitats. Moreover, the site is located closer to anthropogenically altered areas, which limits the losses of forested areas.	The site is located closer to anthropogenically altered areas and closer to the existing access road (Black Post Road), which limits the losses of forested areas. However, the powerhouse, located away from the dam, would lead to greater impact on habitats.	Due to the great distance between the dam and powerhouse, this option will necessitate more forest clearing than any other options, especially for access roads, leading to greater negative impacts on wildlife (collision, disturbances, noise, vibration, etc.).	Due to a toe-of-dam powerhouse, disturbed areas will be limited	Due to the distance between the dam and powerhouse, this option will necessitate forest clearing for access roads leading to greater negative impacts on wildlife.
	Best option				
Plant and wildlife habitat during reservoir impoundment	For this criteria, the best option would be the one that inundates the smallest volume of habitat (in m^3)				
	At reservoir full supply level, 25.2 x 10^6 m^3 of habitat would be inundated		At reservoir full supply level, 7.0 x 10^6 m^3 of habitat would be inundated		
			Best option		
Long term changes to habitat	For this criteria, the best option would be the one that would lead to the least long term pressure on natural resources and the least habitat fragmentation. This criteria is important since it deals with long terms effects.				

Criteria	Site 6e- Option 1	Site 6e- Option 2	Site 7c- Option 1	Site 7c- Option 2	Site 7c- Option 3
	Being located closer to already disturbed areas, with shorter access roads, these options will better preserve upstream natural resources from increased pressure.		These options are located at the edge of a pristine area with undisturbed forests which can shelter more wildlife than disturbed or remnant forests, especially mammals and birds (wildlife surveys have shown that mammals and bird diversity is higher in pristine habitats of the study area). As determined from plant surveys, undisturbed forests located upstream also shelter more vulnerable or threatened plant species than downstream areas. The access road that will lead to the dam will probably be used by local populations to access remote areas. This will inevitably increase hunting and logging pressure on wildlife in pristine areas, and potentially attract new settlers into these areas. Habitat fragmentation is also more pronounced with Site 7c.		
	These options are the best ones				
Fish	For this criteria, the best option would be the one that would lead to the smallest affected length of the Tina River and that would limit aquatic habitat fragmentation. The further upstream a dam is, and the shorter the by-passed section is, the less the fragmentation of aquatic habitat will be. This criteria does not weight much since the habitat gain from one location to the other is rather small (10 km^2).				
	Unless a fish pass is installed, the dam will block the migration of fishes, regardless of the option				
	With a toe-of-dam powerhouse, there will be no reduced flow reach on the Tina River, thus reducing negative impacts on the length of affected river	This option has a 2 km by-passed river reach with reduced flow	This option has a 5.7 km by-passed river reach with reduced flow	With a toe-of-dam powerhouse, there will be no reduced flow reach on the Tina River, thus reducing negative impacts on the length of affected river	This option has a 1.9 km by-passed river reach with reduced flow

Criteria	Site 6e- Option 1	Site 6e- Option 2	Site 7c- Option 1	Site 7c- Option 2	Site 7c- Option 3
	Being located the farthest downstream, these options lead to greater aquatic habitat fragmentation		Being located the farthest upstream, these options lead to less aquatic habitat fragmentation		
				Best option	
Endemic species	Wildlife surveys and data obtained from the literature have shown that endemicity is common in the Solomon Islands. However, regardless of the location, endemic species could be affected to the same extent.				
Downstream water quality for aquatic life	All options will lead to water quality impairment during construction especially turbidity (suspended solid). Diminished water quality could disturb aquatic life				
Sediment continuity	For this criterion, the best option would be the scheme that leaves the largest river bank volume unaffected, allowing for more natural erosion/deposition processes to take place. The difference between sites is, however, small given the small difference in affected (upstream) catchment size, regardless of the site. This criteria does not provide much weight in the assessment, since the gain between one location and the other is rather small (10 km^2).				
	Being located the farthest downstream, more sediment will be trapped by the dam. Trap efficiency of the Tina River catchment is 750 tons/km^2/ year (Entura, 2014). Therefore, this site will trap 101,250 tons per year of sediment (mostly bed load).		This site will trap 93,750 tons per year of sediment (mostly bed load).		
			Best option		
Amount of spoils	For this criterion, the best option would be the one that generates the least amount of spoils (topsoil during road construction and subsoil during tunnel excavation).				

Criteria	Site 6e- Option 1	Site 6e- Option 2	Site 7c- Option 1	Site 7c- Option 2	Site 7c- Option 3
	With a dam and powerhouse located close to the existing Black Post Road, and with a toe of dam scheme, this option will generate the least amount of spoils	The dam and powerhouse are located close to the existing Black Post Road. However, tunnel excavation will generate spoils	With a dam and powerhouse located far from the existing black post road, and with the longest tunnel of all options, this scheme will generate the greatest amount of spoils	The dam and powerhouse are located far from the existing Black Post Road. Therefore, a great amount of topsoil will be excavated for road construction	With a dam and powerhouse located far from the existing Black Post Road, and with the tunnel, this scheme will generate a large amount of spoils
	Best option				
Protected area	There are no protected areas				
Risk of cumulative impact	During construction, all options may result in cumulative water quality impacts with Gold Ridge Mine potential extension project in the Toni River catchment (also called SPL 194), with Oil palm industry drainage discharged, and with logging activities.				
Best option based on environmental criteria	Site 6e – Option 1 is the best option based on environmental criteria				
Technical and Financial*					
Net Present Value ($US) (based on 15m^3/s flow)	$25m – 38m (35m dam – 75m dam)	$53m – 57m (35m dam – 65m dam)	$90 – 103m (35m dam – 65m dam)	$28 – 47m (45m dam – 85m dam)	$55 – 69m (35m dam – 75m dam)
			Best option		
	$ 222 – 314	$ 189 – 285	$158 – 193	$ 218 – 312	$ 186 – 248

Criteria	Site 6e- Option 1	Site 6e- Option 2	Site 7c- Option 1	Site 7c- Option 2	Site 7c- Option 3
Unit cost of energy ($US/MWH) (based on 15m³/s flow)	(35m dam – 75m dam)	(35m dam – 65m dam)	(35m dam – 65m dam)	(45m dam – 85m dam)	(35m dam – 75m dam)
			Best option		
Annual energy (GWh/a) (based on 15m³/s flow)	26 – 57	38 – 69	59 – 82	34 – 65	39 – 70
			Best option		
Geological features	At the time the Phase 3 report was prepared, some elements of geology were still to be confirmed. Preliminary comparison was made between Site 6e- Option 2 and Site 7c – option 2.				
Best option based on technical and financial criteria			Site 7c – Option 1 is the best option based on technical and financial criteria		
Overall conclusion	Preliminary Project optimization (optimization of dam height and position, tunnel size and route, powerstation size and location, etc.) has lead TRHDP PO to select Site 7c with its superior economic performance. The site was also trending to fewer social impacts, especially in terms of resettlement.				

*this only present a few relevant technical and financial criteria, for the full scope please read the Phase 3 report

4.4.3 Evaluation of Selected Ancillary Facilities for Preferred Alternative 7C

4.4.3.1 Fish Passage

4.4.3.1.1 Comparison of Select Ancillary Works and Construction Methods for Preferred Project

The following comparisons have been made for some of the key elements of ancillary facilities or construction methods with a view to selecting alternatives offering the best value for money, while at the same time lessening potential direct and indirect environmental and social impacts.

4.4.3.1.2 Comparison of Fish Pass Options

Hydropower dams present a barrier to upstream migrating fish and, as a result, can reduce the number of fish species and their numbers in upstream areas. Consideration was, therefore, given to methods for enabling fish to move past the dam and access upstream areas of the Tina River watershed. These included:

- Fish pass structures – these are of two basic designs depending on whether the fish that would use them are free swimming or climbing species, both of which are found in the Tina River. Free-swimming fish require fish pass structures (e.g., fish ladders) with sufficient water depth and reduced velocities to enable fish to freely swim up and over a dam. They are generally comprised of inclined ramps with pool/weir or baffle elements to moderate flow velocities and maintain water depth. Climbing fish may also use pool/weir fishways, but some will require fish pass structures comprised of ramps with wetted rough surfaces (e.g., carpet or roughened concrete) up which they can pass. For both types of fishway, sufficient flow of water is required at the base of the structures to attract fish to enter and continue upwards through the fishway.

- Trap and haul facilities – these consist of an area of attraction water into which fish are either attracted to climb the roughened surface of a wetted ramp to enter a tank in which they are trapped (e.g., for climbing species), or swim via a short pool/weir structure into a tank where they are trapped by a screened cage with a one-way entry. The fish are then brailed or pumped out of the trap into a tanker truck, which is then driven to a location upstream of the dam where the fish are released. Alternatively, swimming species can be netted where they congregate in the attraction waters at the base of the dam or powerhouse tailrace, transferred into tanks, then transported upstream of the dam.

Consideration has been given to include two forms of trap-and-haul. An engineered trap-and-haul system to accommodate climbing fish species, plus, a system involving netting and hauling for swimming species, as part of an adaptive management approach to monitor their migrations and congregations with a view to designing an effective but inexpensive engineered structure, should the results of monitoring support this. Each type of system will need to be monitored during operation to determine whether changes to design or operation are required to ensure fish passage over the dam.

Table 4-3 presents the pros and cons of the two approaches for moving fish upstream past the dam.

Based on this analysis, the trap-and-haul facility was selected as the preferred means of ensuring upstream fish passage for the TRHDP, as it offers potentially greater effectiveness, better opportunity for adaptive management, lower capital cost, and provides ongoing social benefits in the form of employment to operators of the facility.

Table 4-3 Pros and Cons of two primary means of fish passage

	Facilities			
	Fish Pass Structures (i.e., pool/weir/baffle fish ladders for swimmers and friction ramp fishways for climbers)		**Trap and Haul Facilities for both swimmers and climbers**	
Parameter	**Pros**	**Cons**	**Pros**	**Cons**
Effectiveness (environmental)	- operates with minimal human intervention - effective at moving species for which it is designed up and over dam	- requires potentially significant volume of water to be effective - a given design of fishway may not serve all species due to different swimming capabilities in the case of free swimming fish - considerable research may be needed to design fishways for target fish species - not effective for climbing fish attracted into tailrace	- trap-and-haul facilities are capable of moving multiple species of fish, if properly designed - relative simplicity of trap-and-haul systems facilitates use at multiple locations - facilities are effective for moving both free swimming and climbing species of fish	- will require that trap-and-haul facilities be installed at least at two locations – at dam site, and at tailrace - requires that ongoing monitoring be undertaken such that trapping and hauling fish be carried out on time and not miss periods when schooling fish are congregating at trap locations
Compatibility with Adaptive Management	- it may be possible to adapt fishway operations to multiple species that might use the fishway at different times of the year by adjusting fishway flows	- costs of changing fishway designs once constructed, or having to add additional fishways of a different design as an adaptive management technique can be very costly and would require additional research to justify - changing operating flow parameters of fishways can have a significant cost on a project especially if this	- relatively easy to change design and operation of trap-and-haul to suit different species and different migration patterns and timing - can add an additional trap and haul system at the mouth of the Ngalimbiu River when certain species school for upstream migration, if this is later	- minimal when compared to fishway structure

	Facilities			
	Fish Pass Structures (i.e., pool/weir/baffle fish ladders for swimmers and friction ramp fishways for climbers)		**Trap and Haul Facilities for both swimmers and climbers**	
Parameter	**Pros**	**Cons**	**Pros**	**Cons**
		removes flow from power generation	determined to be advantageous	
Capital Cost	- issue of capital cost is less of an issue if multiple species can be served by the same fishway design	- high cost relative to trap-and-haul system, especially since two systems, one for free swimmers, the other for climbers, would likely be required	- relatively low capital cost	
Operating and Maintenance Costs (direct and indirect), including social costs	- relatively low if fishway design and operation does not have to be altered	- potentially high cost to ongoing project operations if monitoring determines that adaptive management requires retrofitting fishway, or additional flows that take away from power production	- provides steady employment for a small number of persons within the local community	- ongoing costs of labour, and fuel, maintenance and eventually replacement costs of the tanker truck

4.4.3.2 Quarries and Borrow Sites

Based on the Feasibility Study carried out by Entura, the quarry / borrow sites selected are the closest to the proposed location of the concrete batch plant and are within the Core Area, the land that has been acquired for the project. No other suitable quarry / borrow sites are located within the Core Area. If additional stone is required, it will be purchased from commercial suppliers.

4.4.3.3 Access Roads

The parameters for siting access roads included: using existing permanent alignments that could be upgraded for project purposes, and serve local villages as improved roadways during and after construction; avoiding relocating houses and villages; and, where roads did not exist, use former logging roads providing they could be developed as stable access roads, or routes along ridge-tops that could provide stable roadways. Based on these criteria, the main access road was chosen as it follows the existing alignment from the highway to Managakiki Village with a diversion to minimise physical and economic displacement. From Managakiki to the powerhouse and damsite, the road alignment chosen provides for optimum stability.

4.4.3.4 Drilling and Blasting

A variety of drilling methods were examined, including the use of pneumatic and hydraulic drills. Hydraulic drills were chosen due to their lower noise profile.

Standard blasting methods were chosen since, for the most part, blasting will occur 2 or more kilometres from the nearest settlements. Notwithstanding, for safety purposes, blasting mats will be employed to minimise the spread of shot rock from the blasts.

4.4.4 Conclusions

Under the proposed Site 7c Option for the TRHDP, no villages or households in the Tina River Valley will need to be physically resettled. There will be some loss of resources in the upper catchment, especially fishing and forest materials, due to creation of the reservoir, access road clearing, and in the “low-flow” section of the river between dam and powerhouse. The latter is of central importance to the people living at Choro, Koropa, and Senghe, and to those engaged in timber milling alongside the river.

Development of Site 7c will generate significantly fewer social impacts on local communities than the other options previously advanced and assessed (Site 6a and Site 6e). Site 7c is, therefore, a significant improvement from a social and cultural point of view. The main issue, loss of clean fresh water supplies for all riverside communities located downstream during the project’s construction, will need to be addressed by the Project.

In terms of environmental impacts, development of Site 7c will generate greater disturbance in the long term due to the presence of a 5.7 km by-passed stretch of river, which will be affected by reduced night-time flows, and the presence of an upgraded all-season road that passes close to undisturbed forested areas along the reservoir. This access road can be a strong agent of change, as new settlers could arrive, placing additional pressure on natural resources. To mitigate the potential impact of the access road, the original core land owners have been included in the process by the establishment of a core land company which will make decisions with respect to the use and access of the core land, including the access road to the dam. Further mitigation will be the closure of the dam access road for public traffic except operation and maintenance vehicles. A minimum environmental flow will be a requirement for dam operation to mitigate environmental impacts in the low-flow section, and the project's monitoring program will provide information to allow the effectiveness of the flow to be evaluated and appropriate adjustments to be made.

To mitigate impacts on upstream fish passage, a trap and haul system is proposed, combined with an adaptive management approach to monitor and adjust the scheme.

Of the two options that made it to final review, Site 6e and Site 7c, Site 7c is the superior option from both a technical and economic perspective, with the best NPV, best unit cost of energy and best annual energy production.

Based on more favourable expected technical and economic outcomes, fewer social impacts, and environmental impacts that, while not as favourable, should be manageable, Site 7c was chosen as the preferred project alternative to carry forward for a full environmental land social impact assessment.

5. PHYSICAL ENVIRONMENT BASELINE

5.1 INTRODUCTION

This section describes the existing baseline physical environmental conditions within the project-affected area. Biological environmental baseline conditions are discussed in Section 6 (Terrestrial) and Section 7 (Aquatic).

The information on the environmental baseline is based on detailed on-site environmental studies and field-surveys carried out by the ESIA team from August to September 2013, for the purposes of preparing the initial ESIA. Additional, supplementary studies were conducted in the field to address follow-up review comments. The regional information on the study areas is based on a review of secondary literature, supported by field studies, interpretation of available topographic imagery, and review of the Environmental Scoping Report (Entua, 6 June 2012) and the Feasibility Study Report Phase 2 (Entura, June 2012).

The objective of the environmental baseline was to assess the present state of the environmental conditions in the project area, and to provide a basis for evaluating environmental impacts and issues related to project design and construction, operations and maintenance, and decommissioning and rehabilitation.

The description of the physical environment is based on secondary and primary data sources, including the report entitled “Engineering Geological Assessment of Tina River Hydro Project, Guadalcanal, Solomon Islands” (GeoRisk Solutions, 2012); Entura’s feasibility study (2014); and site visits made by the ESIA team involved in preparing the initial ESIA.

5.2 TOPOGRAPHY AND GEOMORPHOLOGY

The Ngalimbiu River is a large river draining in a northerly direction from some of the highest peaks (2000+ m) on the island of Guadalcanal. The river has two main tributaries, the Tina and Toni rivers. The Tina River catchment is more than three times larger than the Toni River. The catchment area of the Tina River is about 150 km^2 compared to 45 km^2 for the Toni River. The Tina River contains a diverse fish community and is unaffected by human development in its upper reaches. The gradient of the river increases with distance upstream (Table 5-1). Downstream of the Tina/Toni confluence the gradient is 2.3 m/km. This increases to about 5 m/km between the Tina/Toni confluence and the powerhouse site. Upstream of this the gradient continues to increase and is an average of about 9.3 m/km through the reach between the dam and powerhouse, and is steep (19 m/km) between the dam and the head of the proposed reservoir.

Table 5-1 Distance, elevation and gradient of key sections of the Tina River

Location	**Distance from sea (km)**	**Elevation (m amsl)**	**Gradient (m/km)**
Estuary	0	0	0.0
Tina/Toni confluence	19	43	2.3
Powerhouse site	24.7	73	5.2
Dam site	30.1	123	9.3
Proposed reservoir reach	32.7	172	18.8

The changes in gradient with distance upstream are reflected in the substrate and morphology. In the lower reaches downstream of the Tina/Toni confluence, the river is relatively wide and the substrate is dominated by sand and gravel. The bars and braiding are evidence of bedload movement during floods. From the Tina/Toni confluence to approximately 1 km upstream of Tina Village the river gradient is low, and the river unconfined with a substrate comprised of cobble, gravel and sand. The aquatic habitat comprises mainly wide runs and riffles. Upstream of this, the river becomes steeper and more confined and boulders are present, as well as cobbles, gravel and sand. The runs and riffles are generally narrower, with occasional rapids and places where the river splits into two channels. There are also pools which form where the river flows against a bedrock bank and changes direction. Upstream of the powerhouse site, the river becomes even more confined and steeper (50 m in 5.4 km).

Some villages (e.g., Mangakiki and Marava) are located on flat, low elevation ridges, connected by Black Post Road. The elevation of this road ranges from 23masl at Kukum Highway junction, to 235masl at its terminus at Mangakiki village, a distance of 12km. Black Post Road grades are less than 10%, with the average grade around 2%. Other villages (e.g., Koropa, Choro, Sengue, Habusi, Pachuki, etc.) are situated along the edge of the Tina River. These villages are separated from one another by steeply sloped ridges. The Ngalimbiu River runs through flat coastal plains, where human settlements are more numerous.

The dam site is located in a narrow valley comprised of steep slopes and narrow ridge crests. The valley sides at the site of the dam abutments are very steep (30° to 45° slope), and rise to the ridgeline that crests at approximately 200masl.

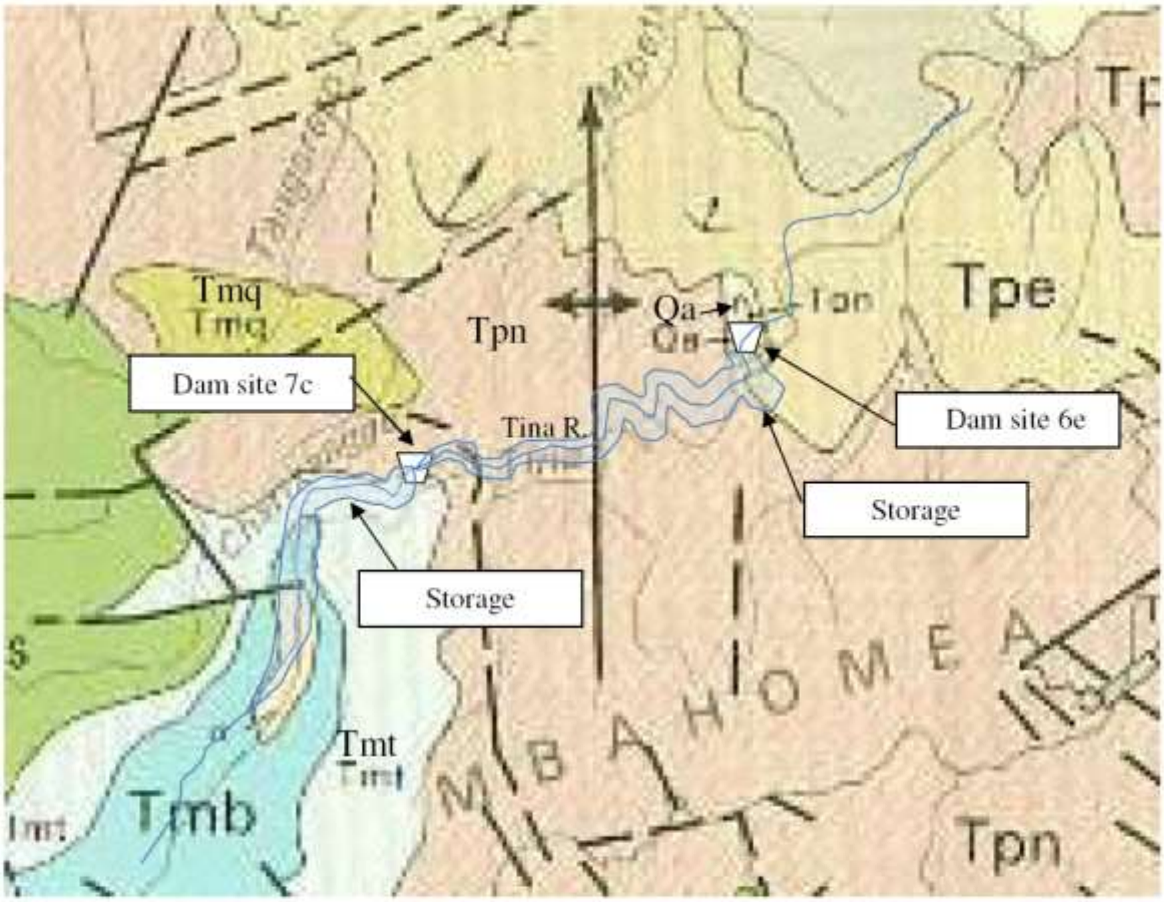
5.3 GEOLOGY AND SOILS

The Tina River is located within five key lithological units, as follows (Entura, 2014):

- Conglomerate (Tpn: Lower and Upper Toni Conglomerate members)
- Limestone (Tmb: Mbetilonga Limestone)
- Sandstone (Tpe: Mbetivatu Sandstone)
- Calcarenite (Tmt: Tina Calcarenite)
- Suta Volcanics

Figure 5-1 includes a map of the local geology found within the Project area. Dam site 7c is the relevant site.

Figure 5-1 Local Geology



Source: Entura (2014)

In addition to these formations, faults and karst are present in the project area. The presence of karst means that sandstone and conglomerate beds have a significant, soluble calcareous content. Entura (2014) considered it most likely that karst features are relatively minor and unlikely to lead to significant geotechnical concern. The proposed Site 7c location for the dam lies within the Toni Conglomerate Formation. This site is composed mostly of sandstone beds, interbedded with conglomerate beds (Entura, 2014). The majority of the proposed reservoir area lies within limestone, overlain by calcarenite. The proposed headrace tunnel and powerhouse are also located within the Toni Conglomerate.

Soils that cover the steep slopes of the construction area, adjacent to the Tina River, are shallow and unstable. They are comprised of colluvial rock debris. However, in stable areas, soils are deep and leached. Based on field observations, topsoils close to the proposed access road that will connect to the dam site are primarily composed of organic red-brown clay loam, or clay silt, with underlying weathered sandstone. Organic matter is primarily restricted to the first 10cm of the topsoil. These soils possess moderate to high fertility, resulting in rapid regeneration of vegetation following disturbance, as long as the topsoil remains undisturbed. Conversely, weathered soils observed in disturbed forested areas often become lateritic, are poor in nutrients, and do not facilitate rapid plant regeneration.

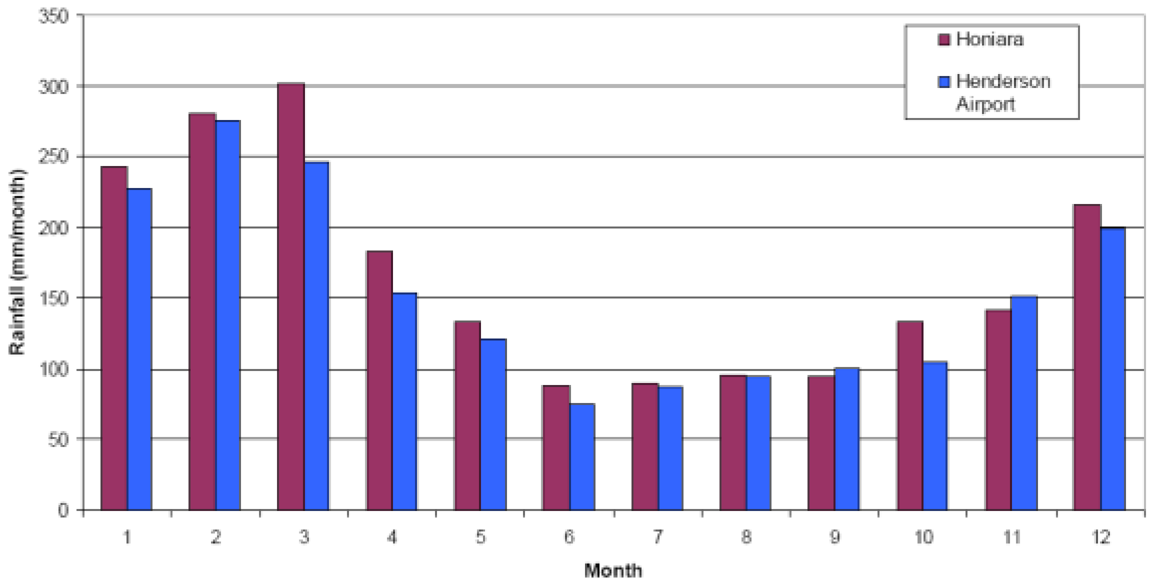
Along Black Post Road, soils are sandy and have low organic matter content, which does not allow for rapid regeneration. In the Solomon Islands, surface soil horizons are usually rich in organic-matter, while underlying mineral horizons contribute poorly to plant growth (SOPAC, 2007). In Guadalcanal, most soils are acidic (pH 3 to 5) (SOPAC, 2007).

5.4 CLIMATE AND METEOROLOGY

Average daily temperatures in Guadalcanal range from 22°C to 31°C throughout the year, with a yearly average of 26.6°C in Honiara. The island has a tropical moist climate with regular rainfall. Rainfall increases with altitude and is higher on the windward coast (South shore). Annual rainfall at both Honiaria, and Honiara International Airport (also known as Henderson Airport), is 1972mm, with summer months being the driest. Figure 5-2 (Entura, 2013) shows the trend in rainfall.

Historic rainfall records for Tina River do not exist. However, based on modeling undertaken by Entura (2012), it was estimated that annual rainfall at the dam site exceeds 2500mm. The same model predicts in excess of 3500mm of total annual rainfall in the headwater reaches of the Tina River.

Figure 5-2 Average monthly rainfall at Honiara and Henderson Airport



Month 1 is January

In Guadalcanal, cyclones are most likely to occur between November and April, and are associated with extreme rainfall events.

In May 1986, cyclone Namu contributed 1200mm of rainfall over a period of a few days, causing rivers to overflow their banks. Water depth at the project site was said to be 7m. The Ngalimbiu River depth reached 7.2m, with a peak discharge of 2,460 m^3/s (Baines & Danitofea, 1987). The extreme rainfall associated with Cyclone Namu contributed to major floods, mudflows and landslides that, in combination, transported logs down the rivers destroying villages and the bridge spanning the Ngalimbiu River.

The floods and mudflows precipitated by Cyclone Namu reshaped the course of the Tina River, and deposited highly fertile silt. The deposited silt has improved soil fertility for the communities that plant crops, and has permitted sustained intense market gardening.

An analysis of a map of sediment deposit patterns from Baines & Danitofea (1987) shows that following Cyclone Namu, communities downstream from Habusi received up to 50cm of deposited sediments. Sediment plumes at the mouth of the Ngalimbiu River mouth extended almost one kilometer offshore.

Meteorological events are important element in people's lives, as they have influenced decisions to move from one location to another. People that currently reside in the project area were originally from the upper Tina River catchment area. Landslides, floods such as those caused by Cyclone Namu, and heavy rains were often mentioned during social surveys, as reasons for moving to downstream areas where the effects of these events are less severe. Heavy rain often brings floods that destroy gardens along Ngalimbiu River. Fear of extreme meteorological events is still very strong among villagers.

5.5 LANDSLIDES, ROCKSLIDES AND SEISMICITY

5.5.1 Landslides and Rockslides

A significant number of landslides occur within the Tina River catchment, particularly on the steeper slopes. However, they remain relatively small, and are primarily associated with rockslides along bedding planes. Slope instability is an active and ongoing process within the proposed reservoir area (Entura, 2014).

A rockslide of $2Mm^3$ to $3Mm^3$ volume is visible at the upstream end of the proposed reservoir. A historic rockslide of $0.3Mm^3$, caused by an earthquake, blocked the Tina River in the proposed reservoir area creating a 20m high dam. One year later, the natural dam failed, and caused one causality downstream (anecdotal).

Other slope failures are located in the upstream end of the proposed reservoir, in Suta Volcanics. Large-scale landslides are unlikely to directly affect the dam.

5.5.2 Seismicity

The damsite is located in an area of significant seismicity (GeoRisk Solutions, 2012).

The U.S. Geological Survey (USGS) notes that along the South Solomon trench, the seismicity is predominantly related to subduction tectonics, and large earthquakes are common. Fourteen earthquakes having a magnitude of greater than 7.5, have been recorded since 1900. On 01 April 2007, an inter-plate megathrust earthquake of a magnitude of 8.1 occurred at the western end of the trench, that generated a tsunami that killed at least 40 people. This was the third megathrust event associated with this subduction zone in the past century; the other two having occurred in 1939 and 1977 (GeoRisk Solutions, 2012).

GeoRisk Solutions (2012) recommended that a site-specific seismic hazard evaluation be undertaken for the Project. This evaluation was undertaken by the Seismology Research Centre in February and October 2014. The evaluation employed probabilistic seismic hazard assessment (PSHA) using an earthquake recurrence model that considered the seismicity and geology of the area.

Peak Ground Acceleration (PGA), a measure of the amplitude of the earthquake motion, has been calculated for the TRHDP as being 0.286 *g*, based on an earthquake of Richter magnitude ML 4 or greater, and 0.273*g*, based on earthquakes of Richter magnitude ML 5 or greater. This is based on a return period of 475 years, with a 10% chance of exceedance in 50 years, and assumes a Vs30 value of 1000m/s.

During feasibility studies, a pseudo-static seismic stability analysis was undertaken to assess the potential damage caused by the earthquake and a post-earthquake analysis was undertaken to assess the stability of the dam after earthquake events. Conclusions of this evaluation will assist in the final design of the dam.

5.6 River (Fluvial) Geomorphology

The Tina River is a single channel meandering river. It has a torrential behavior with regular flash floods. The texture of its bed includes gravel, cobbles and boulders, and fine and coarse-grained sand. In the higher elevation headwaters of the Tina River, very large boulders are intertwined with logs, attesting to the power of its water velocity during floods. Along its banks, some areas have large fluvial deposits.

The River flows through three main geological areas:

- Volcanics, upstream of the Study area and upstream of the Njarimbisu bend area;
- Limestone from the Njarimbisu to the middle reaches of of the Tina River;
- Sandstone, where the Tina River flows through villages upstream of the Toni River.

The following sections describe the Tina River from its upper catchment to its mouth. Figures 5-3 through 5-8 uses Google Earth imagery to identify morphological features of the River. In addition, Annex 1: Description of the Aquatic Survey Stations (see Annex Report) describes the river's morphology at each fish sampling station.

5.6.1 Upper Catchment Area

Figure 5-3 presents an aerial view of the Tina River headwaters (270masl), which are comprised of the junction of two main rivers: Vohara River (1) and Mbeambea River (2) and a minor tributary: Njarimbisu River (3). Becho River (4), a tributary of the Vohara is located further upstream.

This section is characterized by sequences of pools and rapids and sharp meanders. Major boulders, some greater than 3 m diameter, have accumulated along the channel bars. These large boulders indicate that intense floods occasionally occur within this reach. Boulder clasts are predominantly volcanic in origin.

This reach of the Tina River flows along a north-south orientated thrust fault (GeoRisk Solutions, 2012).

Figure 5-3 Tina River headwaters

Source: Google Earth, 2014

5.6.2 Tina River Gorge

The Tina River enters steep limestone gorges (Figure 5-4) where its course is more confined and less meandering. At this location most of the river's course is made of rapids. In many areas, river banks are dominated by rock outcrops. This area is the site of a major historic landslide (1) of around 200,000m^3. The dam and reservoir site are located in this area (2). At the dam site, the river lies at an altitude of approximately 122masl.

Figure 5-4 Tina River Gorge with dam site (Site 7c) and reservoir

Source: Google Earth, 2014

5.6.3 Meandering River Toward the Plain

Figure 5-5 illustrates the river reach downstream of the dam site (1), the river gradually flows through an area having shallower slopes and many meanders. The powerhouse (2) will be located in this area. The density of human settlements also gradually increases as the river flows through villages, until it is joined by the Toni River (3).

Figure 5-5 Tina River between damsite (7c) and Toni River confluence

Source: Google Earth, 2014

Figures 5-6 and 5-7 illustrate the sharp meander bends, channel braiding, and other deposition-erosion features associated with intense flash floods that have the capacity to rapidly shape the river. The inside curves of the meander bends show large point bars of alluvial deposits comprised of cobbles and boulders, while the outside curves show marked cut banks in sandstone. In this area, both size and position of meanders have changed throughout time, and sometimes quickly as a result of weather related events, such as Cyclone Namu. One example of rapid river channel migration is the behaviour of the Tina River (3) at “Tina’s old meander (1)” adjacent to Tina Village (2) where the channel quickly shifted from a straight line channel to a large meander channel before its junction with Toni River (4). The following example shows the evolution of the Tina River channel within one year.

Figure 5-6 Tina River before channel shifted

Source: Google Earth, 2013

Figure 5-7 Tina River after channel shifted

Source: Google Earth, 2014

The riverbed and the adjacent terrace are comprised of rounded cobbles and boulders, predominately less than 0.5m in diameter, within a matrix of silty sand.

5.6.4 Tina and Toni River Confluence: Ngalimbiu River

Figure 5-8 illustrates the flat coastal plain, located downstream of the confluence of the Toni and Tina rivers, where they give rise to the Ngalimbiu River. The Ngalimbiu River flows across an area characterized by denser human settlement, and other anthropogenic human activities, such as gravel extraction. Drainage from agricultural lands, such as oil palm plantations, enters the river. During Cyclone Namu, sediments from the Ngalimbiu River extended across this coastal plain in a path more than 6km wide (Baines & Danitofea, 1987). The Ngalimbiu River also shows intense deposition-erosion processes at work, as illustrated by sharp meanders and fluvial deposits.

At the confluence of the Tina and Toni rivers, the elevation is approximately 40masl.

A small delta has formed at the mouth of the Ngalimbiu River where it enters the Solomon Sea at Lasa Point (close to Tenaru Bay).

Figure 5-8 Ngamimbiu River flood plain

Source: Google Earth, 2014

5.7 RIVER HYDROLOGY

The Tina River catchment covers an area of approximately 150km^2. Upstream of the dam site, the catchment covers an area of about 125km^2.

The Tina River is comprised of three rivers: the Mbeambea, the Voraha and the Njarimbisu rivers. The Tina River's catchment area is delineated by: Chupu Kama to the East; Mount Mbutohaina (1649m) to the West; and a chain of mountains to the South, including Mount Tambunanguu (1902m), Mount Popohanatungga (1877m), and Mount Turipukumahi (1636m). Mount Popomanaseu (2310m), the highest mountain of the Solomon Islands, is located just outside of the Tina River catchment.

The Tina River meets the Toni River 17.8km downstream from the Tina River's headwaters. The Toni River is a much smaller river with a catchment of approximately 45km^2, and a flow roughly 1/3 that of the Tina River.

To model the flow of the Tina River, a river level and rainfall gauging site was installed upstream of the proposed dam site. Another rainfall-gauging site was installed in the upper catchment at Chupu Kama. Hourly rainfall data has been collected since mid-June 2010. River water levels and flows were collected until April 2014 when equipment was destroyed by flooding. The levels and flows have been obtained to allow development of a rating curve for the site (Entura, 2014).

According to Entura (2014), the lack of long-term rainfall data within the upper Tina River catchment is a major constraint to estimating the catchment rainfall and flow at the proposed dam site.

Two years of additional data have been acquired and this has allowed Entura to develop a hydrological model and synthesise a long-term flow data series for the Tina River. One of the conclusions from the additional data and the long-term (29 years) flow analysis is a reduction of the fully absorbed energy of the scheme from 84.7 Gwh to 80.6 Gwh.

5.7.1 Duration Curves of Specific Yield

According to Entura (2014), the duration curves of specific yield for the Tina River is 0.097m^3/s/km^2, which means that, on average, when moving downstream, for every additional km^2 of Tina River catchment, the yield increases by 0.097m^3/s.

5.7.2 Average Flow

Flow data were taken from the Feasibility Study prepared by Entura (2014). Tina River gauging station is located in the upper catchment area between the confluences of the Tina River and the Voraha and Mbeambea rivers (see location at A3 in Figure 5-3). Flow data has been collected by automatic gauging and telemetry from 15 June 2010 to April 2014. Plans are underway to reinstate the gauging station.

According to Entura (2014), the average monthly flow at dam, estimated from extended records, was 11.5 m^3/s. This flow was used in the estimating energy production for the TRHDP scheme.

Using available data from the gauging station upstream of the proposed dam site, for the period 15 June 2010 to 21 September 2013, the average flow at dam site in the wet season (December first to March 31) was estimated to be 19.40 m^3/s, and the average flow at dam site in the dry season (April 1 to November 30), was estimated to be 12.72 m^3/s. This data shows that the average flow appears higher than the average flow obtained from the extended records.

Table 5-2 shows the average flow on a monthly basis, based on the same data. January shows abnormally low values. Although the wet season, this could be the result of abnormally dry conditions that occurred in January 2011, 2012 and 2013. Alternatively, this may have been the result of an error in recording measurements at the gauging station. There is considerable variation around the average flow, as illustrated by the figures in the minimum and maximum columns.

Table 5-2 Monthly flow at damsite (15 June 2010 to 21 September 2013)

Months	**Average monthly flow at dam site (m^3/s)**	**Minimum recorded (m^3/s)**	**Maximum recorded (m^3/s)**
January	13.87	5.97	120.94
February	21.48	4.96	342.38
March	21.94	6.55	233.54
April	18.23	5.04	141.84
May	14.27	4.53	201.50
June	8.69	3.83	185.64
July	10.55	3.42	222.93
August	10.81	3.01	234.85
September	11.62	2.85	220.06
October	12.90	3.91	176.93
November	17.12	3.26	445.62
December	20.46	4.83	298.33

The Phase 3 addendum report based on the 29 years of river flow modelling shows a dry season flow (between June and September) of 7.5 m^3/s with increasing flow in September and a wet season flow up to 20 m^3/s occurring in December to January. This is shown in Figure 5-9 below.

Figure 5-9 Seasonal river flows

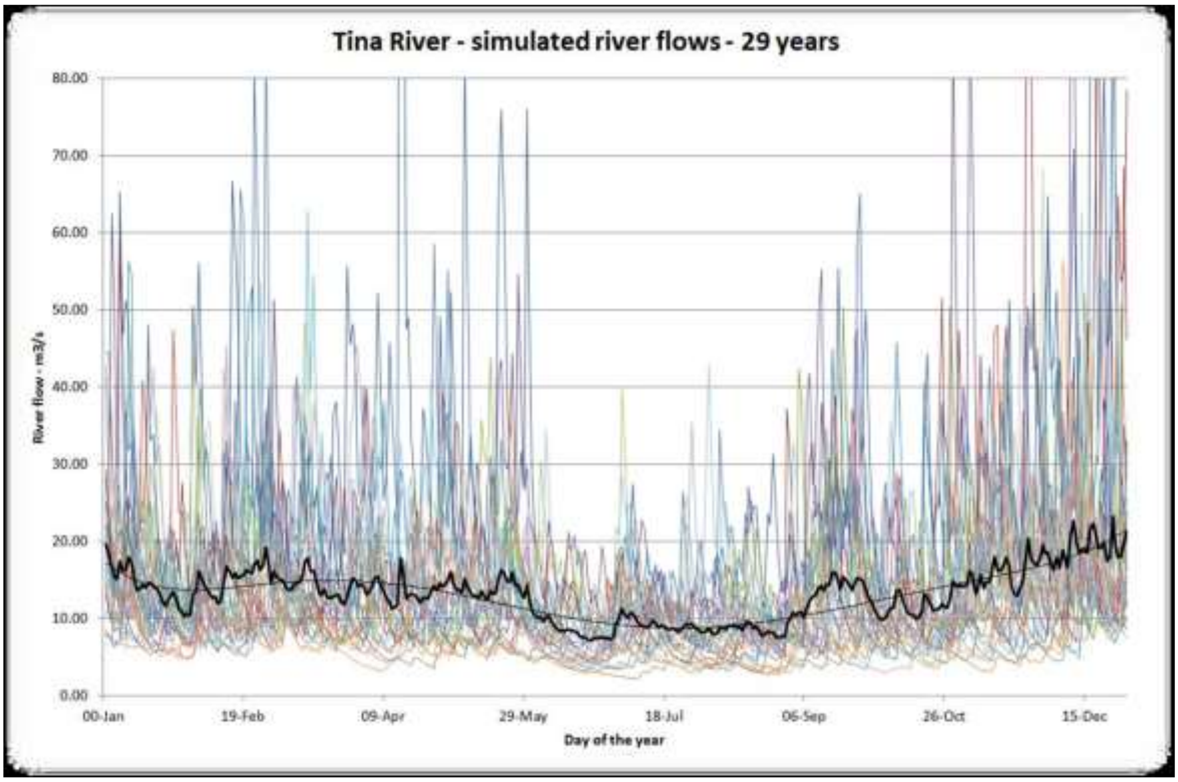


Table 5-3 identifies flow percentiles of long-term estimated flow at the dam site. Flow percentiles provide precise information about occurrences of flows.

Table 5-3 Flow percentiles for long-term estimated flow at damsite

Flow Percentile	**Average daily flow transposed to dam site (m^3/s)**
10	5.1
25	8.0
50	11.8
75	17.0
90	25.4

Source: Entura (2014)

Table 5-3 is interpreted as follow:

- On an annual basis, average daily flow is less than 5.1m^3/s, 10% of the time. This also means that for 90% of the time, flow is greater than 5.1m^3/s.
- On an annual basis, average daily flow is less than 25.4m^3/s, 90% of the time. This also means that for 10% of the time, flow is greater than 25.4m^3/s.

5.7.3 Flow Difference Between Toni River and Tina River

A rapid comparison (Table 5-4) of flows between the Tina River and Toni River was made during the rainy season to quantify the flow input of the Toni River on the Ngalimbiu River. The following table shows that the Toni River has a flow roughly 1/3 that of the Tina River. At approximately 45km^2, the Toni River catchment covers an area approximately 1/3 that of the Tina River catchment, which covers roughly 150km^2.

Table 5-4 Comparison of flows between Tina and Toni rivers

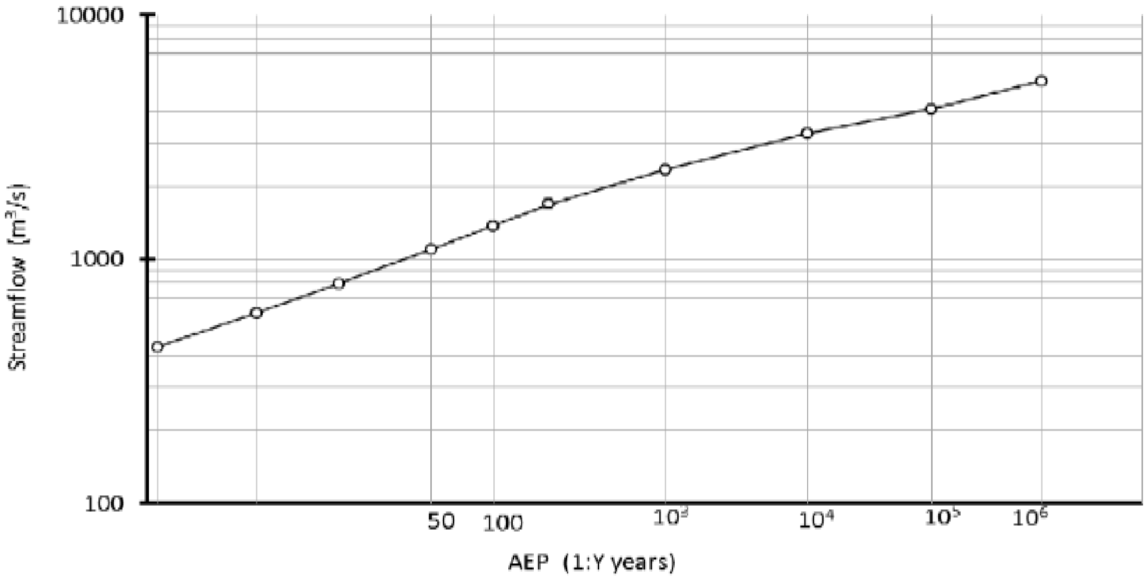
Station	Location	Date	Width (m)	Water level (m) at different locations	Water Velocity (s) for 20 m	Water Velocity (m/s)	Estimated flow (m^3/s)
A5B	Tina River (before its confluence with Toni)	11/02/14	46.40	0.28	35	0.57	28.99
				0.28	20	1	
				1.10	11	1.82	
A6B	Toni River (before its confluence with Tina)	11/02/14	19	0.50	42	0.48	7.16

5.7.4 Flood Frequency

The Tina River flood frequency curve is derived from the Lungga River flood frequency curve, as measured at Lungga Bridge. The Lungga frequency curve, with up to 1:200 Annual Exceedance Probability (AEP), was scaled to the Tina River catchment using catchment area and rainfall scaling.

The maximum observed flow over a period of three years in the Tina River is 445m^3/s, which is close to the 1:5 AEP event. This means that, statically, this AEP event could take place every 5 years, or that there is a 1 in 5 chance that it will occur every year). Figure 5-10 and Table 5-5 show the preliminary estimate of flood frequency curve at the dam site.

Figure 5-10 Preliminary estimate of flood frequency curve at damsite



Source: Entura (2014)

Table 5-5 Preliminary peak inflow estimates for Tina River damsite

AEP (1 : Year)	**Peak Flow (m^3/s)**
1.01	60
2	245
5	460
10	610
20	800
50	1100
100	1375
200	1690
1,000	2340
10,000	3290

AEP (1 : Year)	Peak Flow (m^3/s)
100,000	4140
1,000,000	5050

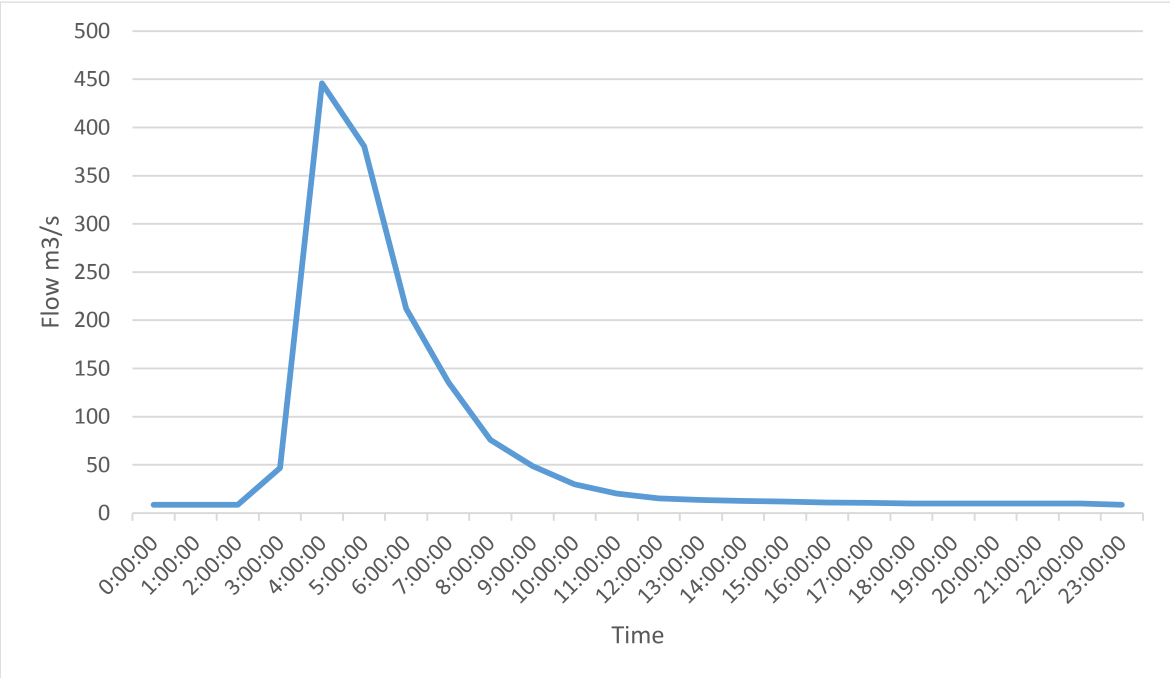
Source: Entura (2014)

The spillway has been designed to pass a Maximum Flood Level of an AEP equals to 1:10,000, which is 3,290 m^3/s. In comparison, according to Entura, 2014 Cyclone Namu was approximately a 1:50 event, meaning that, statistically, it can occur once every 50 years, or that it has a 1 in 50 chance of occurring every year. This compares to data provided in Baines & Danitofea (1987), which indicated that cyclone Namu had a peak discharge at the Ngalimbiu River mouth of 2,460 m^3/s, meaning that it was a 1:1,000 event.

5.7.5 Flash Floods

The Tina River experiences flash floods almost immediately after heavy rainfall events occur in the upper catchment. Flow and water level can change rapidly during such events. Heavy rainfalls in the upper catchment are visible from afar, and people use this visual cue as a warning of an impending flash flood. On 11 November 2010, a spectacular flood occurred that increased the flow from 8.7m^3/s to 445.65m^3/s in only four hours (see graph in Figure 5-11).

Figure 5-11 Example of a significant flash flood that occured on 11 November 2010



Data based on Tina River gauging station

In area where the Tina River runs through gorges, water can quickly rise up to 2 meters in elevation. Whereas, elsewhere these flash floods briefly inundate riparian areas and replenish wetlands.

A dam at 7C can become a means of controlling flash flood for the downstream communities. The Hydro powerstation will have accessories to monitor flow installed and this can be used to advise the downstream communities about possible flooding and the level of flooding can be more easily determined. The downstream communities can access this information to take appropriate actions if required. The downstream communities should not experience any significant changes to the current flooding characteristics as the volume of water flowing down the Tina river after the power station will not be impacted after the power station.

5.7.6 Tina River Tributaries in the Reduced Flow Reach

A number of small, seasonal tributaries enter the Tina River between the dam and powerhouse sites (i.e., "reduced flow reach"). These streams are valuable aquatic resources that will need to be protected during road construction.

These small left and right bank tributaries cover an area of 1,042ha (+/- 10 km^2). Given the specific yield of 0,097$m^3/s/km^2$, calculated for the watershed upstream of the dam, with its higher elevation and rainfall, the run-off supply from the smaller tributaries entering the reduced flow reach is estimated to be less than 0.97m^3/s (~1m^3/s) on average. Hence, this represents only a small proportion of Tina River flow. Table 5-6 identifies the length of the tributaries that enter the reduced flow reach.

Table 5-6 Left and right bank tributary streams

Small left bank tributaries of Tina River	**Length of the tributary (m)**
Vurahairauha	1149
Vurapokola	1088
Valemalamala	362
Choro	250
Hainalovo	511
Senge	314
Nembo	607
Small right bank tributaries of Tina River	
Kaka'uha	3044
Jarikela	757
Puaka	3760
Valebou	3113
Valepohopoho	509
Mbabakoechir	273
Aho	406
Chongo	853
Chanbaulo	446

Pihu	645
Koeropa	705
Lotulotu	583

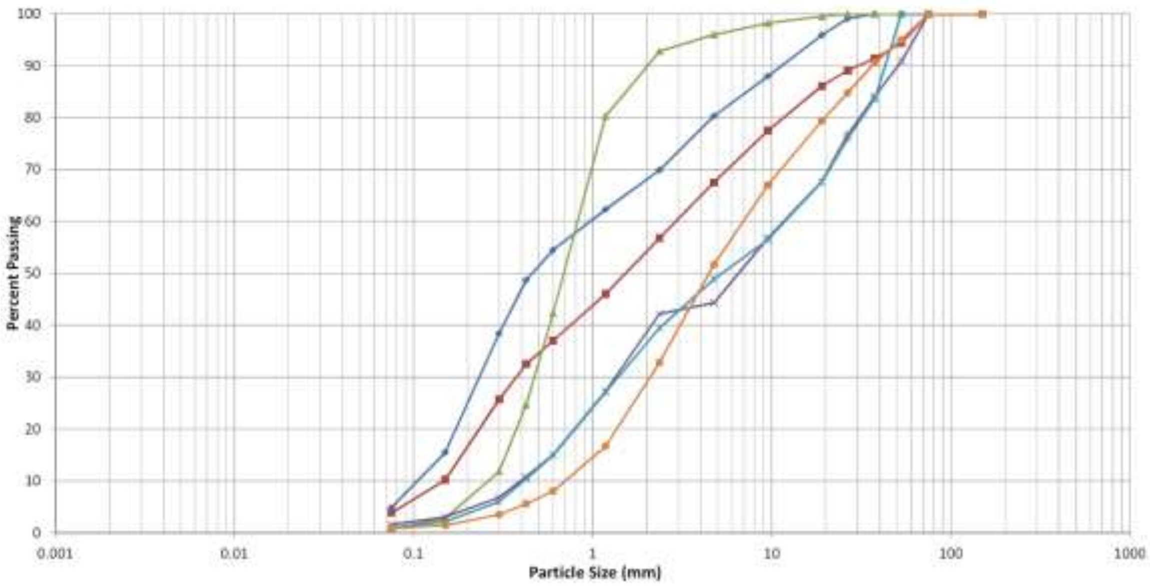
5.8 RIVER SEDIMENT TRANSPORT

According to Entura (2014), alluvial deposits are the predominant river-bed material. It is assumed that the depth of alluvium reaches approximately 10 m within the river channel. Although, alluvium deposits within the Option 6 area extended to a depth of 25m. Alluvial terraces occur adjacent to the current river course and bars. Terraces vary from 1.5m to 5m above the current river level. They are comprised of cobbles and boulders, predominately less than 50cm in diameter, with a matrix of silty sand. At some locations, large boulders up to 3m in diameter are found, indicating that intense floods occasionally occur.

Bed load sediment ranges in size from silts and sands in low flow area, to large boulders in very high flow areas. Bed load sediments are materials likely to be deposited into the storage reservoir because of reduced water velocity and will accumulate over time in the dead storage zone of the reservoir and are, therefore, unlikely to be transported downstream. In addition to bed load, additional material may be transported into the reservoir from landslides, and from surficial materials eroded from the land as a result of upstream logging and construction activities.

According to Entura (2014), bed load sediments deposited in the Tina riverbed and alluvial bars range from 0.1mm to 100mm in size, as shown in Figure 5-12 (sample taken in the vicinity of Site 7c).

Figure 5-12 Particle size distribution of bed load sediment and alluvial bars in the Tina River



Source: Entura (2014)

By opposition to bed load sediments, suspended sediment are material transported by the river that remain in suspension even when water velocity is reduced. These materials are likely to be transported downstream through the headrace tunnel and turbines. Sand, silt and clay make up suspended sediments. Based on field surveys by Entura (2014), total suspended solids in Tina waters range from 8mg/L to 157mg/L.

Based on trap efficiency for the suspended sediment of 50% and 100% for bed load, Entura (2014) has estimated that the amount of material (both suspended sediment and bed load) that will be trapped would be of 750t/km^2/year (93,750 tons per year or 45,000m^3) would be deposited in the reservoir. It would therefore take about 65 years until the reservoir fills to the intake invert level at 162.5masl.

Despite the dam acting as a barrier for sedimentation transport to the downstream areas, the over topping of the dam during flooding will continue to carry sediments from tributaries downstream of the dam and this will continue to supply sediments to the downstream communities which will allow them to continue with their livelihood activities such as gardening on fertile land along the river bank.

5.9 AIR QUALITY

Air quality is generally excellent in the Project area and there are no air quality non-attainment areas in the vicinity. Construction activities can be sources of dust pollution during wind events in the general region.

Impacts: There would be short-term dust impacts during excavation work although this would be limited to fugitive dust emissions and emissions from machinery and vehicles used and dust control would be followed during construction. There would be no negative long-term adverse impacts on air quality due to operation and maintenance of the hydropower facilities. As with other hydropower projects, there would be an offset of emissions of carbon dioxide and other green house gases.

5.10 WATER QUALITY

5.10.1 General Water Quality

Tables 5-7 and 5-8 include water quality results for both dry and rainy seasons, respectively. The locations of water quality sampling stations are set out in Table 5-9, at the end of this section. Dry season water sampling was carried out in July and August 2013 and rainy season sampling was carried out in February 2014.

Generally speaking, the water quality in the upper Tina River, upstream of inhabited areas, is assumed to be good owing to there being no anthropogenic sources (i.e., no domestic use, no gold panning, etc.) of pollution. Natural peaks in turbidity following flash flood events are considered to be the primary cause of degraded water quality. Current water quality in the Tina River does not appear to be a limiting factor for aquatic life, given this low level of pollution.

Table 5-7 Dry season surface water quality monitoring results

Water course			Upper Tina				Middle Tina.			Upper Ngalimbiu			Lower Ngalimbiu		Ngalimbiu Mouth				
Station Code			A1	A2	A2b	A3	A4	A5	NA	A6	A7	NA	A8	A9	A10a	A10b	A10c	A10d	A10e
Rivers & location			Becho-Voraha river	Mbembea riv.	Tina river pool.	Tina river gauging .stat.	Tina river. Koropa	Tina river. Sengue	Valekocha	Toni river. Kathihana	Ngalimbiu riv.. Horohutu	Ngalimbiu riv.. Birao	Ngalimbiu riv. Bridge	Ngalimbiu riv. Saele	Ngalim.m outh. Upp right bank	Ngalimbi mouth. Lower	Ngalimbiu mouth. Upstream mouth	Ngalimbiu mouth	Ngalimbiu Downstre am mouth
			PK																
Parameters	**Norms**	**Reference**	38.1	37.96		37.14	28.29	27.69		19.81	16.12		7.76	2.62	0	0	0	0	0
pH	**6.5-8.5**	**ADWG**	8.1	8	7.9	8.2	-	-	-	8	8.5	-	8	8.3	7.9	7.8	-	-	-
Turbidity (NTU)	**<5 NTU**	**WHO**	0.61	1.07	0.48	0.98	-	-	-	9.77	6.87	-	5.09	9.66	12	12.8	-	-	-
Cond.(µS/cm)	**20-250 (uS/cm)**	**ANZECC***	166.3	135.7	270.8	154.7	-	-	-	243.8	173.7	-	186.3	215.2	191.7	319.4	212.6	218	242.3
N02 (mg/l)	**<3.0mg/L**	**WHO**	0.042	0.041	0.012	0.042	-	-	-	0.039	0.046	-	0.045	0.011	0.049	0.046	-	-	-
PO4 (mg/l)			1.4	1.3	1.3	1.2	-	-	-	1.4	1.1	-	1.5	1.6	1.8	1.9	-	-	-
Total phosphorus (mg/l)	**<0.01 mg/l**	**ANZECC***	0.5	0.4	0.4	0.4	-	-	-	0.4	0.4	-	0.5	0.5	0.6	0.6	-	-	-
***E.coli* (MPN)**	**0 MPN**	**WHO**	-	-	-	-	-	-	7.5	12.4	-	42.9	-	129	-	-	-	-	-
Total Coliform (MPN)	**<10 MPN**	**WHO**	-	-	-	-	-	-	16.4	94.5	-	> 200.5	-	> 200.5	-	-	-	-	-

* Norms for Rivers in tropical Australia

ADWG: Australian Drinking Water Guidelines; WHO: World Health Organization

Stations A10C, A10 D and A10E are not mapped, they were taken in the river mouth at the shore line about 20m upstream inland and about 20m downstream in the river outflow outside of the shoreline. The conductivity measurements clearly show that, at the time of the observation, there was no estuarine effect: the freshwater flows directly to the sea. No salinity gradient inland. This was confirmed by the presence of fresh water helophytes and can toad tadpoles at the river mouth.

Table 5-8 Rainy season surface water quality sampling results

			Tina Village. gravel filtered water	Tina village	Toni River	Ngalimbiu after junction of Toni and Tina	Ngalimbiu Bridge	Saele village	Saele. gravel filtered water	River Mouth	River Mouth
			Water course								
			Tina	Tina	Toni	Ngalimbiu	Ngalimbiu	Ngalimbiu	Ngalimbiu	Ngalimbiu	Ngalimbiu
			Sample Code								
			A5B	**A5B**	**A6B**	**A6C**	**A8**	**A9**	**A9B**	**A10A**	**A10B**
			Date								
			11-Feb-14	**11-Feb-14**	**11-Feb-14**	**11-Feb-14**	**10-Feb-14**	**10-Feb-14**	**10-Feb-14**	**10-Feb-14**	**10-Feb-14**
			PK								
Parameters	**Norms**	**Reference**	18.90	18.90	17.97	17.37	7.76	2.62	3.35	0	0
pH	**6.5-8.5**	**ADWG**	-	6.82	7.89	7.08	7.36	7.35	6.6	7.91	6.62
Turbidity (NTU)	**<5 NTU**	**WHO**	-	16.1	2.54	15.5	8.69	14.6	2.34	15.3	18.4
Conductivity (uS/cm)	**20-250 (uS/cm)**	**ANZECC***	-	155.2	239.3	166.8	191.9	195.2	488.5	190.8	995.1
TDS (ppm)	**<600mg/L**	**ADWG**	-	97.4	153.4	105.3	121.7	124	321.8	120.8	676.6
Nitrate (NO3) in mg/L	**<50mg/L**	**WHO**	-	0.9	1	0.9	0.9	0.8	1.1	1	0.7
Nitrite (NO2-N) in mg/L	**<3.0mg/L**	**WHO**	-	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	0.016	0.019
Nitrogen Ammonia (NH3-N) in mg/L	**<0.01 mg/l**	**ANZECC***	-	<0.06	<0.06	<0.06	0.1	0.2	0.1	0.3	0.2
Dissolve oxygen (ppm) (in situ)	**>6 ppm**	**ANZECC**	-	6.69-7.13	6.54-6.68	7.20-7.24	6.00-6.06	6.28-6.43	-	5.71-5.84	5.69-5.69
T° (in situ)			-	24.5-25.0	28.4-29.4	26.4-27.2	31.2-32.0	29.3-30.5	-	26.9-27.4	28.3-27.7
***E.coli* (MPN)**	**0 MPN**	**WHO**	8.6	10.9	75.4	18.1	14.8	12.2	20.3	6.3	6.3
Total Coliform (MPN)	**<10 MPN**	**WHO**	>2419.6	>2419.6	>2419.6	>2419.6	>2419.6	>2419.6	461.1	>2419.6	>2419.6

***** Norms for River in tropical Australia

ADWG: Australian Drinking Water Guidelines; WHO: World Health Organization

Table 5-9 Table of location of water quality sampling sites

Station	Area	River	Location	Chainage*	WQ sample
A1	Upper catchment	Bicho-Voraha Riv.	confluence	CH -1km	X
A2	Upper catchment	Mbembea River	confluence	CH -1km	X
A3	Upper Tina	Tina River	Gauging st	CH 1km	X
7C	Middle Tina	Tina River	Dam	CH 7km	
A4	Middle Tina	Tina River	Koropa	CH 11km	
A5	Middle Tina	Tina River	Sengue	CH 11.5km	
A6	Upper Ngalimbiu	Toni River	Horohutu	CH 19km	X
A7	Upper Ngalimbiu	Ngalimbiu Riv.	Kathihana	CH 20km	X
A8	Lower Ngalimbiu	Ngalimbiu Riv.	Ngalimbiu	CH 28km	X
A9	Lower Ngalimbiu	Ngalimbiu Riv..	Saele	CH 34km	X
A10a	Mouth area	Old Ng. mouth	Komporo	CH 36 km	X
A10b	Mouth area	New Ng. mouth	Komporo	CH 37 km	X

* Based on Entura Phase 1 chainage, starting at Tina River between the upstream confluence of the Mbeambea and the Voraha (chainage 0km)

For further details on the location of the water quality sampling sites see Section 7.3.3.

5.10.2 Specific Water Quality Parameters

5.10.2.1 Turbidity

During the dry season water quality sampling (August 2013), the water was very clear in the vicinity of the gauging station (turbidity of 1 NTU or less). In the Toni River, a high turbidity (9.7 NTU) was observed on a rainy day. In the Ngalimbiu section (Horohutu to Saele), turbidity values were significantly higher, ranging from 5NTU to 9NTU (5NTU is considered as noticeable when observing). The maximum turbidity (12NTU) was observed at the mouth of the River.

During the rainy season water quality sampling (February 2014), the water was less clear than it had been at the same location during the dry season water quality sampling. In all river stations, turbidity was higher than the World Health Organisation's (WHO) recommended norm of 5NTU for drinking water. At the time the rainy season sampling was conducted, frequent heavy high rainfall events were generating silt and soil laden runoff originating from within the large catchment area.

Turbidity in downstream reaches of the Tina River (16.1NTU) was higher than in the downstream reaches of the Toni River (2.52NTU). As would be expected by these NTU levels, visually, the Toni River was also much clearer than the Tina River. The difference between the water clarity in the two rivers could be explained by the fact that Toni River catchment does not extend to the same higher elevations as the Tina River catchment.

In Guadalcanal, rainfall is directly related to altitude, the higher the altitude, then the higher the amount of rainfall. In addition, The Toni River catchment is much smaller than the Tina River catchment. During the dry season water quality survey, according to laboratory results, the mouth of the river was less turbid than at other stations. During the rainy season water quality survey, the river mouth appeared more turbid. This difference could be explained by the slower currents in the vicinity of the river mouth, where the water is also deeper, versus the stronger currents observed at the upstream sampling stations (Tina, Toni and Ngalimbiu).

People residing next to the rivers extract water from small holes dug into the river gravels adjacent to the shore, to obtain water that has been filtered through the sand, before drinking it. Water sampled from a hole dug into the gravel showed reduced turbidity (2.34NTU), compared to water taken directly from an adjacent location in the river (14.6NTU).

The increase in turbidity in the Ngalimbiu River is likely the result of both anthropogenic (high population with increasing water usage, and agricultural drainage in the coastal plain), and natural causes (increase of primary productivity in the lower reach of the river due to the degradation of organic matter from the upper reach, “spiral effect”).

The level of turbidity observed indicates good quality of water for aquatic life.

5.10.2.2 pH

During the dry season, the water had a slightly basic pH (7.8 to 8.2) with no particular variation along the river. During the wet season, the water had a pH that ranged from 6.6 to 7.89.

The observed pH levels indicate good water quality for aquatic life.

5.10.2.3 Conductivity

During the dry season, conductivity readings on the upper Tina River were relatively low (136 µS/cm to 155µS/cm), compared to isolated pools, where readings were roughly double (271µS/cm). Conductivity appeared to increase slightly in the Ngalimbiu River (173µS/cm to 215 µS/cm) for the same reasons that dry season turbidity was higher in this reach.

At the mouth of the river, conductivity readings (191µS/cm to 242µS/cm) were not significantly higher (319µS/cm) than in the Ngalimbiu reach, even at the point where freshwater was pushing the ocean outwards. No salinity gradient was observed during the survey (i.e., no brackish water estuary). During flood tides, ocean waters can intrude upstream as a salt wedge beneath the freshwater for a distance of roughly 500m.

During the rainy season, the river mouth shows a significant increase in conductivity (995.1µS/cm) when compared to the upstream river reaches (155.2µS/cm to 239.3µS/cm). Total Dissolved Solids (TDS) exhibited the same trend as conductivity.

5.10.2.4 Other parameters

Regarding nutrients (nitrate, phosphate), during both the rainy and dry seasons, nutrient concentrations were found in low concentrations in the upper Tina River, and were slightly elevated in the Ngalimbiu reach.

Nutrients are more a concern for drinking water quality for humans, than for aquatic life.

5.10.2.5 Faecal Coliform Bacteria Levels

During dry season, the level of faecal coliform contamination was low in the upper Ngalimbiu reach and in the Toni River, where few riparian settlements occur. Faecal coliform levels increased within the lower reaches, especially downstream of Ngalimbiu village.

During the rainy season, the level of total coliform contamination was high in all sampled stations. Total coliform indicates the presence of coliform derived from both vegetative, and human and animal sources. The presence of *Escherichia Coli* (E. Coli) bacteria indicates faecal contamination from human or animal origin. Sample results exceeded WHO standards but, surprisingly, remained lower than during the dry season. These results were counter-intuitive, as it would have been expected that, due to heavy rains and the volume of runoff from nearby villages, higher levels of E. Coli would have occurred during the rainy season.

5.10.2.6 Water Temperature

Water temperatures were obtained using a Hanna HI 9146 dissolved oxygen and temperature meter. River water temperatures increase in a downstream directly from higher elevation to lower elevation. At the river mouth water temperatures decrease, somewhat, due to the moderating influence of the ocean. During the rainy season, water temperatures ranged from 24.5°C in the Tina River to 32.0°C in the Ngalimbiu River.

Anthropogenic processes have no influence on water temperatures in the sampled rivers.

5.10.2.7 Dissolved oxygen

Dissolved Oxygen (DO) measurements were made using a Hanna HI 9146 dissolved oxygen and temperature meter. Sampling was conducted during the rainy season, at depths of 20cm and 40cm, to obtain a range of results. Along the Tina, Toni and Ngalimbiu rivers, DO ranged from 6.00mg/L to 7.24mg/L, levels that are considered good aquatic life. At the mouth of river, DO decrease to between 5.71mg/L and 5.84mg/L, indicating poorer conditions for aquatic life. According to ANZECC, DO levels below 6mg/L result in conditions that are stressful for aquatic organisms. No DO measurements were obtained during the dry season.

The source of DO is aquatic plants that expel oxygen into the water during photosynthesis, or from the atmosphere through turbulent mixing (entrainment) and diffusion. In the river system, DO comes from entrainment and atmospheric diffusion rather than from aquatic plants, since high water velocities and frequent flash flooding does not facilitate the establishment of aquatic plants. DO is affected negatively by the amount of soil and vegetation debris (organic matter) that enters the river system, both of which consume oxygen through adsorption and decomposition. The presence of fast moving water over rapids and riffles positively affects the amount of oxygen that diffuses into water. Temperature also influences DO, with the higher the temperature the lower the oxygen content of the water. Warm, slow moving water, as observed at the mouth of the river, negatively influences oxygen content.

Erosion caused by human activities, such as agriculture or forest clearing, runoff that occurs during the rainy season, and natural landslide events, all contribute to reducing DO levels in the river, thereby affecting aquatic life. However, notwithstanding the negative effects on DO, floodwaters rich in organic material from the Tina River's large catchment area are valuable for some aquatic species.

5.10.2.8 Dissolved Metal Concentrations at Ngalimbiu River Bridge (2006)

Water quality at the Ngalimbiu River Bridge has been monitored by Golder Associates (August 2006, November 2006, March 2007 and September 2007) as part of a water quality baseline survey. The Ngaliumbiu site was used as a reference site for the Matepono River, which is effected by mine activities. Results were obtained from the Gold Ridge Mine Environmental Audit report (Golder Associates 2008).

The report focuses on metal concentrations in surface water, and includes analyses for aluminium, copper, arsenic, cadmium, manganese, nickel, lead and zinc. Concentrations of dissolved metals were below the ANZECC trigger thresholds for drinking water with the following exceptions: Aluminum (August 2006 and September 2007), Copper and Cadmium (August 2006), Zinc (September 2007).

5.10.2.9 Pesticides Associated with Oil Palm Cultivation

Pesticides, including Glyphosate CT, Basta, 2-4-D Amine, Ally (Metsulfuron Methyl), Kamba 500 selective herbicide (present as the dimethlyamine salt), and Gramoxone Tropical (Paraquat), are most likely present in the Ngalimbiu River, since they are used by the oil palm industry in the area. Since 2011, Paraquat is no longer used (New Britain Palm Oil Limited, 2011) but is most likely still present in the sediments of the Ngalimbiu River.

No water quality data were available for these parameters, and it is suspected that they have never been analysed in the Ngalimbiu River. National laboratories do not have the capabilities to analyse pesticides.

5.10.3 Water Quality Study Limitations

The three main study limitations regarding water quality sampling are:

- Limited capacity of the Solomon Islands Water Authority (SIWA) laboratory;
- Lack of national laboratories with the capability to analyze heavy metals and pesticides; and
- Sampling was undertaken as unique events, rather than as recurring events over a period of time.

The quality of analyses by SIWA Laboratory could not be verified, since blank samples needed for quality control, were lost by the laboratory.

The river system is highly variable, with sudden flash floods rapidly changing turbidity, dissolved oxygen, temperature and Total Suspended Solids (TSS). With the exception of logging, the Tina and Toni rivers are not affected by other anthropogenic disturbances, (e.g., no gold panning, no other major sources of TSS, no agriculture activities, etc.). Therefore, heavy metal and pesticide pollution are not likely to affect the Tina River system. It is, however, likely that the Ngalimbiu River, downstream of the Tina River, is affected by pollution resulting from drainage of oil palm plantations that use fertilizers and pesticides. National laboratories do not have the capability to analyze these sources of pollution. To establish a benchmark for aquatic organisms and the aquatic environment, it is recommended that a program of water, sediment and fish tissue sampling for heavy metal and pesticide toxicity be implemented for the river system, prior to construction of TRHDP (as presented in Section 6). Samples could be sent to Brisbane, Australia.

5.11 AMBIENT NOISE LEVELS

5.11.1 Ambient Noise – Baseline

Ambient noise monitoring was not undertaken for the TRHDP. This is because the Project will be located in a rural setting in which ambient or background noise is consistent with a largely un-mechanised society. Night time noise levels for undeveloped rural settings typically range from 30dBA to 40dBA, and 40dBA to 50dBA during day time hours. Occasional spikes up to 75dBA to 80dBA may occur close to villages when chainsaws, petrol powered electrical generators or petrol powered water pumps are in use.

5.11.2 Noise Emissions – Construction and Operation

Impact Identification and Rating

During project construction, noise levels will increase considerably at the dam site and powerhouse site over a period of up to three years. However, as the dam site is approximately 2km from the nearest village, only minimal impacts will accrue to local inhabitants as a result of dam construction. Noise disturbance from powerhouse construction will affect Habusi village, which is located across the river and approximately 400m away from the site.

Noise levels will also increase close to villages during the period that access road improvements are underway. This noise disturbance will be transient, extending over a matter of days or weeks, as the road construction progresses. Transient noise levels will also increase within villages located along the access road as a result of truck / vehicle movements, which are estimated at almost 10 transits per hour during the daytime construction period (7:00am to 5:00pm). Heavy truck movements will also generate vibrations that may affect any buildings located in close proximity to the road.

Overall, noise impacts will be significant adjacent to the dam. However, as there are no villages within 2km of the dam site, the effects on villages will be low-moderate. Noise impacts from access road construction and operation, and powerhouse construction will be moderate during the daytime construction period, and low during nighttime.

During project operation, noise disturbance will be minimal and primarily related to occasional vehicle movements to/from the dam and/or powerhouse.

Typical noise levels associated with machinery used to construct a hydropower project are included in Table 5-10.

Typical levels of noise disturbance are shown in Figures 5-13 and 5-14.

Table 5-10 Equipment Noise Emission Levels

Equipment Description	Impact Device?	Actual Average dBA Measured L_{max} @ 50 feet or Spec (where actual not available)
All Other Equipment > 5 HP	No	85 (spec)
Auger Drill Rig	No	84
Backhoe	No	78
Bar Bender	No	80 (spec)
Blasting	Yes	94 (spec)
Boring Jack Power Unit	No	83
Chain Saw	No	84
Clam Shovel (dropping)	Yes	87
Compactor (ground)	No	83
Compressor (air)	No	78
Concrete Batch Plant	No	83 (spec)
Concrete Mixer Truck	No	79
Concrete Pump Truck	No	81
Concrete Saw	No	90
Crane	No	81
Dozer	No	82
Drill Rig Truck	No	79
Drum Mixer	No	80
Dump Truck	No	76
Excavator	No	81
Flat Bed Truck	No	74
Front End Loader	No	79
Generator	No	81
Generator (<25KVA, VMS Signs)	No	73
Gradall	No	83
Grader	No	85 (spec)
Grapple (on backhoe)	No	87

Equipment Description	Impact Device?	Actual Average dBA Measured L_{max} @ 50 feet or Spec (where actual not available)
Horizontal Boring Hydraulic Jack	No	82
Hydra Break Ram	Yes	90 (spec)
Impact Pile Driver	Yes	101
Jackhammer	Yes	89
Man Lift	No	75
Mounted Impact Hammer (hoe ram)	Yes	90
Pavement Scarifier	No	90
Paver	No	77
Pickup Truck	No	75
Pneumatic Tools	No	85
Pumps	No	81
Refrigerator Unit	No	73
Rivit Buster/Chipping Gun	Yes	79
Rock Drill	No	81
Roller	No	80
Sand Blasting (single nozzle)	No	96
Scraper	No	84
Sheers (on backhoe)	No	96
Slurry Plant	No	78
Slurry Trenching Machine	No	80
Soil Mix Drill Rig	No	80 (spec)
Tractor	No	84 (spec)
Vacuum Excavator (Vac-Truck)	No	85
Vacuum Street Sweeper	No	82
Ventilation Fan	No	79
Vibrating Hopper	No	87
Vibratory Concrete Mixer	No	80
Vibratory Pile Driver	No	101
Warning Horn	No	83
Welder/Torch	No	74

Source: US Federal Highway Authority - Construction Noise Handbook

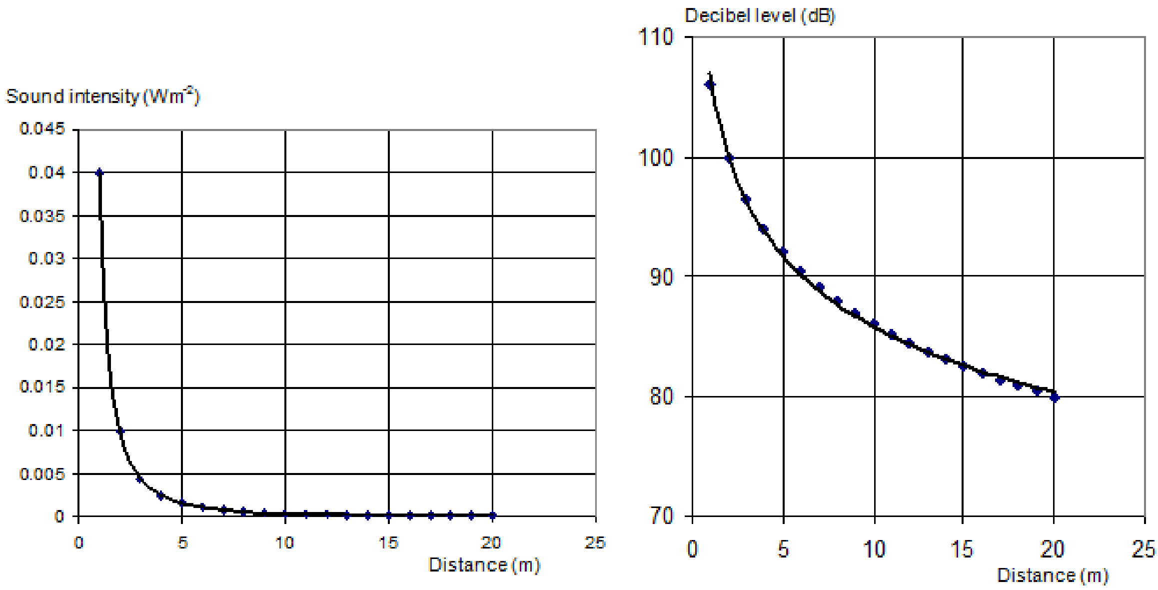
(https://www.fhwa.dot.gov/environment/noise/construction_noise/handbook/handbook09.cfm)

For each generic type of equipment listed in Table 5-10, the following information is provided:

- an indication as to whether or not the equipment is an impact device;
- the acoustical usage factor to assume for modelling purposes;
- the measured "Actual" emission level, or the specification "Spec" limit for each piece of equipment (where actual not available) expressed as an Lmax level in dBA at 50 feet
- Data obtained from a number of construction projects over the period beginning in the 1970s through 2006

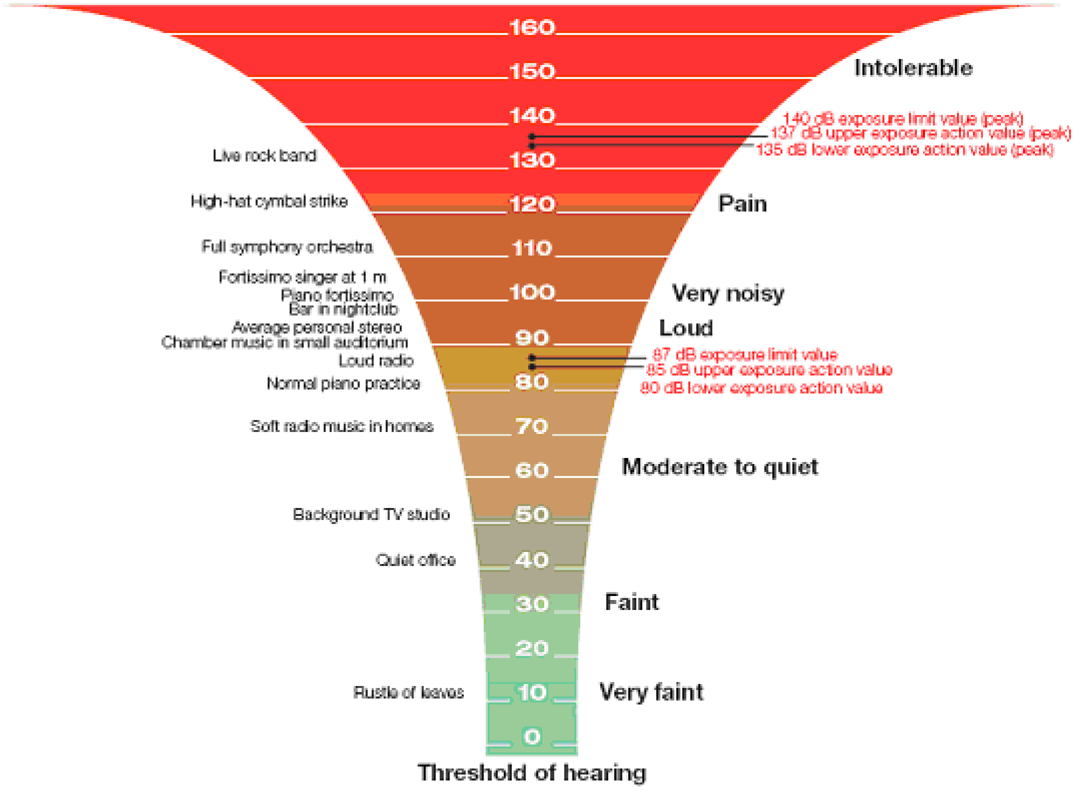
Sound intensity decreases by the inverse square of the distance.

Figure 5-13 Variation of sound level intensity and the decible level with distance from the source of sound (decibel level of 80 dB at 200 m)



Source: *http://www.schoolphysics.co.uk/age1619/Sound/text/Sound_levels_and_distance/index.html*

Figure 5-14 Noise disturbance levels



Source: Sound Advice. http://www.soundadvice.info/thewholestory/san1.htm

Mitigation Measures

Noise emissions and vibration effects will be mitigated through best practice, including:

- Restricting construction in areas close to villages (access road and transmission lines, powerhouse) to the period 7:00am to 5:00pm;
- Restricting blasting at the dam site or other locations that require blasting to the period 7:00am to 5:00pm;
- Restricting movement of heavy vehicles through villages to the period 7:00am to 5:00pm;
- Requiring that all mobile and stationary equipment be equipped with fully functioning noise mufflers and baffles.

Residual effects and their significance

By implementing best practices to control noise emissions, including restricting construction work adjacent to villages to daytime hours, noise impacts will be moderate during daytime hours, and low during night time hours and, therefore, are considered to be not significant. http://www.soundadvice.info/thewholestory/san1.htm

6. BASELINE BIOLOGICAL ENVIRONMENT - TERRESTRIAL

6.1 INTRODUCTION

This section presents baseline information on the fauna and flora found within the study area.

According to UNESCO (2013), no other areas of comparable size support more unique bird species than the Solomon Archipelago. Solomon Islands has about 4500 species of plants and is recognized as being rich in plant diversity, and endemism (MECM, 2008). Solomon Islands supports breeding populations of 47 endemic bird species. The country has 4 Endemic Bird Areas (EBAs), one of which is located on Guadalcanal. An EBA is an area of less than 50,000km^2 that encompasses breeding range for two or more restricted-range land birds (Bird Life International, 2013).

Solomon Islands and Guadalcanal are rich in biodiversity and endemicity, not only for birds, amphibians, reptiles and mammals, but also invertebrates. The degree of variation in bird species between islands is very marked. Guadalcanal is home to many small mammals mostly bats, rats and possums, some of which are rare (MECM, 2008). As it is the case with other islands that make up Solomon Islands, Guadalcanal's interior mountain species have been poorly studied, and much more scientific information is needed (MECM, 2008; McCoy, 2008). The mountains of Guadalcanal reach elevations up to 2,310 meters, and are uninhabited by humans. They provide pristine wildlife habitats.

6.2 METHODOLOGY

Field surveys to inventory fauna were undertaken by Edgar Pollard, an expert on fauna of the Solomon Islands. Field surveys to inventory flora were carried out by Myknee Sirikolo, an expert on the flora of Solomon Islands. Eric Deneut, biologist and assistant team leader, provided additional observations and discussion concerning terrestrial fauna. Field visits and sampling were carried out from 5 to 17 August 2013. A total of 24 flora stations and 22 fauna stations were studied for the purpose of characterizing the environmental baseline.

Sampling locations were selected to reflect potentially project-affected areas. Prior to conducting the field visits, the location of fauna and flora stations was presented to the TRHDP PO and fauna and flora experts, for discussion and approval. To enable experts to precisely locate each station and to facilitate the process of data gathering in the field, special field maps were prepared using BaseCamp (Garmin). These maps were then printed on waterproof sheets. An example of one of these field maps is included in Annex 9 of the Annex Report. Maps used in recording aquatic environment data show the exact location of each sampling station. Three categories of sampling area were selected:

- Upper Stream sampling area - a typical upper stream area within undisturbed lowland forest (primary forest).
- Middle Tina River sampling area - a large area that represents the main location of potential impact generating activities (e.g., access road, powerhouse, tunnel, and dam).
- Transmission line sampling area - these stations represent the future location of the transmission line. All sampling stations were located along the road that connecting to Tina River village (Black Post Road). This will be the access road used by trucks and machinery to connect to the construction site.

6.3 TERRESTRIAL FLORA

6.3.1 Survey Locations and Methodology

The upper catchment of the Tina River provides important terrestrial habitat, consisting of areas of Montane forest spread across the high peaks of Guadalcanal (see Figure 6-1). The ESIA team accessed this upper catchment to sample flora and fauna, using a helicopter. However, due to issues of limited access and availability of scientific data, many questions remain regarding the flora and fauna assemblages in the upper catchment's montane forest. Notwithstanding, the ecosystem of this area will not be directly affected by the Project.

Fauna and flora surveys were carried out at specific survey sites across the project area of influence as shown in Figure 6-1, and further described in Appendix A. Flora species at each station were identified within circular plots having a radius of 10m to 20m from their centre point (see Annex 8 in the Annex Report for a list of identified plant species). In some cases, the radius was increased to reflect the need to sample the diversity of plant species. Although the flora survey was undertaken at one specific time, timing of the surveys is irrelevant since species were identified regardless as to whether they were flowering at the time of the survey, or not. Survey results also confirmed the presence of plants and wildlife that were identified from previous studies.

To ensure that no major rare or protected plant communities will be affected as a result of construction activities, a ground level reconnaissance survey will be done at the time the final road and transmission line alignments are identified, with the purpose of identifying potential threatened or vulnerable plant species that would need to be avoided. This reconnaissance survey would serve as the baseline for monitoring the construction of the access road to ensure that no threatened or vulnerable flora is destroyed.

A constraint for undertaking the flora survey was the lack of site-specific information on the Project area.

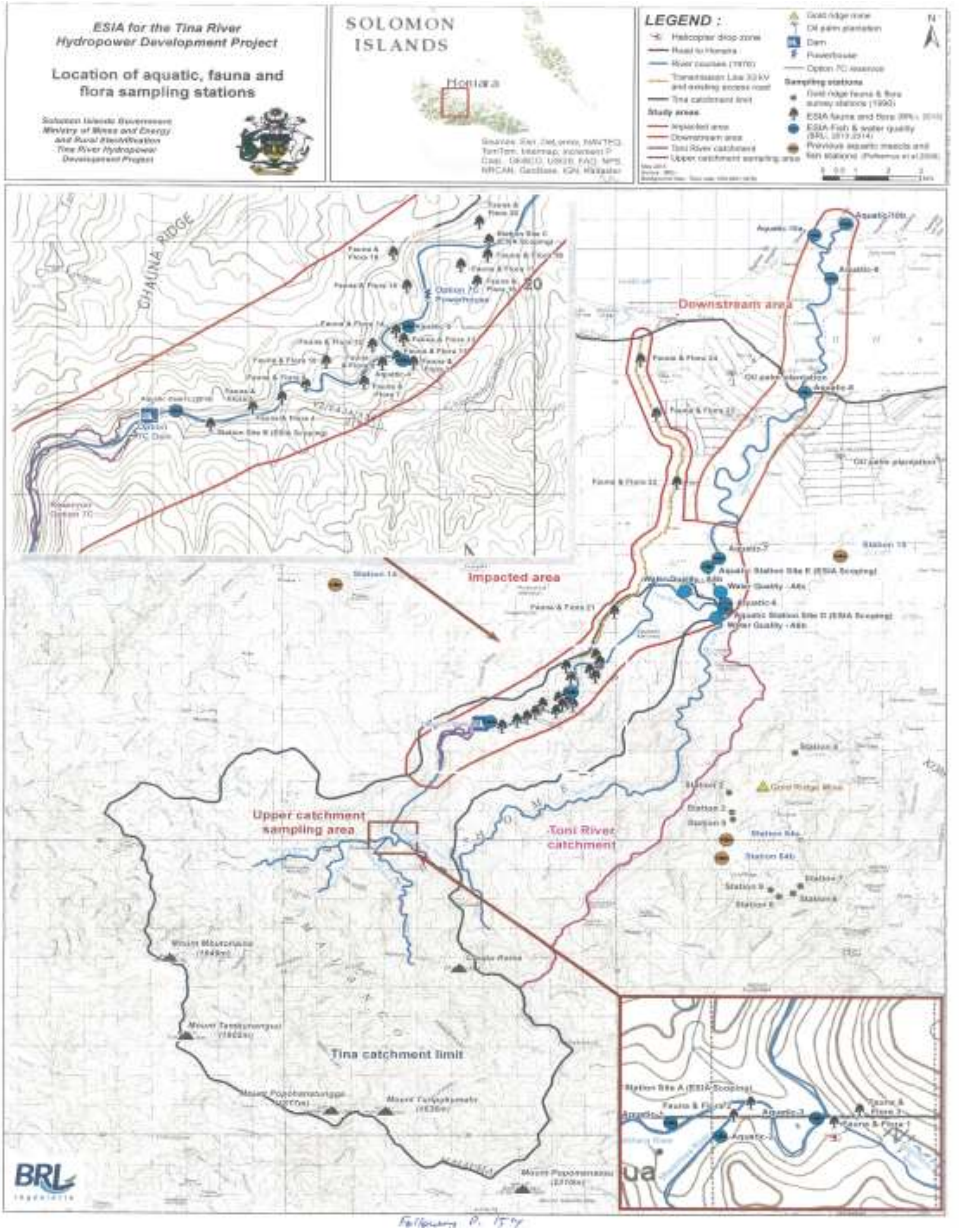
6.3.2 Flora Survey Results

From the flora survey, the floral expert identified a total of 159 plant species. Among the species identified, 5 are listed as vulnerable, and 19 are listed as threatened. A total of 66 species of trees, fern trees and palm trees were identified. They are classified in the "tree stratum". Many species are regrowth and secondary trees species and are, therefore, good indicators of past disturbances, whether from natural events (e.g., cyclones; landslides) or anthropogenic activities (e.g., timber harvest). At least 23 identified tree species are of commercial timber value. A total of 36 shrubs and vines, and a total of 57 herbaceous plants were identified.

The ESIA flora baseline survey was supplemented by information obtained from the Feasibility Study rapid flora assessment, which had identified 23 additional species of plants, including: 2 trees, 3 palms, 4 shrubs (including bamboo) and 14 orchids (herbaceous plants). Many plants are used by local communities as medicinal plants, as a source of building materials, and for food.

Disturbed areas such as Black Post road, and the proposed access road and transmission line corridor, are colonized by invasive plant species. The level of disturbance increases from upstream to the downstream in the catchment. Disturbance is the result of human activity, mainly logging and human settlements (garden, houses, etc.)

Figure 6-1 Biological sample sites



6.3.3 Species of Concern

Three categories of habitat disturbance were defined according to their level of disturbance: weakly disturbed habitats, moderately disturbed habitats and highly disturbed habitats. According to the flora survey, the highly disturbed areas, such as the areas around the Black Post Road, have fewer species of concern (see Table 6-1 and Figure 6-2) (see Annex 8 in the Annex Report for the list of floral species, including species of concern).

Table 6-1 Number of flora species of concern

	Stations	**Number of species of concern**	**Percentage of species of concern**
Increasing level of disturbances	Fauna&Flora2	5	36
	Fauna&Flora1	5	17
	Fauna&Flora3	5	28
	Fauna&Flora7	5	15
	Fauna&Flora6	2	11
	Fauna&Flora5	4	18
	Fauna&Flora4	3	13
	Fauna&Flora14	5	33
	Fauna&Flora10	4	17
	Fauna&Flora19	2	10
	Fauna&Flora12	11	48
	Fauna&Flora15	4	29
	Fauna&Flora13	3	12
	Fauna&Flora9	3	13
	Fauna&Flora11	1	10
	Fauna&Flora8	2	11
	Fauna&Flora18	0	0
	Fauna&Flora17	5	23
	Fauna&Flora16	1	7
	Fauna&Flora20	0	0
	Fauna&Flora21	5	19
	Fauna&Flora22	0	0
	Fauna&Flora23	0	0
	Fauna&Flora24	0	0

Figure 6-2 Number and percentage of flora species of concern

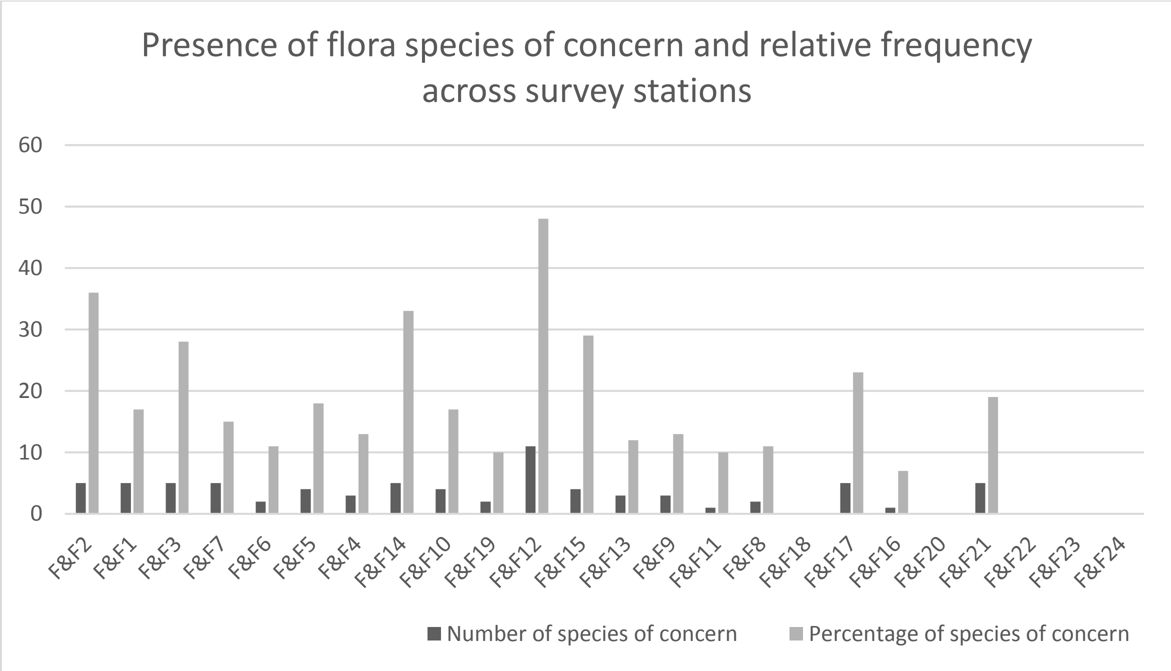


Table 6-2 identifies the threatened and vulnerable flora found within the study area (i.e. core area plus areas adjacent to the access road and transmission line). The majority of flora species listed as either threatened or vulnerable are timber species harvested for the local or export trade. Most of the area downstream of the dam has been affected by commercial timber harvesting, village settlements and gardens. With the exception of approximately 100m of access road, the road alignment from the powerhouse to the intersection with Black Post Road, and all of the transmission line, will be located within existing highly modified habitat.

Table 6-2 Threatened and vulnerable species of flora

Location	Species	Common Name	Distribution Status within Study Area	Protection Status	Comments
Lowland forest, open vegetation, secondary regrowth along transmission line corridor – Station #1	Canarium indicum	Ngali, Canarium nut	Planted, Few Trees	Threatened	Planted food nut tree, also used for timber
“	Intsia bijuga	Kwila, Iron wood	Few Trees	Threatened	High value timber species
“	Pometia pinnata	Pometia, Taun	Few Trees	Threatened	High value timber species
“	Vitex cofassus	Vitex, Vasa	Few Trees	Threatened	High value timber species
“	Alstonia scholaris	Alstonia, Milky Pine	Few Trees	Threatened	Export timber species
Lowland forest on ridge-tops along access road corridor – Station #1	Pometia pinnata	Pometia, Taun	Few Trees	Threatened	High value timber species
“	Canarium indicum	Ngali, Canarium nut	Planted, Few Trees	Threatened	Planted food nut tree, also used for timber
Lowland forest on ridge-tops along access road corridor – Station #2	Calophyllum peekelii	Calophyllum	Uncommon	Threatened	Export timber species
“	Syzygium onesima	Syzygium	Uncommon	Threatened	Shrub species
“	Syzygium tierneyana	Syzygium	Uncommon	Threatened	Shrub species

Location	Species	Common Name	Distribution Status within Study Area	Protection Status	Comments
“	Syzygium myriadena	Syzygium	Uncommon	Threatened	Shrub species
“	Canarium salomonense	Small Ngali nut, Canarium	Uncommon	Threatened	Planted food nut tree, also used for timber
“	Pometia pinnata	Pometia, Taun	Uncommon	Threatened	High value timber species
“	Intsia bijuga	Kwila, Iron wood	Uncommon	Threatened	High value timber species
“	Calanthe longifolia	Terrestrial Orchid	Uncommon	Threatened	
“	Calophyllum paludosum	Calophyllum	Rare, Uncommon	Vulnerable	Export timber species
“	Pterocarpus indicus	Rose wood	Uncommon	Threatened	High value timber species
Lowland forest on ridge-tops along access road corridor – Station #3	Cycas seemannii	Cycad	Rare, Uncommon	Vulnerable	
“	Pterocarpus indicus	Rose wood	Uncommon	Threatened	
“	Calophyllum peekelii	Calophyllum	Common	Threatened	Export timber species
“	Pometia pinnata	Pometia, Taun	Uncommon	Threatened	High value timber species

Location	Species	Common Name	Distribution Status within Study Area	Protection Status	Comments
Lowland Forest - Power Plant – Station #2	Calophyllum peekelii	Calophyllum	Common	Threatened	Export timber species
“	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species
“	Syzygium onesima	Syzygium	Common	Threatened	
“	Canarium salomonense	Small Ngali nut, Canarium	Uncommon	Threatened	Planted food nut tree, also used for timber
“	Vitex cofassus	Vitex, Vasa	Uncommon	Threatened	High value timber species
Lowland forest - Secondary regrowth and riparian vegetation – Reservoir Station #1	Vitex cofassus	Vitex, Vasa	Uncommon	Threatened	High value timber species
“	Pometia pinnata	Pometia, Taun	Uncommon	Threatened	High value timber species
“	Drymophloeus salomonense	Drymophloeus	Uncommon	Threatened	Palm
“	Calophyllum peekelii	Calophyllum	Uncommon	Threatened	Export timber species
“	Elaeocarpus sphaericus	Elaeocarpus	Uncommon	Threatened	
Lowland forest overlapping secondary vegetation (old garden and village site) –	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species

Location	Species	Common Name	Distribution Status within Study Area	Protection Status	Comments
Reservoir Station #2					
“	Canarium indicum	Ngali nut, Canarium	Uncommon	Threatened	Planted food nut tree, also used for timber
Lowland forest - Secondary regrowth on a very steep slope – Reservoir Station #3	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species
“	Paraserianthis falcata	Albizia	Uncommon	Threatened	Timber species
“	Terminalia brassii	Brown Terminalia Swamp Oak	Uncommon	Threatened	Export timber species
“	Alstonia scholaris	Alstonia, Milky Pine	Common	Threatened	Export timber species
Lowland forest - Riparian vegetation – Reservoir Station #4	Paraserianthis falcata	Albizia	Uncommon	Threatened	
“	Terminalia brassii	Brown Terminalia, Swamp Oak	Uncommon	Threatened	Export timber species
“	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species
Riparian Vegetation – Dam Station #1	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species

Location	Species	Common Name	Distribution Status within Study Area	Protection Status	Comments
“	Paraserianthis falcata	Albizia	Uncommon	Threatened	
“	Nastus obtusus	Bamboo	Uncommon	Vulnerable	
Secondary Lowland Forest – Dam Station #2	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species
“	Palaquium firmum	Pencil Cedar	Uncommon	Threatened	Export timber species
“	Calophyllum peekelii	Calophyllum	Uncommon	Threatened	Export timber species
Old Garden Area – Secondary Forest – Dam Station #3	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species
Lowland forest and Riparian Vegetation on very steep cliff substrate – Dam Station #4	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species
“	Terminalia brassii	Brown Terminalia, Swamp Oak	Common	Threatened	
Lowland forest - Secondary Vegetation	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species
Uphill forest - Riparian vegetation on Very Steep Cliff Substrate – Cliff Station #1	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species

Location	Species	Common Name	Distribution Status within Study Area	Protection Status	Comments
"	Cycas seemannii	Cycad	Uncommon	Vulnerable	
"	Pandanus sp?	Pandanus	Uncommon	Threatened	
"	Pholidota sp?	Orchid	Uncommon	Vulnerable	
"	Spathoglottis plicata	Ground Orchid	Common	Vulnerable	
Uphill forest - Riparian vegetation on Very Steep Cliff Substrate – Cliff Station #2	Terminalia brassii	Brown Terminalia, Swamp Oak	Common	Threatened	
"	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species
"	Pterocarpus indicus	Rose wood	Common	Threatened	
"	Elaeocarpus sphaericus	Elaeocarpus	Common	Threatened	
Lowland - Riparian vegetation – Upstream Station #1	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species
"	Terminalia brassii	Brown Terminalia, Swamp Oak	Common	Threatened	
"	Crinum asiaticum	Crinum, Lilly	Uncommon	Threatened	

Location	Species	Common Name	Distribution Status within Study Area	Protection Status	Comments
“	Pterocarpus indicus	Rosewood	Common	Threatened	
“	Calophyllum peekelii	Calophyllum	Common	Threatened	Export timber species
Lowland - Riparian vegetation – Upstream Station #2	Paraserianthis falcata	Albizia	Common	Threatened	
“	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species
“	Vitex cofassus	Vitex, Vasa	Common	Threatened	High value timber species
“	Calophyllum peekelii	Calophyllum	Common	Threatened	Export timber species
“	Alstonia scholaris	Alstonia, Milky Pine	Uncommon	Threatened	Export timber species
Lowland - Riparian vegetation – Upstream Station #3	Terminalia brassii	Brown Terminalia, Swamp Oak	Common	Threatened	
“	Calophyllum peekelii	Calophyllum	Common	Threatened	Export timber species
“	Pterocarpus indicus	Rose wood	Common	Threatened	
“	Pometia pinnata	Pometia, Taun	Common	Threatened	
“	Paraserianthis falcata	Albizia	Uncommon	Threatened	

6.3.4 Plant Diversity and Protected Area Status

The project area lies outside any formally recognized protected areas. However, there are nearby areas that are considered to be of great landscape and biodiversity value, and are either protected or could be considered for protection. Despite its great biodiversity and landscape richness, the Solomon Islands has one of the poorest records for forest protection in the world, with only 0.28% of its terrestrial territory included in protected areas (WWF, 2005).

6.3.4.1 World Heritage Site

Guadalcanal does not have any World Heritage sites. However, one site, the Tropical Rainforest Heritage of Solomon Islands, is on its Tentative List (UNESCO, 2013). This site is comprised of four areas that, together, cover approximately 1500km^2:

- Mt. Popomanaseu region of Guadalcanal Province;
- Bauro Highlands of Makira-Ulawa Province;
- Mt. Maetambe region of Choiseul Province; and
- Central caldera forests of Kolombangara of Western Province.

Mt Popomanaseu region includes the nearby forest catchment and lowland valleys of the Itina River, which flows towards the windward coast. It partially overlaps the Tina River Catchment. The lowland riverine forests and montane forests, which make up this site, are intact. According to UNESCO, this site offers the best chance of conserving representative, distinctive and unique biodiversity. This area has outstanding biodiversity and a high proportion of endemic plants and wildlife (up to 75% of known species are endemic). The proposed area supports the largest contiguous area of montane forests in the country. Due to limited surveys, it is suspected that many of its species have not yet been identified. Endemic means that a species is only found in a restricted area, such as Guadalcanal. The area is customary land and any formal or informal protection would require the support of the local landowning tribes.

Unfortunately, the Sutakiki River headwaters of the Mt. Popomanaseu area are currently being prospected for gold, copper and zinc (Veronica Webster Pty. Limited, 2012).

6.3.4.2 National Park

Queen Elizabeth National Park is the only National Park in Guadalcanal Province. It covers an area of 1093 ha, and is located approximately 5km South of Honiara, along the Lungga River between the Matanikau River, Kolaa Ridge and Mount Austen. The British High Commissioner declared the area as a National Park in 1953. The local population disputed the government's right to use the land, and cleared vegetation to make way for farming instead. By the time money was allocated to rangers to protect the Park, squatters and farmers had already cleared much of the rainforest of Mount Austen. Today the National Park is highly degraded (Tedder, 2008). The National Park does not share any boundaries with the Project, or the Tina River catchment.

6.3.4.3 Areas with Informal Protection

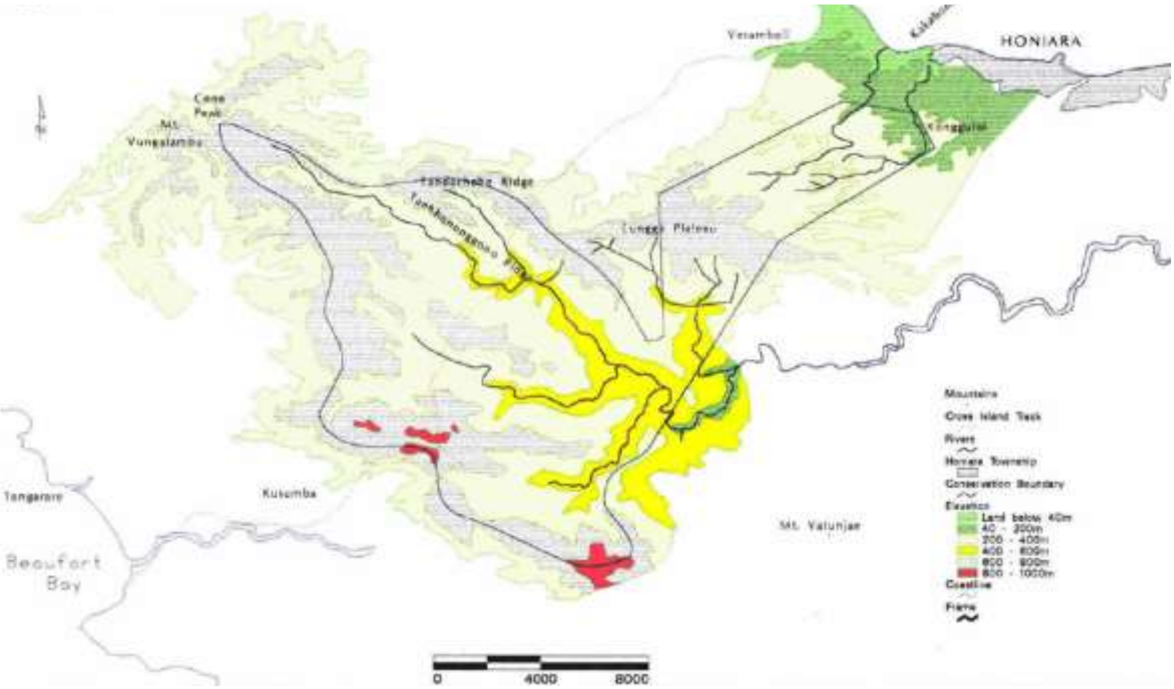
Informal protection of many small, natural sites is afforded by the local population, which protects these areas in a traditional manner. These sites are named “tambu” (for more information see Section 8). However, with modernization, traditional sacred beliefs associated with these sites have been eroded, and their protection is, therefore, threatened.

Komarindi Conservation Catchment Area (KCCA), located 30km west of the Project’s Core Area, is a vast informally protected area, managed under customary estates. It was established as a Wildlife Sanctuary in the early 1990s, and covers an area of 19,300 ha. A community-based ecotourism development program functioned from 1997 to 1999 but was terminated due to ethnic unrest. Support for the conservation project came principally from the (then) Solomon Islands Department of Forests, Environment and Conservation (DFEC), the South Pacific Biodiversity Conservation Programme (SPBCP), and the South Pacific Regional Environment Programme (SPREP) (SPREP, 2013).

The KCCA was designed in conjunction with the Komarindi Hydroelectric Power Project, and was supposed to be integrated with the hydropower scheme, which was never implemented (SPREP, 2013). The parallel development of the KCCA ecotourism program and the Komarindi hydroelectric scheme was supposed to provide an opportunity for SIG to implement a locally-managed, integrated conservation and hydropower project, and to achieve economic and social benefits for the local landowners and the wider community, while conserving the natural environment and cultural heritage (SPREP, 1996).

Since the late 1990s, the KCCAP has ceased to function and there are no longer any ecotourism activities. Figure 6-3 shows the boundaries of the KCCA.

Figure 6-3 The former KCCA boundaries



Source: SPREP, 1996

6.3.5 Conclusions on Flora

The tropical forests from PNG, along with the forests of the Solomon Islands, represent the largest block of tropical rainforests in the Asia-Pacific region, and are part of the three great rainforests of the planet (WWF, 2005). As shown in Table 6-3, forests have high ecological values, and play an important role for people's livelihoods, providing sources of timber, medicinal plants, food and wood fuel.

The forests of Guadalcanal, especially the lowland forests such as those of the Project site, are threatened by logging, which is considered an important source of income for the country. According to FAO (2009), deforestation is a result of an increased population on the island, and is influenced by a high demand for agricultural land, new settlements, and timber.

The study area encompasses the Core Area around the Tina River, as well as the access and transmission line corridors, which traverse primarily grassland and plantation areas. The primary habitats of the study area are comprised of forested and non-forested ecosystems, which represent a mix of modified and natural habitats. The Tina River catchment upstream of the dam site, is dominated by highly valued, undisturbed lowland forest and, in its upper portion, undisturbed montane forest, whereas, the area downstream of the dam site near Choro, is dominated by disturbed forests. This is mainly the result of anthropogenic activities (e.g., logging, settlements, garden, trails, etc.). However, even though the forests are disturbed, they still show rich plant diversity, which is a factor of rapid vegetation regeneration due to a tropical humid climate and fertile soils. Indeed, disturbed forests are quickly recolonized by various second growth species of trees, shrubs and herbaceous plants. The Tina River catchment is primarily dominated by forests, with some grassland areas on its northern side. The mid-river catchment is dominated by lowland forests, whereas, the upper catchment is dominated by montane forests.

Table 6-3 Summary of habitat ecological values

Habitat Units	**Location Relative to Project Components**	**Ecological value**
Grassland	Transmission line and access road	Moderate
Undisturbed forest (primary lowland forest)	Reservoir and dam abutments	High
Undisturbed forest, montane forest	No interaction	High
Disturbed forest (secondary lowland forest)	Transmission line, access road, reservoir and dam abutments	Moderate
Remnant forest (secondary forest colonized by pioneer species)	Transmission line, access road, reservoir and dam abutments	Moderate
Riparian	Dam, reservoir and reaches downstream of dam	High
Cliffs	Dam and reservoir	High
Garden	Transmission line and access road	Low

Habitat Units	Location Relative to Project Components	Ecological value
Fallow brush land	Transmission line and access road	Low
Oil palm	Transmission line and access road	Low
Settlements	Adjacent to transmission line, access road and reaches downstream of dam	Low

The Project footprint, including areas of inundation during operation, access and construction activity, will affect parts of the study area which are largely disturbed forest and modified grassland with extensive and ongoing anthropogenic change.

6.4 TERRESTRIAL FAUNA

6.4.1 Methodology

Visual and auditory encounter surveys (diurnal and nocturnal), plot counts and mist netting, were used to identify terrestrial vertebrate, birds, reptiles, amphibians, and mammals. Informal interviews were carried out with villagers to determine the presence of important species. Point counts involved visual and auditory surveying from a set location (sampling station) for a duration of 20 minutes. Binoculars were used for the visual surveys. All faunal species (amphibians, birds, mammals and reptiles) observed (seen or heard) during the sampling period, were recorded. Sampling effort was the same for each station, with approximately 30 minutes per station. Mist netting involved the placement of 8 mist nets (15m x 2m, 20mm mesh size) at sampling stations to capture and record birds and mammals. Nets were placed in forested areas, and also in locations adjacent to waterways. Informal interviews with local populations were carried out to obtain local knowledge about important fauna, habitats, and associated use of fauna by local communities. These informal interviews resulted in the recording of local knowledge.

'Potential Presence' of each species in the Tina River study area was based on a review of the following available literature, and on species observations made in close proximity to the study site:

- TRHDP ESIA Scoping Study (Entura, 2011);
- Birds of Melanesia (Dutson 2011);
- Guadalcanal Island Bird Checklist (Tarburton 2007);
- Frogs of the SI (Pikacha et al. 2008);
- Reptiles of the Solomon Islands (McCoy 2006); and
- Gold Ridge Report (Ross Mining N. L. 1997) since Gold ridge mines are located nearby the Project site.

6.4.2 Terrestrial Fauna Survey Results

6.4.2.1 Invasive and Feral Species

Feral animals such as cats and rats, introduced species such as cane toads, invasive plants (e.g., *Merremia peltata*), and introduced trees (e.g., paper mulberry) are widely distributed in the study area. Feral cats are a major threat to many vertebrate species, such as ground nesting birds, and introduced rats compete with native rats and prey on fledgling birds and eggs (Pikacha, 2008).Cane toads have a devastating effect on the population of indigenous frogs (Pikacha, 2008), as they are aggressive predators of native frog species. Moreover, eggs and tadpoles are poisonous and affect native tadpoles that eat them (IUCN, 2014). These species were observed by the ESIA team as far upstream as the upper Tina River catchment area.

The Giant African Snail was introduced into Solomon Islands, most likely by foreign logging machinery contaminated with soil containing eggs and juvenile snails. It competes with native species and damages food crops. During mitigation workshops, it was mentioned that the Giant African Snail had already reached Veraande village (along Black Post Road) and is a concern for villagers.

Insects such as the fire ants (*Wasmannia auropunctata*) are also a concern. Pathways created by logging roads have allowed this aggressive ant species that affects native insect biota to colonize new sites.

6.4.2.2 Game Species

Some species in the area are opportunistically hunted for food. According to social surveys on food eaten by households in the Project area (see Annex 6 of the Annex Report), except for wild pigs, game species were not declared as a significant part of people's diet. The harvesting pressure on game species around villages is unknown. However, people from surveyed villages sometimes go to the upper Tina River catchment on hunting trips.

6.4.2.3 Amphibians

Amphibians are sensitive animals, and are often seen as good indicators of ecosystem health. This is due to their dependence on certain moisture regimes and their sensitivity to pollutants, as they are able to 'breathe' through their skin. Therefore, amphibians require moist environments that are relatively pollutant free. Along the Tina River, flash floods bring water to riverine wetlands, these riverine wetlands are valuable habitats for amphibians. Heavy rainfalls in the project areas also bring moisture to forested areas. Amphibians are not highly mobile and, therefore, any changes to their habitat could lead to impacts on species. See Appendix B for a listing of amphibian species by family, including scientific and common names.

A total of 9 amphibian species were observed from a total of 13 potential species[25] from 4 families. This represents 64% of all amphibian species expected to occur within the Project study areas. None of the amphibian species is endemic to Guadalcanal or the Tina River catchment.

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[25] The term 'potential species' is defined as species that were found in the vicinity by previous studies and have a likelihood of being present, even if they were not observed in the course of this study.

Three native frog species deserve particular mention and are discussed below along with their relative vulnerability to the project.

Solomon Island's Treefrog (Litoria lutea) - This frog is deemed ecologically important because of its vulnerability based on the IUCN Red List assessment (IUCN, 2013). It is a rare forest frog in the Solomon Islands, and little information about it is available (Pikacha et al., 2008). It inhabits the upland forest habitats and was observed there during the ESIA field investigations. The Project would have minimal, if any, impacts on this species as it will not impact upland forest habitats.

Giant Webbed Frog (Discodeles Cornufer guppyi) - This frog is deemed ecologically important because of its dependence on the river system and is usually found along smaller rivers and streams (Pikacha et al., 2008). It is the largest frog in the Solomon Islands, and members of local communities report eating it. This species belongs to the riparian habitat. It was observed only in the upper catchment in small streams26.

San Cristobal Treefrog (Hylarana Papurana kreffti) – This frog is deemed ecologically important because of its dependence on the river system. It is an aquatic breeder that lays eggs in pools of water (Pikacha et al. 2008). It is the only Solomon Islands frog that has a tadpole stage, as opposed to direct development evident in the Ceratobatrachidae frogs (Figure 6-4). The species is found in the riparian habitats. Possible impacts of the Project on this species include loss of its wetland habitats for feeding. The creation of a dam may increase habitats for breeding.

Figure 6-4 SanCristobal Treefrog tadpoles and eggs

[26] Personal Communication with Pikacha 2016.

Figure 6-5 is a photo of two species of frogs found within the study area.

Figure 6-5 Weber's Wrinkled Ground Frog (left) and Solomon Islands Eyelash Frog (right)

Source: Edgard Pollard 2013

6.4.2.4 Insects

Species of damselfly (Odonata spp.), including *Neurothemis stigmatizans*, *Neurothemis terminata* and *Xiphiagrion cyanomelas* were commonly observed along the Tina River, and its adjacent micro-wetlands. The life cycles for these species are closely linked to the Tina River and riparian habitats, since they spend much of their life cycles as benthic organisms. Flash floods can occasionally convey water to small branches of the river allowing the Odonata to breed and reproduce there.

Photographs of four species of damselflies are shown in Figure 6-6.

Figure 6-6 Odonata species observed during field surveys

Neurothemis stigmatizans (left) and Neurothemis terminata (right)

Xiphiagrion cyanomelas (left) and Odonate imago (juvenile) (right)

Many spiders were observed along the Tina River, including Spiny orb-weavers of the genus *Gasteracantha* and spiders of the genus *Argiope*.

6.4.2.5 Reptiles

Reptiles are important animals of the forest and provide a large proportion of faunal biomass, thus playing an important role in the food web of the ecosystem. Reptiles are ectotherms and require heat from the sun. Their body heat is regulated externally, similar to amphibians. Therefore, they can also be susceptible to changes in micro-habitats. Due to their size, reptiles are not considered to be very mobile species, and changes to their environment often lead to impacts, such as interactions with road vehicles, with damaging consequences to the reptile. Appendix C lists reptile species by family, including scientific and common names.

A total of 5 reptile species were observed from a total of 23 potential species representing 5 families. This is about 22% of all reptile species expected to occur within in the general study area. The ESIA team has observed evidence of salt-water crocodiles (*Crocodylus prosus*) in the mouth of the Ngalimbiu River. According to villagers, adjacent wetlands are used by the crocodiles.

The relative importance of 5 of the reptile species expected to occur within the general study area and their relative vulnerability to the project are discussed below.

Guadalcanal Bow-fingered Gecko (*Cyrtodactylus biordinis*) - This gecko is deemed ecologically important because it is a Guadalcanal island endemic (McCoy, 2006). It is commonly found on smaller trees and within tree hollows where it lays its eggs. In forested habitats it feeds on insects, especially moths. It is not considered as threatened. However, it will be affected by construction activities, such as forest clearing.

Solomon's Bent-toed Gecko (*Cyrtodactylus salomonensis)* - This species has been listed on the IUCN Red List (IUCN, 2013) as Near Threatened. It is also an endemic species that thrives in forested habitat up to 400masl, where it lives in the forest canopy. Its population is currently listed as static. It is a strictly arboreal species found in larger trees. In Solomon Islands, it is threatened by logging activities and the illegal pet trade. The TRHDP will overlap with the lower elevation range of this species, but not its upper elevation range. Given the relatively small footprint of the Project relative to the extensive area of available forested habitat upstream of the dam, the impacts accruing to this species as a result of the Project are expected to be minimal.

Prehensile-tailed Skink (*Corucia zebrata*) - This skink is deemed ecologically important because of its CITES protection status (UNEP-WCMC, 2013). It is endemic to the Solomon Islands (McCoy, 2006) and is classed as Near Threatened on the IUCN Red List (IUCN, 2013). It is also opportunistically hunted for food. This species is probably the largest skink in the world and prefers large trees with dense foliage in forest habitats. It has a vegetarian diet and feeds on vine leaves, vines, fruits and flowers. It may be threatened by habitat loss and so may be affected by project related construction activities, such as forest clearing.

Schmidt's Crocodile Skink (*Tribolonotus schmidti*) - This skink is deemed ecologically important because it is a Guadalcanal island endemic (McCoy, 2006). It is relatively common and prefers moist areas under fallen and rotting timber in forest habitats, where it feeds on insects. It is not threatened. However, it will be affected by construction activities, such as forest clearing.

Solomons Ground Boa (*Candoia paulsoni*) - This common snake is deemed ecologically important because of its CITES protection status (UNEP-WCMC, 2013). It occurs in a wide variety of habitats, from forests to gardens, and feeds on frogs, skinks and smaller snakes. It is not threatened. However, it will be affected by construction activities such as forest clearing and, being a snake, probable persecution by workers.

Figure 6-7 includes photos of two different species of skinks that occur within the study area.

Figure 6-7 Pacific Black Skink (left) and Solomons Blue-tailed Skink (right)

Source: Edgard Pollard 2013

6.4.2.6 Avifauna (Birds)

There are a wide variety of birds that occupy different ecological niches, in various habitats, from grasslands to waterways to upland forests. Birds play an important ecological role in the dispersal of plant seeds, the control of insects and the pollination of plants, amongst other things. Specialist birds that occupy very narrow niches are very good environmental indicators as their disappearance indicates a degraded habitat. Appendix D lists bird species by family, including scientific and common names, along with their CITES or IUCN (Red List) status, and endemicity, and their relative vulnerability.

A total of 41 bird species, representing 28 families, were observed out of a total of 67 potential species previously recorded. This is around 61% of all birds expected to occur in the general study area.

Of the species of birds that potentially occur within the study area, one species – the White-eyed Starling (*Aplornis brunneicapilla*) -- is listed as endangered on IUCN's Red List (IUCN, 2013). As a result of this status, it is deemed ecologically important. Although not listed as a Guadalcanal endemic, it is identified as a Solomon Islands endemic (Dutson, 2011), where it is found in forested habitats, feeding on insects, flowers and fruits. It is threatened by habitat loss and human predation. The ESIA and feasibility report baseline studies did not detect presence of this species in the study area, which extends several kilometers beyond the extent of project construction and operation activities. While the species does appear to have some reliance on primary forest for nesting (in colonies in trees with high epiphyte cover), it also regularly feeds in semi- and heavily-degraded areas, where small fruit trees provide abundant food.[27] Even when present, it is not always easy to find this species during field surveys, and it appears to have seasonal or interannual movements which are not yet understood.[28] There is thus potential for the species to use the project area, for example on a seasonal or periodic basis in response to fruit availability.

An additional seven species of birds (see Table 6-4) that could potentially occur within the study area, are listed as vulnerable or near threatened. Of these, only four species were observed during field investigations. These four species are discussed below:

Solomon Sea-Eagle (*Haliaeetus sanfordi*) - This bird is deemed ecologically important because of its CITES protection status (UNEP-WCMC, 2013) and its vulnerability based on the IUCN Red List assessment (IUCN 2013). It is also important as being endemic to Solomon Islands (Dutson, 2011). It feeds mainly on pigeons, doves, fish, possums and lizards. The eagle is wide ranging, from coast to upland forests, and is found throughout the entire study area. Although it is considered to be rare, it was observed at sampling site #5 on the proposed transmission line corridor, and above the proposed dam site at upstream sampling station #1. The Project will likely have only minimal impact on it, given that the project footprint is small in relation to its wide-ranging territory, and parts of the range it inhabits will not be affected by project construction.

[27] Guy Dutson, *in litt.* 2017; Chris Filardi, pers. comm. 2017

[28] Chris Filardi, pers. comm. 2017

Guadalcanal's Rail (*Hypotaenidia woodfordi*) - This bird is deemed ecologically important because it is endemic to Guadalcanal (Dutson, 2011) and is classified as being Near Threatened on IUCN's Red List (IUCN, 2013). It is opportunistically hunted by inhabitants of local communities as a source of food. During the ESIA field studies, it was observed at sampling stations #1 and #3 along the proposed transmission line corridor, where the forest habitat has already been significantly modified. The impacts of the hydropower project on this rare rail should be minimal because the project is not expected to have significant impacts on the thicket and grassland habitat where it occurs.

Red-knobbed imperial pigeon (*Ducula rubricera rufiglia*) – This bird is deemed ecologically important because it is listed as Near Threatened on IUCN's Red List (IUCN, 2013) due to rates of deforestation largely associated with development of oil palm plantations. It is found on nearly all forested islands in Solomon Islands and inhabits lowland rainforest up to 1,200m on Guadalcanal. Although it is still common where extensive forest remains, it is much rarer in degraded habitats. Its population is suspected to have declined rapidly in recent years due to ongoing clearance of lowland forest, at least in parts of its range. During the ESIA field studies, this species was observed at multiple sampling stations throughout the study area. Owing to the relatively small footprint of the hydropower project, the widespread distribution of this species within the study area, and its wider distribution in unaffected rainforest areas at elevations well above the TRHDP, the Project is unlikely to have only minimal potential impact on this species of bird.

Crested Cuckoo-Dove (*Reinwardtoena crassirostris*) – This bird is deemed ecologically important because it is listed as Near Threatened by IUCN's Red List (IUCN, 2013), primarily as a result of removal of lowland forests. It is a large pigeon endemic to Bougainville (Papua New Guinea) and Solomon Islands, where it occurs at relatively low densities that suggest the total population is small. It may be declining rapidly in the lowlands, although the hill populations are probably declining very slowly. Within the study area, it was observed on the right bank of the river, which is an area that has been previously logged and has secondary forest regrowth. Given that the Project footprint is primarily in areas where populations have already been affected (i.e., close to village settlements and where commercial tree harvesting has already occurred), it is unlikely to have an effect on this species. Further, the Project will not materially affect hilly, forested areas outside the Tina River Gorge, where populations of this species are considered to be less threatened.

Table 6-4 Near to threatened and vulnerable bird species

Scientific name	Common name	IUCN category	Population trend	Observed in ESIA Extended[29]
Haliaeetus sandfordi	Solomon sea eagle	Vulnerable	Declining	Yes – Station TL5; Upp1
Hypotaenidia woodfordi	Guadalcanal rail	Near threatened	Declining	Yes – TL1, TL3
Ducula rubricera rufigila	Red-knobbed imperial pigeon	Near threatened	Declining	Yes – multiple stations and reports
Reinwardtoena crassirostris	Crested cuckoo dove	Near threatened	Declining	Yes - Tun
Charmosyna margarethae	Duchess lorikeet	Near threatened	Declining	No
Edolisoma holopolium	Solomon cicadabird	Near threatened	Declining	No
Monarchus b. barbatus	Solomon's monarch	Near threatened	Declining	Yes – Res3, Dam2

[29] The extended ESIA includes the ESIA survey stations, the scoping study by Entura in 2011, and recorded local knowledge

Figure 6-8 includes photos of two different species of Monarch that occur within the study area.

Figure 6-8 Solomons Monarch (left) and Chestnut-bellied Monarch (right)

Source: Edgar Pollard, 2013

6.4.2.7 Mammals

Guadalcanal is home to some of the most cryptic and rare mammals in the Pacific, including flying foxes and giant native rats. Appendix E lists mammal species by family, including scientific and common names.

A total of 5 mammal species were observed out of a total of 14 potential species from 4 families. This is roughly 36 percent of all mammals that are expected to occur within the general study area. The 5 species were the Island Tube nosed Fruit Bat (*Nyctimene major*), the Rousette Bat (*Rousettus Amplexicaudatus*), the Fawn Leaf nosed Bat (*Hipposideros cervinus*) the Solomon's Flying Fox (*Pteropus rayneri*) and the Wild Pig (*Sus scrofa*).

Of the 14 potential mammal species, the relative importance of the 5 most ecologically significant and their relative vulnerability to the project are discussed below.

Solomon's Flying Fox (*Pteropus rayneri*) - This bat is deemed ecologically important because of its CITES protection status (UNEP-WCMC 2013) and its classification as Near Threatened by the IUCN's Red List (IUCN 2013), and because it is endemic to the Solomon Islands. It is opportunistically hunted as a food resource by inhabitants of local communities. This large bat is found over a wide variety of habitats, though it uses forests for roosting, especially large trees and caves, and for foraging for fruits. It is threatened by habitat loss and hunting. Forest clearing and removal of big trees for access roads will likely affect the species.

Island Flying Fox (*Pteropus admiraltatum*) - This bat is deemed ecologically important because of its CITES protection status (UNEP-WCMC 2013). Like the Solomon's Flying Fox, it is also opportunistically hunted as a food resource by inhabitants of local communities. This large bat is found in forest habitats, where it feeds on wild and cultivated fruits. It is threatened by habitat loss and hunting. Forest clearing and removal of big trees to construct access roads will affect the species.

Emperor Rat (*Uromys imperator*) - This species is known from only three specimens collected by Charles Woodford between 1886 and 1888, at Aola, a coastal location on northern Guadalcanal, Solomon Islands (IUCN 2016a).

Listed as Critically Endangered (Possibly Extinct) because it has not been recorded with certainty since three specimens were collected between 1886 and 1888. Anecdotal information suggests that the species survived until the 1960s. This species is quite possibly extinct, however, Guadalcanal has not been adequately surveyed (Lavery 2013). Should this species still exist, it is almost certain to be very few in number.

It seems as though this was a largely terrestrial species that was at one point found throughout much of Guadalcanal, including the dry northern lowlands and areas close to the coast. Later reports suggest that the species became restricted to mossy montane forest (IUCN 2016a).

Resent surveys for native rodents have been conducted at sites between 200m and 1,500m altitude across Solomon Islands using baited camera traps. So far, the emperor rat has not been detected, increasing fears it is extinct. According to Tyrone Lavery of the University of Queensland (Lavery, 2016),

> . . . camera traps used to carry out the surveys have provided some alarming data on densities of feral cats present in the archipelago. These data support long-held suspicions that predation by cats has been the main cause of extinction for Solomon Island mammals and ground dwelling birds such as the Makira moorhen.

With respect to the TRHDP, the core area of the Project does not overlap with the mossy montane forest, which is found at higher elevations. Therefore, the Project is unlikely to have any effect on the Emperor Rat, should it still exist on Guadalcanal.

King Rat (*Uromys rex*) - This species is endemic to the island of Guadalcanal, Solomon Islands, but is absent from large parts of the island. It has been recorded at elevations of 20 and 600 masl. It is an arboreal species that has been recorded from primary tropical moist forest, including relict patches of native forest. It is listed as Endangered because its area of occupancy is probably less than 500 km^2, its distribution is fragmented, and the extent of its forest habitat is declining.

There are few recent records of this species. The most recent recorded captures include a single specimen in 1987 from a relict outlier of tall rainforest in the Poha Valley, approximately 35km west of the Project, and two specimens at Gold Ridge in 1989. An intensive survey of Mount Makarakomburu in 1990 failed to locate the species. Interviews with local inhabitants conducted by Roger James (pers. comm. in IUCN 2016b) suggest that the species may occur elsewhere on the island. However, no specimens have been captured that would confirm this anecdotal information.

Relatively recent records in and near the project area, and some apparent tolerance of the species to forest fragmentation and invasive species, suggest that the King Rat may still persist in the higher quality forests of the project area. The absence of records on project surveys should not be taken as evidence of the species' absence, since it is extremely difficult to survey for rare, nocturnal, arboreal rodents.

Northern Common Cuscus *(Phalanger orientalis)* - Cuscus are the only marsupial mammal in the Solomon Islands. Northern Common Cuscus has a good tolerance to degraded forested areas (IUCN, 2013). It feeds on fruits, leaves and seeds, and dwells in *Ficus* trees. Cuscus forage in the high canopy but will also feed in gardens. Cuscus require shade, moderate temperature and humidity (Pikacha, 2008). The species is nocturnal and sleeps in hollow trees. They mate and give birth only once a year between June and October. They will be affected by project related forest clearing. Figure 6-9 shows an exposed Cuscus following forest clearing.

Figure 6-9 Exposed Cuscus after forest clearing

Source: Pikacha, 2008

Figure 6-10 includes photos of two different species of bats that occur within the study area.

Figure 6-10 Fawn Leaf-nosed Bat (left) and Rousette Bat (right)

6.4.3 Conclusions Based on Fauna Surveys

Valued species occupy ecological niches that can be simplified in four categories:

- Grassland species – which require openings and limited tree cover;
- Forest interior species – which require high canopy coverage and dense vegetation, and do not tolerate openings and dryer environments;
- Disturbed forest and forest edge species – for most of the time these are ubiquist species, that can occupy a range of ecosystem types;
- Riparian species – which need to be close to rivers and wetlands.

Table 6-5 shows the ecological niche of each valued species.

Table 6-5 Ecological niches occupied by valued species found within the study area

Valued species	Grassland	Forest interior	Disturbed forest and forest edge	Riparian
Amphibians				x
Giant Webbed Frog				
Solomon Island's Treefrog		X		
San Cristobal Treefrog				x
Reptiles				
Guadalcanal Bow-fingered Gecko		X		
Solomons Bent-toed Gecko		X		
Prehensile-tailed Skink		X		
Schmidt's Crocodile Skink		X		
Solomon Ground Boa		X	X	
Birds				
Nankeen Night Heron				x
Little Pied Cormorant				x
Pacific Black Duck				x
Brahminy Kite	X	X	X	x
Pacific Baza	X		X	
Variable Goshawk	X		X	
Meyer's Goshawk	X		X	
Solomon Sea-Eagle	X	X	X	x
Red-backed Button-Quail	x			
Guadalcanal Rail	x			
Common Sandpiper				x
Yellow-bibbed Fruit-Dove		X		
Ducorp's Cockatoo		X	X	
Cardinal Lory		X	X	
Coconut Lorikeet		X	X	
Yellow-bibbed Lory		X	X	
Duchess Lorikeet			X	
Finsch's Pigmy Parrot		X	X	
Eclectus Parrot	x	X	X	

Valued species	**Grassland**	**Forest interior**	**Disturbed forest and forest edge**	**Riparian**
Song Parrot	x	X	X	
Guadalcanal Boobook		X	X	
Blyth's Hornbill		X	X	
Common (River) Kingfisher				x
Variable Dwarf Kingfisher				x
Cockerell's Fantail		X		
Rufous Fantail		X	X	
Golden Whistler		X	X	
Midget Flowerpecker		X	X	
Black-headed Myzomela		X	X	
Brown-winged Starling	x		X	
White-eyed Starling		X	X	
Mammals				
Solomon's Flying Fox		X	X	
Island Flying Fox		X	X	
King Rat		x (mostly upland forest)		
Emperor Rat		x (upland forest)		

6.5 WILDLIFE HABITAT VALUE DELINEATION

This section describes the value of the general habitat types for terrestrial wildlife (highly valued, moderately valued, weakly valued) in all study areas. This section also defines what are considered to be the important habitats found within the study area from a strictly biological point of view. These include areas: with protected species colonies; with endemic species, with migratory species; and with endangered species. Natural habitats include grassland, riparian and forests.

6.5.1 Natural habitat and Critical Natural Habitat

Forests provide high ecological values, as they play an important role as wildlife habitat, and provide livelihood for inhabitants of local communities who selectively harvest timber, obtain medicinal plants, and hunt and forage for food (fruits, nuts, wild game), fuel and non-wood products. The forests of Guadalcanal, especially lowland forests, are threatened by logging which provides an important source of income for the country. However, according to FAO (2009), deforestation is also a result of increasing population in the islands that fuels demand for rising agricultural activities, new settlements, and timber harvesting.

After the tropical forests of PNG, the forests of the Solomon Islands comprise the largest block of tropical rainforest in the Asia Pacific region and are one of the three great rainforests of the planet (WWF, 2005).

Appendix F contains information on the types of natural habitat found within the Tina River catchment, the characteristics of each habitat type (vegetation assemblage, elevation, etc.), the ecological value of each type of habitat, and provides photographs to illustrate how the habitat typically appears. The map in Figure 6-11 illustrates the different habitats and land use of the study area.

The World Bank considers conservation of natural habitats, particularly Critical Natural Habitats, as essential for long-term sustainable development and supports projects that apply a precautionary approach to natural resource management.

Natural Habitats are defined as areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition.[30]

Critical Habitats are areas with high biodiversity value, including (i) habitat of significant importance to Critically Endangered or Endangered species; (ii) habitat of significant importance to endemic and/or restricted range species; (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species; (iv) highly threatened or unique ecosystems; and/or (v) areas associated with key evolutionary processes.[31] The World Bank does not support projects that involve significant conversion or degradation of natural habitat unless :

- No other viable alternatives within the region exist for development of the project on modified habitat;[32]
- Consultation has established the views of stakeholders, including Affected Communities, with respect to the extent of conversion and degradation; and
- Any conversion is mitigated according to the mitigation hierarchy.

In areas of natural habitat, mitigation measures will be designed to achieve no net loss of biodiversity where feasible.[33]

The World Bank does not support projects in areas of critical habitat unless:

- No other viable alternatives within the region exist for development of the project on modified or natural habitats that are not critical;
- The project does not lead to measurable adverse impacts on those biodiversity values for which the critical habitat was designated, and on the ecological processes supporting those biodiversity values;
- The project does not lead to a net reduction in the global or national/regional population of any Critically Endangered or Endangered species over a reasonable period of time; and

[30] World Bank Performance Standard 6

31 Ibid.

32 Performance Standard 6 defines modified habitats as areas that may contain a large proportion of plant and/or animal species of non-native origin, and/or where human activity has substantially modified an area's primary ecological function. Note that a modified habitat may also be a critical habitat if it meets any of the criteria in the critical habitat definition above.

33 Performance Standard 6

- A robust, appropriately designed, and long-term biodiversity monitoring and evaluation program is integrated into the project management program.

Where a project is able to meet all of those requirements, the mitigation strategy must be described in a Biodiversity Action Plan and must be designed to achieve net gains of those biodiversity values for which the critical habitat was designated.[34]

For the purpose of habitat analysis, the study area has been divided into three sub-regions based on elevation: the higher elevation area of the upper Tina River catchment (above 400 masl) which lies to the south, and is dominated by undisturbed montane forests; the mid-elevation river gorge area which is dominated by lowland forests modified by extensive logging and semi-commercial timber operations, as well as gardens and habitation clearings; and the lower elevation area which is dominated by grassland and plantations within the downstream (northern) Tina River catchment. The degree of anthropogenic modification increases markedly with decreasing altitude, with a large proportion of the Project area comprising modified habitats.

The TRHDP will be located within the mid-elevation river gorge and downstream catchment areas where human settlements and commercial logging activities have previously contributed to habitat alteration. No critically endangered or endangered terrestrial or aquatic species have been found within these project-affected areas. Likewise, the area does not support any areas associated with key evolutionary processes or globally significant numbers of migratory or congregatory species. Whilst there are restricted-range and endemic species, the habitat available within these project-affected areas represents only a small portion of larger habitat area available to these species adjacent to, and upstream of, the proposed development.

Except for the upper catchment area, most habitats in the vicinity of the project site are not in a pristine state, having been used and degraded, to a certain extent, by human activity including clearing land to establish settlements and gardens, and commercial and artisanal logging.

The undisturbed montane forest above 400masl in the upper catchment to the south and east of the dam site and reservoir, and remaining areas of undisturbed lowland forest below 400 masl, qualify as critical habitat because of this ecosystem's limited global distribution and particularly unique assemblages of species.

The TRHDP footprint represents a very small proportion of the overall Tina River catchment (<3% of land area) and only directly impacts a very small area of natural forest which could potentially be considered Critical Habitat. These impacts are not considered significant.

A range of measures will be implemented to mitigate against impacts on natural habitat, indirect impacts to the Critical Habitat, to provide for no net loss of biodiversity, and to achieve net gains of those biodiversity values for which the potential critical habitat was designated.

The Project will take a series of steps to protect the upper Tina River catchment. Immediate protection measures will include actions of the TCLC and Project Company to restrict access to vehicles (including commercial logging machinery) to the upper catchment through the Core Area, to monitor changes in forest coverage in the upper catchment, to monitor logging truck activity on existing logging roads, and to support SIG to enforce seldom used statutory restrictions on logging at elevations above 400 masl (which if enforced would represent the vast majority of the upper catchment).

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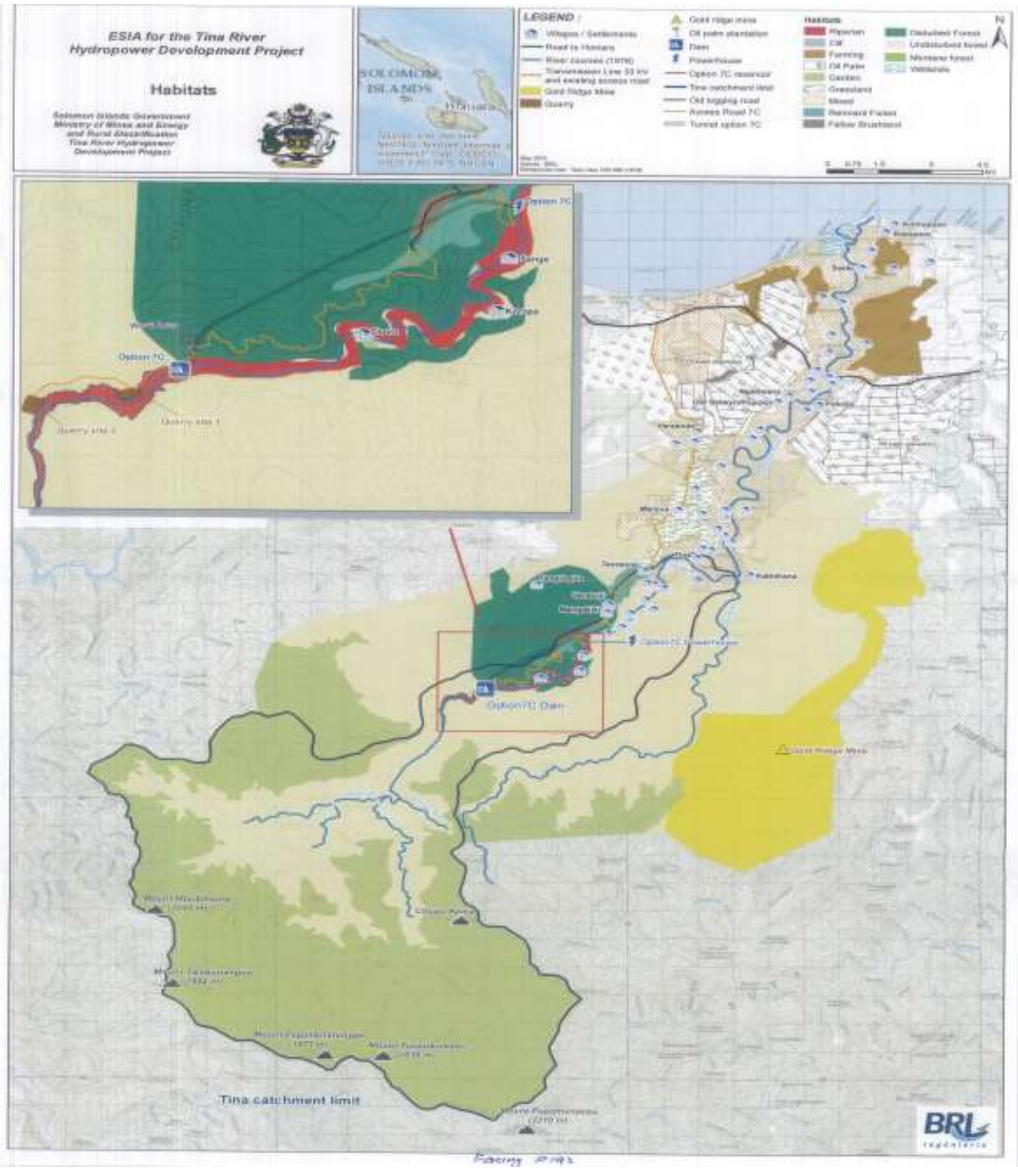
[34] Ibid.

This protection work will be furthered by Project Office funding for an NGO to facilitate consultations with customary landowners to seek support for the creation of a protected area in the upper catchment and to conduct mapping and forestry studies, towards preparation of a management plan. The NGO will work closely with customary landowners as in Solomon Islands, establishment of a protected area should originate with the customary landowners of the land.

In addition to upper catchment offset activities, the Project Company will implement measures including a post construction rehabilitation plan for disturbed areas, and an offset within the Core Area which will include measures to protect the remaining natural habitat in the Core Area, and to rehabilitate an area of modified habitat within the Core Area of at least 9.5 ha. These measures will be set out in the Biodiversity Management Plan.

Figure 6-11 Study area habitat types and land use



6.5.2 Discussion on Wildlife and Wildlife Habitat

The ESIA team observed a general trend of habitat degradation from upstream areas to downstream areas. Human settlement increases in a downstream direction, and land use shifts from forested areas to remnant forests and grasslands. Disturbed forests were observed in all of the study area, but the level of disruption was low in Choro. The upper catchment area, inland and up-elevation from the project site, remains covered by pristine forest.

Except for birds, the impacts of habitat degradation is not noticeable when observing the number of species. This could be attributed to some species being able to thrive in modified habitats that are close to settlements. Regarding endemic species (except for birds), their abundance does not decrease with habitat degradation. Most of the areas covered by the project are utilized by endemic wildlife species.

Table 6-6 classifies three types of modified habitat: weakly disturbed, moderately disturbed and highly disturbed. As shown in the table, the number of species observed in each habitat type, during the period when field surveys were conducted (August, 2013), did not decrease with habitat disturbance, except for birds, which seem to prefer undisturbed areas.

Table 6-6 Number of species observed by habitat quality

	Weakly disturbed												Moderatly disturbed					Highly disturbed				
	Upper Stream		Middle Tina River sampling area										Middle Tina River sampling area					Transmission line sampling area				
	F&F2	F&F1	F&F7	F&F6	F&F5	F&F4	F&F14	F&F10	F&F13	F&F9	F&F11	F&F8	F&F19	F&F12	F&F18	F&F17	F&F16	F&F24	F&F23	F&F22	F&F21	F&F20
Amphibian	0	4	1	4	4	2	0	0	0	4	1	0	0	0	0	0	0	1	0	0	0	0
Birds	9	12	5	8	17	7	3	4	0	11	1	7	3	4	4	2	5	2	0	8	6	4
Reptiles	1	2	0	0	0	1	0	0	2	2	0	0	3	0	1	1	0	1	0	0	1	2
Mammals	0	0	0	1	5	2	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0

Table 6-7 Number of endemic species observed by habitat quality

	Weakly disturbed												Moderatly disturbed					Highly disturbed				
	Upper Stream		Middle Tina River sampling area										Middle Tina River sampling area					Transmission line sampling area				
	F&F2	F&F1	F&F7	F&F6	F&F5	F&F4	F&F14	F&F10	F&F13	F&F9	F&F11	F&F8	F&F19	F&F12	F&F18	F&F17	F&F16	F&F24	F&F23	F&F22	F&F21	F&F20
Amphibian	0	3	0	3	2	1	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0
Birds	5	10	5	8	13	4	3	3	0	10	1	4	3	4	4	2	5	1	0	3	4	4
Reptiles	1	1	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	1
Mammals	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0

6.5.3 Conclusions on Wildlife Habitat

The fauna baseline study has shown that wildlife species thrive in the undisturbed forest of the upper Tina River catchment, upstream of the Project, but also in the more anthropogenically modified areas in the lower reaches of the Tina River, in which the Project is located. The ESIA team observed a total of 60 species of wildlife within the study area, including: 9 species of amphibians; 5 species of reptiles; 41 species of birds; and 5 species of mammals. Approximately 45% of the species are endemic, including: 1 species of amphibian; 1 species of reptile; and 25 species of birds. The extent of potential impacts of the TRHDP on these fauna, and proposed measures to mitigate impacts to them, are addressed in Section 10.

7. BIOLOGICAL ENVIRONMENT BASELINE - AQUATIC

7.1 METHODOLOGY

Various methods were used to characterise the baseline aquatic environmental conditions within the study area, including:

- a review of existing information (literature & previous studies);
- a field survey of the Tina river system undertaken from 30 July to 06 August 2013, which encompassed water quality sampling, observations on fish and river system, and interviews with local fishermen and other river users. Field surveys were carried out by Loïc Trébaol, with the assistance of Robson S. Hevalao;
- a second fish and water quality survey carried out by Robson S. Hevalao in February 2014, the results of which are compiled in this ESIA report. In addition to the dry season stations, this additional survey included sampling at the proposed dam site (Site 7C); and
- a supplementary study of environmental flow requirements and associated habitat suitability for migratory fish, prepared by Jowett Consulting in March and July 2016 in association with Robson S. Hevalao and David Boseto. The methodology and result of this study are summarised in Section 7.5.6.

7.2 LITERATURE REVIEW

The following sources of available information were used to obtain an understanding of, and describe, the baseline freshwater ecology in the study area**.**

7.2.1 Fresh and Brackish Water Fishes in Guadalcanal, by Gray (1974)

This small publication records 36 fish species collected from roughly twelve sampling stations located in estuarine environments of Guadalcanal, mostly on the North coast, West of Honiara, and two stations on the South coast at Lauvi lagoon. It provides a representation of each species and a description of some ecological features**.**

Most species are marine forms entering into estuaries. Ten species are identified as being likely to occur in inland reaches of the rivers (*Anguilla marmorata, Kuhlia marginata, Mesopritis argenteus*, some Eleotridae and some pipefish), and represent only one component of freshwater biodiversity. Gobiidae, the predominant family in the inland river reaches of the Solomon Islands, was not described in the study**.**

7.2.2 Aquatic Ecology Surveys for the Gold Ridge Project (Since 1990)

In support of the Gold Ridge Project, extensive baseline studies and water quality and aquatic ecology monitoring has been undertaken from 1990 to the present.

The information collected is particularly useful for characterizing the baseline conditions of the TRHDP study area, as the Matepono River watershed is directly adjacent to the Tina/Ngalimbiu watershed and, therefore, shares a number of environmental features. Additional data were collected from the Tina/Ngalimbiu watershed, especially at Ngalimbiu River Bridge, to use as control data.

The different sets of data include:

- *Initial field studies by AMOCO/ARIMCO (1990)*

In 1990, two studies were undertaken regarding the feasibility of discharging treated tailings fines into the river. These included:

- "Hydrology, meteorology and water quality" (Scott Technical instruments, Aug 1990); and
- "*Aquatic flora & fauna study*" (Dr D. Fannings, Sept-Oct 1990) in which 14 survey stations were sampled, including 8 stations on the Matepono River system, 1 station at Ngalimbiu River bridge, and 6 stations on other adjacent watersheds. Several species of prawns (dominant taxa in the samples), a variety of fish species, and a few species of frogs, were collected. Most species were unidentified due to a lack of information at that time regarding freshwater ecology in the SI.

The concentration of arsenic, mercury and cadmium in fish flesh was determined for each location. The results showed highly significant, naturally occurring levels of contamination, especially for arsenic (at, or greater than,1 mg/kg).

The discussion of aquatic ecology biota in the initial Gold Ridge EIS (Ross Mining N. L., 1996) was based on these field results.

Water quality samples (1989 to 1995)

- The Gold Ridge EIS report (Tables 3-13 and 3-14) refers to a compilation of water quality samples from 6 stations on the Matepono River system (1989-1992), with an additional sampling station added in 1995.

Additional aquatic fauna surveys (2003 & 2006)

- At the reopening of the Gold Ridge mine, following a period of political unrest, two additional aquatic fauna surveys were undertaken at 8 sample stations, including: 7 stations on the Matepono River system; and 1 station at Ngalimbiu River bridge. The methodology and main results are described in the Environmental Performance Report 2009 by Golder Associates (pp 99-100).
- A first survey by Golder Associates (Dec 2003) showed good fish and crustacean abundance in the river system. Analyses of heavy metal concentrations in fish/prawn flesh (As, Cu, Cd, Zn, Hg) showed evidence of increased arsenic (As) levels, resulting from bioaccumulation downstream of the mine site. The arsenic concentrations were below levels considered detrimental for human consumption.
- A second survey by Hydrobiology Pty Ltd (July 2006), using electrofishing and dip net methods of capture, was undertaken to collect additional specimens for tissues analysis.
- Gold Ridge's 2009 Environmental Performance Report includes a table with 32 species of fish recorded in Matepono River system and 45 species of fish recorded at Ngalimbiu River Bridge (see Annex 2 of the Annex Report).

7.2.2.1 Survey of Freshwater Biota in Solomon Islands.

For the first time in the Solomon Islands, a scientific survey of Solomon archipelago freshwater biota was undertaken during 2004 and 2005, by staff from Bishop Museum Hawaii, and four other research organizations with long-standing interests in Melanesia.

Altogether, 70 stations were sampled with a focus on freshwater fish and aquatic insects. The insect taxa included: Heteroptera (aquatic true bugs), Odonata (damselflies), Coleoptera (whirligig beetles, Gyriniidae) and Diptera (Simuliidae).

Fish were sampled at 31 stations, on 10 islands. Sampling stations ranged in elevation from sea level to 460masl. Four stations were located on Guadalcanal (see following table), with two of them near the Gold Ridge facilities. Table 7-1 identifies the location of the four sampling stations that were located on Guadalcanal.

Fish survey techniques consisted of underwater observations using mask and snorkel at each site, as well as selective capture of specimens using small hand nets. Digital photographs were taken of most species, either in situ within their habitats, or with the captured specimen in a small field aquarium.

The results were compiled in the report "*Freshwater biota of the Solomon Islands; analysis of richness, endemism and threats*" (Polhemus *et al.*, 2008). Altogether, 52 species of fish were recorded in Solomon Islands, with 13 of these recorded from the Guadalcanal sampling stations.

Table 7-1 Location of fish sampling stations on Guadalcanal, Nov 2004 and Jul 2005 (Polhemus et al., 2008)

Stat n°	Date	River	Location	GPS location	Elevation (m)
14	21/11/05	Tenaru riv.	At Tenaru falls, 12 km SE of Honiara	9°31'01,0"S 160°00'59,5"E	40
15	27/11/05	Tina Hulu riv.	Above Gold Ridge road bridge, at Bemuta village	9°31'26,8"S 160°09'20,3"	35
50	28/07/05	Lungga riv.	At mouth of gorge, near proposed dam site, SW of Mt Austen	9°23'44.3"S 159°50'47.6"E	25
64	03/08/05	Charebuma riv.	Above Gold Ridge mine	9°35'39.8"S 160°07'28.6"E	290-460

7.2.2.2 Survey of Freshwater Fishes on Tetepare Island (2006)

A very comprehensive freshwater fish survey was undertaken in September 2006 by Jenkins, A.P and Boseto, D., on Tetepare Island, Western Province. The area was considered at the time as being the "*largest unlogged and uninhabited lowland rain-forest island in the South Pacific*". Fifteen 150 m sections were sampled from four rivers and 2 lakes for fresh water fishes and water quality, with 797 specimens being captured by different means.

Though taking place in the Western Province, this comprehensive scientific study is an important reference, as it provides a precise description of the fish assemblage in the fresh waters of Solomon Islands.

7.2.2.3 Survey of the Tina River System, by Entura (2010)

An ESIA scoping study of the TRHPD was prepared by Entura (2010). The study included a rapid ecological assessment survey of the Tina River system, that was undertaken from 10 to 12 September 2010 by Pacific Horizons Consultancy Group.

Observations on aquatic habitats and fish biodiversity were limited to the proposed dam and reservoir area, as it was then defined, with 3 sampling stations located at Habusi, Toni River and Horohutu, respectively, corresponding to Stations C, D and E, respectively. In addition, bacteriological quality was measured at stations C and E.

These first results on aquatic ecology in the project area (see Annex E of the ESIA scoping study) raised some environmental concerns about baseline data, and impacts of the project on aquatic ecosystems.

A total of 20 fish species were recorded, 12 of these based on visual observation.

7.3 FISH AND AQUATIC ENVIRONMENT SURVEY

7.3.1 Delineation of the Aquatic Ecology Study Area

The aquatic ecology study area covers the whole river system, upstream and downstream of the dam/reservoir sites, from the upper catchment to the river mouth. Delineation of the study area is based on the likely area of influence of the project, as follows:

- upstream of the reservoir area, the fish and crustacean assemblage is likely to be affected, with the hydroelectric facilities being a barrier to the migration of amphihaline species.
- within the reservoir area, a major change will occur to aquatic ecosystem, which will be transformed from rheophilic to lentic conditions.
- downstream of the dam site, changes in water quality, flow and sediment transport patterns are likely to impact aquatic ecology in Tina/Ngalimbiu River down to the river mouth.

7.3.2 Organization of Field Survey

The first aquatic ecology survey was undertaken between 30 July and 06 August 2013 by the local and international BRLi experts in aquatic ecology, who were assisted by local guides.

The schedule was optimized to take advantage of the availability of transportation to and within the study area (e.g., by helicopter and automobile), and meteorological conditions (e.g., rainfall events, flash floods)

The field survey of upstream the reservoir area, in the vicinity of the hydrometric gauging station, was undertaken on 07 August 2013, by the aquatic ecology team, which was transported to the area by helicopter.

Field surveys in the reservoir area and downstream of the dam site were undertaken separately by the aquatic and terrestrial teams, which were transported to and within the area, by automobile.

Night sampling of fish was carried out at a few sites (Koropa and Choro), when aquatic animals, especially eels and prawns, are active from dusk to dawn.

A second aquatic ecology survey was conducted by Robson S. Hevalao, with the assistance of Eric Deneut, during the rainy season in February 2014.

A third field survey to was conducted in March 2016 by Ian Jowett, Mark Taylor, Robson Hevalao and David Boseto, during the 2016 rainy season. This survey was part of a study specifically designed to evaluate the impact of scheme operation on migratory fish and determine minimum environmental flow requirements for the region between dam and powerhouse tailrace. The survey involved quadrat sampling for species density in different habitats, habitat characterisation as well as the measurement of river cross sections for the purposes of determining habitat suitability curves in terms of water depth, substrate type and flow velocity.

Jowett and Hevalao conducted a follow up survey in July 2016 to obtain more low flow measurements.

7.3.3 Location of Survey Stations

Eleven aquatic survey stations (A1 to A10b) were selected to identify aquatic ecosystem habitat types, determine presence of fish species, and undertake water quality sampling. The selection of stations was based on the longitudinal geomorphological zonation of the river, previous fish survey stations used by Entura (2010), and areas that would be most likely affected by the Project. The stations were located as follows:

- 3 stations in the upper Tina River, upstream of the reservoir area:
    - one at the Tina River gauging station (A3) and two on the immediate upstream tributaries, Becho/Voraha (A1) and Mmembea (A2). The confluence of these two rivers forms the Tina River;
- 2 stations in the middle Tina River area downstream of the dam site and upstream of the power station:
    - one at Koropa (A4), and one at Senge (A5);
- 2 stations in the upper Ngalimbiu River:
    - one on the Toni River at Kathihana (A6), and one at Horohutu (A7);
- 4 stations in the lower Ngalimbiu River:
    - Ngalimbiu River bridge (A8), Saele (A9), old river mouth (A10a) and new mouth (A10b)

The first survey included the 3 stations surveyed by Entura in mid-December 2010, at Senge, Kathihana and Horohutu (see ESIA Scoping Study, page 57).

Table 7-2 lists the location of the aquatic ecology survey stations. To take into account the environmental and flow changes brought by the rainy season on the Tina River and its aquatic biota, another fish survey was carried out in February 2014. An additional station (7C) was surveyed during the rainy season, it was located at the option 7C dam site.

Table 7-2 Aquatic ecology survey stations

Station	Area	River	Location	Chainage *	WQ sample
A1	Upper catchment	Bicho-Voraha Riv.	confluence	CH -1km	X
A2	Upper catchment	Mbembea River	confluence	CH -1km	X
A3	Upper Tina R.	Tina River	Gauging st	CH 1km	X
7C	Middle Tina R.	Tina River	Dam	CH 7km	
A4	Middle Tina R.	Tina River	Koropa	CH 11km	
A5	Middle Tina R.	Tina River	Sengue	CH 11.5km	
A6	Upper Ngalimbiu R.	Toni River	Horohutu	CH 19km	X
A7	Upper Ngalimbiu R.	Ngalimbiu River	Kathihana	CH 20km	X
A8	Lower Ngalimbiu R.	Ngalimbiu River	Ngalimbiu	CH 28km	X
A9	Lower Ngalimbiu R.	Ngalimbiu River	Saele	CH 34km	X
A10a	River Mouth area	Old River mouth	Komporo	CH 36km	X
A10b	River Mouth area	New River mouth	Komporo	CH 37km	X

***** Based on Entura Phase 1 chainage, starting at Tina River between the upstream confluence of the Mbeambea River and the Voraha River (chainage 0km)

The fact sheets included in Annex 1 of the Annex Report, provide a comprehensive description of the survey stations, including their exact locations by GPS coordinate, altitude, and river length chainage relative to the Tina River/Voraha River confluence. The Annex also includes photographs that identify the biophysical and social characteristics of each site.

7.3.4 Survey Methodology

The methodology used to conduct the aquatic ecology survey is explained by the following steps.

7.3.4.1 Obtain Local Knowledge

For those sampling stations located in inhabited areas (i.e., from Senge to the river mouth), local guides accompanied the experts. Fishermen, and other river users encountered in the field, were interviewed, using an interview guide.

Questions were asked pertaining to:

- river system functions (e.g., historical floods and other main features, changes in river morphology, etc.);
- river and riparian area use (e.g., domestic use, drinking water, transporting logs, fishing, gold panning, recreation, access, gravel extraction);
- fish species observed in the area, and their abundance (e.g., dominant, common, occasional); and
- main features concerning fishing activities (e.g. type of fishing gear and fishing techniques, target species, seasonal and long-term capture trends, personal consumption versus commercial sale of catches).

7.3.4.2 Describe the River

Photographs were taken at each station, and observations made regarding the following (see fact sheets in Annex 1 of the Annex Report):

- physical environment (velocity and flow pattern, turbidity, water depth, characteristics of minor and major stream beds, sediments, banks and riparian areas);
- biological environment (aquatic and riparian vegetation, wetlands and other sensitive environments); and
- human environment (uses of the river and riparian area**s**, access, habitations, etc.).

7.3.4.3 Conduct Fish Surveys

Fish survey techniques consisted of:

(i) underwater observations using mask and snorkel at each site, obtaining digital underwater photographs of each encountered species; and

(ii) obtaining information on fishermen's catches, including whether they were subsistence fishing or commercial fishing, location of fishing sites, and the type of gear they were using.

7.3.4.4 Conduct Water Quality Sampling

A 1.5L sample was collected on each sampling site, and brought to SIWA WQ laboratory in Honiara, where they were analyzed for pH, conductivity, turbidity, nitrates, and total phosphorus. Other parameters were added in the second survey campaign, as well as in situ measurements of dissolved oxygen.

In addition, the baseline level of *E. coli* contamination was surveyed on 14 August 2013 at 4 stations (Toni river, Valekotcha, Birao and Ngalimbiu River bridge). Samples were transported to SIWA laboratory for *E. coli* and total coliform analysis.

7.4 AQUATIC ECOLOGY BASELINE

In addition to the baseline physical conditions of the Tina River system (watershed, river geomorphology, and hydrology), the following sub-sections describe the aquatic ecology baseline for: (1) aquatic habitats, (2) water quality and (3) aquatic biota, with a focus on fish assemblage.

Additional details are provided in the fact sheets and photographs describing the survey stations included as Annexes 2 and 3 in the Annex Report.

While the operation of the hydro scheme will divert most of the Tina River through the headrace tunnel, there will be sufficient minimum permanent flow, referred to as environmental flow (as determined in the Aquatic Ecology section) remaining in the river, between the dam and the powerhouse downstream, to meet the current water consumption needs (i.e., for washing, bathing, drinking water, and garden irrigation) of the people living along this reach at Choro, Koropa, and Senge. However, the dynamics of the river flow will change, and most noticeably, some swimming or fishing holes will shrink during the dry season, while river crossings that are necessary for accessing Koropa and Choro will become easier and safer to access. A regime for releasing water from the dam could be implemented by the operator to provide sufficient volume of flow to keep river pools adjacent to Koropa and Senge villages filled with water. This operating regime would have to be formalized prior to operation**.**

7.4.1 Fisheries

As discussed later in Section 5 Social Baseline Conditions, fresh fish from the Tina River do not feature prominently in the diet of local inhabitants that reside along the river. Rather, canned tuna is their main source of fish protein. Despite their knowledge of fish species found within the river, from a livelihoods perspective it appears that fishing is only a minor activity. Fishing is undertaken during “fishing trips” in the upper catchment, upstream from Choro. The main mode of fishing is by snorkeling with a spear gun and is sometimes carried out at night.

Fishing is a significant source of livelihood only at the mouth of the Ngalimbiu River, where semi-commercial fishing occurs using mosquito seine nets, gill nets, and other fishing techniques.

7.4.2 Aquatic Habitats

The Ngalimbiu/Tina River flows approximately 35km in a N/N-E direction, from the central ridge of Guadalcanal (Mt. Popomanaseu to Mt. Mbutohaina) to the sea. For the purpose of the study, the river was been divided into 5 areas, based on elevation and geomorphology (see Section 5.6 – River (Fluvial) Geomorphology):

Several aquatic habitats of specific ecological interest have been identified along the river. These include:

Mountain streams - though not included in the surveys, the dense network of steep streams draining the central mountain ridge (cloud forest area) is likely to represent a particular aquatic habitat. Relative to other Pacific islands, these streams form rapids under a dense cover of vegetation. A few amphihaline species (*Anguilla megastoma,* Sicyniids, *Macrobrachium sp.*) are likely to be found at such altitudes.

Runs and riffles - these habitats, which are common in the Tina River reach (Figure 7-1), are characterized by current velocities that range from 1.5m/s to 3m/s, that decrease with decreasing river bed slope and elevation, and have a substrate comprised of cobbles and pebbles. The substrate is covered with a thin film of periphyton (algae and diatoms), which requires sunlight and nutrients (nitrogen and phosphorus) to thrive. Water depths are typically less than 2m. Run and riffle areas are significantly harsh environments in the riverine system due to their velocity and depth. Fish species found here are mainly rock-suckers Gobiids (*Sicyopterus, Stiphodon*) that use their mouths to suck the surface film on the cobble and pebble substrate.

Figure 7-1 Typical run/riffle sequence in Tina River

Beds of pebbles, gravels and coarse sands - these habitats are common in the middle and lower reaches of the Tina River. They represent a trophic resource for detritivores like Syciidinae and other Gobiidae. However, unlike European or North America rivers, this habitat is unlikely to be used for spawning, due to the substrates constantly shifting during flash floods.

Under-rock habitats - these habitats are present in high velocity areas of the Tina River where the substrate is comprised of pebbles, sands and gravels either in interstitial cavities of boulder or block accumulations, or where boulders are laying on a bed of sand and gravels. Fast flowing water removes the pebbles, sands and gravels from under the downstream side of boulders, creating cavities. These dark areas shelter juvenile prawns and fish, and are used as spawning substrate by Syciidinae. Fertilized eggs, forming white plates, are stuck onto the boulder or block surface. The cavities accumulate organic material, including algae and diatoms, providing a source of food for bottom dwellers and detritivores. They also offer dark shelters where prawns and eels can hide by day. Bottom dwellers and detritivores are also common. Fertilized eggs of amphidromous[35] Gobiidae were found in under-rock habitats. *Anguilla marmorata* and prawns are also usually found in such habitats.

Pools - these habitats are deep (up to 2m or more) sections of the river (Figure 7-2), with water velocity less than 0.5m/s, or near to being still. They typically occur on outside of river bends, where the current runs deep before coming up to the surface in areas of less than 2m. Pool areas are increasingly present in the upper reaches of the Tina River where the river channel more confined, and decrease on the flood plains (e.g., Ngalimbiu River floodplain and river mouth), where the river channel is less confined and more braided. Substrates in the pools of the upper reaches are predominantly cobbles and pebbles, with associated boulders on the banks, which are bounded on either side by cliffs. Fluctuations in water levels increase with increasing elevation, due to the narrow and confined nature of the river as it flows through mountain gorges. Pool habitats are areas known to be nutrient rich, where very large fish and eels were observed.

Figure 7-2 Typical pool in Tina River

[35] Fish that move between fresh and salt water habitats at some point in their lifecycle, other than for purposes of spawning.

Aquatic/terrestrial contact zones (ATTZ) - these micro-wetland habitats, which are found at the margins of the river, are characterized by shallow stagnant waters, with fines (sands, silt and muck mud) deposited between boulders, pebbles and cobbles. These areas have high nutrient levels and available food resources for life cycles of various aquatic organisms, especially for Oligocheate worms, fish and larvae. Some areas are exposed to sunlight, which facilitates development of algae. Other areas are shaded under tree canopies.

Juvenile tree frogs were observed in this type of habitat at Njarimbisu. Nocturnal surveys confirmed that invasive *Bufo* sp. inhabit such areas at night to feed, mate and brood their young.

Some ATTZ, represented by ponds, were disconnected from the main river channel. These ponds were observed among boulders (see Figure 7-3) (see Station 6 factsheet in Annex 1 of the Annex Report), where species that were rarely observed at night in the river (*Anguilla marmorata, Macrobrachium sp.)* had become trapped.

Figure 7-3 Use of micro-wetlands by amphibians along the Tina River

Confluences where smaller tributaries enter the Tina River form another type of ATTZ. Here, the substrate is comprised of detritus, mud, clay and sand, deposited among boulders. Prawns and juvenile fish are abundant at these locations. Water velocity at some confluences is near to still, whereas at others, tributary streams enter as waterfalls, having very steep slopes at the point of confluence, and no still water pools are formed.

River mouths – this is a key habitat on the Ngalimbiu/Tina River system due to the diverse interaction between the ocean and freshwater entering from the river. Local inhabitants have confirmed that the river has changed course where it enters the sea, several times since Cyclone Namu. The new river mouth (Station A10a) is now considered as the main mouth of the river. It was formed in mid-2013 as a result of high river flood conditions and obstruction of the main channel by logs, and now flows laterally across the delta, roughly 500m West of the old river mouth. The old river mouth (Station A10b), occupied a more central position within the delta, and although it still connects the river to the sea, the outflow is much smaller.

As shown by measures of conductivity, only limited saltwater intrusion occurs into the mouth of the river. There appears to be no longitudinal gradient of brackish water. The river appears to discharge directly into the sea without forming a brackish water estuary. The presence of cane toad tadpoles and rushes along the banks of the river is evidence of sustainable freshwater conditions. Nutrients levels are high as a result of numerous connections to the many adjacent wetlands and swamps, estimated to cover 40ha. This area provides habitat for saltwater crocodiles and wetland species of fish.

The river mouth is a key habitat for fish populations, especially amphihaline species (larvae of Sicyniidae and other Gobiidae, adult and juvenile eels) that transit the area to reach the sea as part of their life cycles, and for marine forms that enter the mouth and lower reach of the river, which provides temporary feeding habitat. As observed during the field survey, the river mouth area supports intense fishing activity, for both subsistence and commercial purposes.

7.5 FISH BIODIVERSITY BASELINE

The following sub-sections present the baseline fish biodiversity conditions in the Tina/Ngalimbiu River system. Information has been compiled from the first BRLi fish survey conducted between 30 July and 06 August 2013, and from previous surveys conducted by others in Solomon Islands. A list of fish species identified from different surveys is included as Annex 2 in the Annex Report. An additional fish survey was carried out during the rainy season in February 2014.

Two fish surveys were conducted to ensure that identification was made of the widest range of species present throughout a given year. However, no conclusions can be drawn regarding migration behaviour based on the results of dry and wet season sampling. Therefore, any difference between dry and the wet season species distribution and abundance, across the different sampling stations, does not demonstrate any particular migratory behaviour.

7.5.1 Species Diversity

Table 7-3 provides a list of all fish species recorded by BRLi's local fish expert during field surveys both for dry and wet seasons. A total of 52 species, representing 30 genera and 15 families, was recorded during the dry season, and 57 species were recorded during the wet season. The letter "O" in Table 7-3 represents fishes that were observed either in the dry or the wet season, while the letter "S" represents the use of the site as a likely spawning ground, based on the literature review and observations made for other studies conducted since 2006 for the Ngalimbiu/Tina River catchment. A question mark "?" denotes a supposition of presence or use, without benefit of field verification.

Fish biodiversity in the Tina River system is difficult to assess with certainty, given the following:

(i) scientific information on the fish of Solomon Islands is still poor, with taxonomic uncertainty and absence of field guides.

(ii) the survey methods (underwater observations and photographs), though particularly appropriate to large fast flowing rivers with clear water, do not always facilitate a precise determination. In some cases, the determination was limited to the genus level only.

Nevertheless, underwater observations and interviews with local fishermen, combined with information from previous studies, allowed a good picture of the fish assemblage to be developed for the Tina/Ngalimbiu River.

Compared to the previous quick survey conducted by Entura in 2010, when 20 species were recorded, the number of recorded species observed during the present study was higher. This is the result of increased sampling effort across different elevations, including the River mouth with its high diversity of marine forms.

The recorded species diversity (52 dry season / 57 wet season) is similar to that recorded in scientific surveys by Jentkins and Boseto (2006) for Tetepare Island, Western Province (60 species), and by Polhemus *et al.* (2008) for all Solomon Islands (52 species), and is higher than the diversity recorded by Golder Associates (2009) at the Ngalimbiu River bridge (32 species) and in the Matepono River system (45 species).

Nevertheless, when the results of the different surveys carried out for Solomon Islands are combined, a much greater diversity (122 recorded species) would seem to be the case (see Annex 2 in the Annex Report). However, this may be the result of uncertain or wrong determination, as well as changes in the taxonomy (i.e., synonymous species being identified).

7.5.2 Longitudinal Distribution

The distribution of fish species recorded from the various survey stations located along the river, during the first and second fish surveys, is summarized in Table 7-3. An additional station was added in the rainy season, to sample fish in the area of the proposed Option 7c dam site.

Table 7-3 Results of the BRLi fish survey

River area		Upper Tina			Middle Tina			Upper Ngalimbiu		Lower Ngalimbiu			Coastal or Marine*	Life Cycle	IUCN Status **	Remark regarding the species abundance in Guadal.
Stations		**A1**	**A2**	**A3**	**7C**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**				
River & location	**Seasons**	**Bicho-Vorah a River**	**Mbembe a River**	**Tina river gauging . station**	**Dam site**	**Tina River Koropa**	**Tina River Sengue**	**Ngalimbiu River Horohutu.**	**Toni River Kathihana**	**Ngalimbiu River bridge.**	**Ngalimbiu River Saele**	**Ngalimbiu River mouth**				
Family and Species																
Ambassidae																
Ambassis interrupta	Wet										O S	O S		Amphi	LC	
	Dry											O				
Ambassis miops	Wet											O S		Amphi	LC	
Anguillidae																

Anguilla mamorata	Dry	O	O	O		O						O		Cata	LC	Rare
	Wet	O	O	O	O			O					S			
Apoginidae																
Apogon hyalosoma	Dry											O		Marine form	LC	
	Wet											O S				
Apogon sp.	Wet											O S		Marine form		
Carangidae																
Carangoides malabaricus	Dry											O		Marine form	NA	Commo n
	Wet											O S				
Caranx sp.	Wet	S?	S?	S?	S?	S?	S?	S?	S?	S?	S?	O	O	Marine form		Commo n
Caranx sexfasciatus	Dry											O		Marine form	LC	
	Wet											O S	O			

Scomberoides sp.	Wet										O	O S	Marine form		Rare
Scomberoids sp. Juveniles	Dry										O		Marine form		
Cichlidae															
Oreochromis mossambicus	Wet								O			S	Non migratory	NT***	Common invasive
Eleotridae															
Allamogurnda sp.	Dry					O							Amphi		
Belobranchus belobranchus	Dry					O				O			Amphi	DD	
	Wet	S?	S?	S?	S?	S?	S?	O S?	S?	S?	O S?	S?	S?			
Butis sp.	Dry															
Butis amboinensis	Dry						O			O				Amphi	LC	
	Wet					O	O S	S	O							

Eleotris fusca	Dry					O	O							Amphi	LC	
	Wet	O S	O S	O S						O						
Ophieleleotris hoedti	Dry					O	O			O				Amphi	NA	
Ophieleotris margaritacea	Dry													Amphi	NA	
Ophieleotris sp.1	Wet	O S	O S	O S		O			O					Amphi		Common
Ophieleotris sp. 2	Wet	O S	O S	O S	O				O					Amphi		Common
Ophiocara aporos	Dry													Amphi	NA	
Bunaka gyrinoides (Eleotris gyrinoides)	Wet				O S	O								Amphi	LC	Common
Gerreidae																
Gerres sp.	Wet												S	Marine form	NA	
Gobiidae																
Awaous guamensis	Dry	O	O	O		O	O							Amphi	LC	
Awaous melanocephalus	Wet	O S	O S	O S	O			O						Amphi	DD	Common
Awaous ocellaris	Dry	O	O	O		O	O			O				Amphi	LC	

Awaous sp.	Wet	O S	O S	O S										Amphi		Common
Bathygobius andrei[36]	Dry	O	O	O		O	O			O				Amphi	LC	
Glossogobius celebius	Dry						O			O				Amphi	DD	
Glossogobius sp. 1	Wet	S?	S?	S?	S?	S?	S?	O S?	O S?	S?	S?	S?	S?	Amphi		Common
Glossogobius sp 2	Wet	S?	S?	S?	S?	S?	S?	O S?	S?	S?	S?	S?	S?	Amphi		Common
Lentipes multiradiatus	Dry					O	O							Amphi	NA	
	Wet	O S	O S	O S	S	O S	O									
Lentipes sp.1	Wet	O S	O S	O S	O S		O							Amphi		Common
Lentipes sp. 2	Dry	O	O	O		O								Amphi		
Redigobius bikolanus	Dry	O	O	O		O	O		O					Amphi	LC	
Redigobius tambujon	Dry	O	O	O		O	O		O					Amphi	LC	
	Wet	O S?	O S?	O S?	S?	O S?	S?	S?	O S?	S?	S?	S?	S?			

36 This identification is questionabe, based on known range and current understanding of species biogeography. Records are pending further confirmation of identification.

Schismatogobius sp. cf. ampluvinculus[37]	Dry					O	O	O	O					Amphi	NA	
Schismatogobius sp. cf. roxasi[38]	Dry					O	O	O	O					Amphi	NA	
Schismatogobius sp.	Wet	S?	S?	S?	S?	S?	S?	O S?	O S?	S?	S?	S?	S?	Amphi		
Sicyopterus lagocephalus	Dry	O	O	O		O	O		O					Amphi	LC	Common
	Wet	O S	O S	O S	O	O	O	O	O	O						
Sicyopterus longifilis	Wet	O S	O S	O S										Amphi	DD	
Sicyopterus ouwensi	Wet	O S	O S	O S	O									Amphi	DD	
Sicyopterus sp.	Dry					O			O					Amphi		
	Dry					O	O		O					Amphi	DD	Rare

[37] This identification is questionable, based on known range and current understanding of species biogeography. Records are pending further confirmation of identification.

[38] This identification is questionable, based on known range and current understanding of species biogeography. Records are pending further confirmation of identification.

Sicyopus discordipinnis	Wet	O S	O S	O S		O										
Sicyopus mystax	Dry					O	O		O					Amphi	NA	
Sicyopus sp.1	Wet	O S	O S	O S	S									Amphi		
Sicyopus sp.2	Dry					O			O					Amphi		
Sicyopus zosterophorum	Dry					O	O		O					Amphi	LC	Common
	Wet	O S	O S	O S												
Stenogobius hoesei	Dry					O	O		O					Amphi	LC	
Stiphodon atratus	Dry						O			O				Amphi	LC	Rare
	Wet	O S	O S	O S	O S		O									
	Dry					O	O	O	O					Amphi	NA	Common

Stiphodon sp. cf. atropurpureus[39]	Wet	O S	O S	O S	O	O	O	O	O	O						
Stiphodon birdsong	Dry	O	O	O		O	O	O	O	O				Amphi	LC	Common
	Wet	O S	O S	O S	O S	O	O	O								
Stiphodon sp. cf. multisquamus[40]	Dry	O	O	O		O	O	O	O					Amphi	NA	
Stiphodon sp. cf. ornatus[41]	Dry	O	O	O		O	O	O	O					Amphi	NA	
	Wet	O S	O S	O S	O	O	O	O	O	O						
Stiphodon rutilaureus	Dry					O	O		O					Amphi	LC	Rare

[39] This identification is questionable, based on known range and current understanding of species biogeography. Records are pending further confirmation of identification.

[40] This identification is questionable, based on known range and current understanding of species biogeography. Records are pending further confirmation of identification.

[41] This identification is questionable, based on known range and current understanding of species biogeography. Records are pending further confirmation of identification.

	Wet					S	O S									
Stiphodon semoni	Dry	O	O	O		O	O	O	O	O				Amphi	DD	Rare
	Wet	O S	O S	O S	O S	O	O	O	O	O						
Stiphodon sp.1	Wet	O S	O S	O S										Amphi		Rare
Stiphodon sp.2	Dry					O	O							Amphi		
Kuhliidae																
Kuhlia marginata	Dry										O	O		Cata	LC	Rare
	Wet	O	O	O	O		O						S			
Kuhlia rupestris	Dry										O	O		Cata	LC	Rare
	Wet	O	O	O	O	O	O	O	O				S			
Lutjanidae																

Lutjanus argentimaculatus	Wet											O	O S	Marine form	NA	
Lutjanus fuscescens	Dry										O	O		Marine form	NA	
	Wet											O	S			
Lutjanus vitta	Dry										O	O		Marine form	NA	
	Wet	S?	S?	S?	S?	S?	S?	S?	S?	S?	S?	O S?	S?			
Mugilidae																
Liza tade	Wet											O	S	Marine form	LC	Rare
Liza vaigiensis	Dry					O		O		O				Marine form	NA	Rare
	Wet								O				S			
Muraenidae																
Gymnothorax polyuranodon	Wet								O				S	Cata	LC	
Ophichthidae																

Scolecenchelys macroptera (Muraenichthys macropterus)	Wet	S?	S?	S?	S?	S?	S?	S?	S?	S?	S?	O S?	S?	Marine form	NA	Rare
Poeciliidae																
Gambusia holbrooki	Dry	S?	S?	S?	S?	S?	S?	S?	S?	S?	O S?	S?	S?	Non migratory	LC	Common invasive
Rhyacicththyidae																
Rhyacichthys aspro	Dry					O				O				Amphi	DD	Common
	Wet	O S?	O S?	O S?	O S?	S?	O S?	S?	S?	S?	S?	S?				
Syngnatidae																
Chelon macrolepis	Dry					O				O				Cata	LC	
Microphis (Oosthetus) manadensis	Wet	S?	S?	S?	S?	S?	S?	O S?	O S?	S?	S?	S?	S?	?	NA	
Microphis sp.	Dry					O								?		
Microphis leiaspis	Dry											O		Amphi	LC	
	Wet							O S		O						

Microphis(Doryichtys) retzi	Dry											O		?	NA	
	Wet	S?	S?	S?	S?	S?	S?	S?	O S?	S?	S?	S?	S?			
Terapontidae																
Terapon jarbua	Wet									O			S	Marine form	LC	
Mesopristes argenteus	Dry										O	O		Marine form	LC	Rare
	Wet	O	O	O			O				S	O S				
Mesopristes cancellatus	Dry					O					O	O		Marine form	LC	Rare
	Wet	O	O	O	O		O				S	O S				
Zenarchopteridae																
Zenarchopterus dispar	Wet											O S		Marine form	LC	
Zenarchopterus sp.	Wet											O S		Marine form		

Total number of observed species, dry season	52	12	12	12	NA	33	25	8	17	12	6	14	NA	Number of species observed per station, dry season
Total number of observed species, wet season	57	24	24	24	15	11	14	9	10	8	1	15	4	Number of species observed per station, wet season

*Coastal area and Site 7C dam site location were only sampled during the rainy season, as Site 7C was had not been chosen until after the dry season sampling was completed

** Source: The IUCN Red List of Threatened Species. Version 2014.3. Unidentified species are not assessed. NT: Near Threaten; NA: Not assessed; LC: least concern; DD: Data deficient.

*** Near threatened in its natural habitat in East Africa

Amphi: Amphidromous; Cata: Catadromous; Pota: Potadromous

7.5.3 Fish Assemblage

7.5.3.1 Gobioids

In Solomon Islands, like other high islands of the Indo Pacific area, the fresh water fauna is dominated by Gobioid fishes, mainly members of Gobiidae and Eleotridae families. Most species are relatively small (< 10cm in length). In Solomon rivers, the species varies considerably in size. The largest species found was *A. guamensis* (adults reach 24cm). The most common species, *S. semoni*, does not exceed 5-6cm in length. Regarding the observations made during the first BRLi survey, the Gobioid group was represented by 34 species (25 Gobiidae, 8 Eleotridae and 1 Rhyacichthidae), representing 71% of the entire ichthyofauna.

Among Gobiidae, clinging gobies of the subfamily Sicydiinae (containing genera *Stiphodon, Lentipes, Sicyopterus* and *Sicyopus)* are particularly dominant in the study area, especially in the upper sections of the river where rock dominated, fast flowing clear streams, occur. These fishes present a “sucking disk” formed by the two pelvic fins, allowing them to “cling” to rocks in rapid stream flows.

Sicydiinae are typically brightly coloured, exhibiting neon shades of blue, gold and red. This group includes many recent discoveries and the taxonomy is relatively unstable, particularly for the genus Sicyopterus.

These species have an opportunistic diet. They feed on filamentous algae, worms, crustaceans, insects and suspended food particles. Sicydiins, which is the most abundant group in Solomon Islands rivers, feeds by sucking periphyton that grows on pebbles. They are known to play a key role in the food chain, especially as prey for eel *A. marmorata* (the top predator in such an environment), especially in the upper watershed.

During the surveys, *Stiphodon semoni* seemed to be the most common species, being largely present from Becho/Voraha River to Ngalimbiu River Bridge.

Among amphidromous species, the Sicydiinae are characterized by a massive migration of oceanic pelagic larvae entering the river and migrating upstream. Commercial harvest was observed at the river mouth, and shoals of juveniles were observed inland, migrating upstream along the banks. No doubt this group plays a crucial role in the river ecology (Keith, 2003).

According to discussions with local communities, Gobioids’ fish size and abundance have decreased due to overfishing, both in the river and at the river mouth.

7.5.3.2 Non-Gobioids

A few non-gobioid species are likely to be found far upstream in the river. During the fish survey, the species observed beyond Choro were the giant Eel (*Anguilla marmorata*), pipefish (*Microphis sp. Chelon macrolepis),* jungle perch (*Kuhlia sp*.), mullet (*Liza vaiengensis*) and grunter (*Mesopristes argenteus* and *M. cancellatus*). With the exception of eels, that are likely to be found very far upstream, most species have limited abilities to migrate upstream from the first encountered waterfalls.

Most non-gobioid species are itinerant estuarine and marine forms tolerant to fresh water that will inhabit the lower reaches of streams. These fish are a combination of juvenile forms and adult forms that will spend periods in freshwater for feeding. The following species were recorded: *Ambassis interruptus, Ambassia macracanthus, Carangoides malabaricus, Caranx sexfasciatus, Lutjanus vitta, Lutjanus fuscescens, Apogon hyalosoma, Scomberoides sp.* Some of these fish are of sufficient size to represent an interest for subsistence/commercial fisheries. Some species, like *C. sexfasciatus, L.vitta, L.fuscescens and A.interruptus,* can be found as far as the Toni-Tina confluence. Some species are connected to the coastal wetland area surrounding the mouth of the river, estimated to be about 40 ha.

7.5.4 Migration Pattern and Life Cycle

Similar to other tropical islands of the Indo-pacific, almost all native species encountered in inland fresh water systems are migratory species, with a life cycle between ocean and river. Two main migration patterns can be distinguished: catadromous and amphidromous. In addition, Potadromous and Oceanodromous are less important migration patterns in the Ngalimbiu/Tina River system.

7.5.4.1 Catadromous

Catadromous migration involves downstream migration for adults to spawn, and upstream migration for juveniles to mature. Spawning takes place in the ocean.

Eels are catadromous, with adults migrating to the ocean to spawn, and juveniles (glass eels) migrating back into freshwater systems. During their upstream migrations, glass eels are able to climb to the upper reaches of the river. The life cycle starts in late November with adults moving downstream toward the ocean to spawn, and May with hatching of Juveniles in the ocean. Juveniles were observed moving back upstream to mature in July 2013. At their maturing stage, *Anguilla sp.* migrates to higher elevation reaches above 300masl. It will not mate until it reaches several kilometers upstream. After spawning in the ocean, the adult eels die. Compared to eels, *Kuhlia rupestris* (another catadromous species) spawns several times before it dies. The life cycle of *Kuhlia* begins in December with downstream migration. Upstream migration occurs in July (Note: females were observed with eggs in July during 2013 BRLi surveys). As with eels, *Kuhlia* migration reaches far upstream reaches of elevation 300 masl.

7.5.4.2 Amphidromous

Amphidromous migration involves downstream migration of larvae and upstream migration of juveniles to mature. Spawning takes place in the upstream river systems.

Most migratory species like Gobioids (e.g., *Stiphodon, Sicyopterus, Awaous, Eleotris, and Glossogobius sp.*), *Mesopristes* and prawns, are amphidromous. Spawning occurs in the rivers (under rocks for some Sicydiinae). Larvae drift passively to the ocean before migrating back as juveniles to the freshwater system to grow into adults. The factors controlling such upstream migration of juveniles are not well understood. Flooding (high turbidity) and lunar cycles are assumed to play a role in some species such as Sicydiinae. Migration from the ocean to upstream rivers takes place on a monthly basis. Amphidromous species migrate to the upper Tina River catchment attracted by its cooler water, better water quality and fewer habitat disturbances. For example, *Sicyopterus lagocephalus* was observed in the mountainous region of the upper Tina River catchment. Between maturing eggs, upstream migration and spawning in the upper Tina River, the average life cycle takes 3 to 4 months to complete. Important water temperature gradients found along the Tina River are suspected to trigger migration of fishes, as water temperatures are progressively cooler upstream.

7.5.4.3 Potadromous

One Potadromous species, *Gambusia holbrooki,* was found at Station 9 downstream in the Ngalimbiu River, upstream of the river month. The species was introduced by the Solomon Islands Malaria Training and Research Institute (SIMTRI) in the 1980s and 1990s, to control mosquito larva in swamp sites. It may be a threat to both adult and juvenile fish species.

Potadromous fish are characterized as species that are born in the higher reaches of freshwater systems and migrate downstream, where they mature before migrating upstream again. *Gambusia holbrooki* is present in the Guadalcanal plains near river mouths, where it tolerates harsh environments. Its migration might extend upstream to the confluence of the Tina and Toni rivers. It was not found at the higher reaches, probably due to lower temperatures upstream. Most of this species spawns in the lower reaches from the Toni-Tina confluence, downstream to wetlands of the Ngalimbiu River mouth.

7.5.4.4 Marine form (Oceanodromous)

Oceanodromous species spawn and hatch on the outer edges of reefs or mangrove areas. They drift in the ocean as larvae, before settling as juveniles and growing into adults, to migrate back to their spawning sites. Marine species are tolerant of fresh water, entering into the lower reach of the River as juveniles, sub-adults or adults, to feed.

7.5.4.5 Conclusions on Migration

Catadromous and Amphidromous regimes, besides playing a crucial role in the river ecology, have been considered with particular attention through supplementary studies in the project ESIA because the hydroelectric project will affect their colonization upstream of the dam. Most of the Gobidaea family species mature and spawn in the dam area (*Awaous, Sicyopterus, Stiphodon,* etc.).

7.5.5 Locomotion Behavior

Regarding the abilities of juvenile fish to pass obstacles when migrating upstream, different locomotion behaviors can be observed. These have been taken into account when designing possible fish pass systems.

7.5.5.1 Strict swimmers

Some species like silverfish *Mesopristes sp*., *Kuhlia sp*., river mullet (*Liza vaiengensis*), and others, can be qualified as “strict swimmers” with a pelagic behavior. They remain constantly within the water column (i.e., make no contact with the substrate). These species are not capable of climbing obstacles, such as natural cascades, waterfalls or dams). In their natural environment, these species are not found upstream of waterfalls.

7.5.5.2 Crawlers and climbers

Other species of fish exhibit a benthic behavior (Syciinidae and other Gobiidae, prawns, eels), and are able to migrate upstream of cascades and waterfalls. They can be classified in two categories:

- Syciidinae juveniles or climbing gobies (genus *Lentipes, Sicypoterus*, *Sicyopus, Stiphodon*), are presumably the most abundant taxa in the Tina River, and are known to climb quasi-vertical smooth surfaces up to several hundreds of meters, using their pelvic suckers and, for some species, their buccal suckers.
- Eels and prawn juveniles, unlike Syciidinae, are not able to climb sub-vertical smooth surfaces. However, they are known to climb over steep slopes with wet and rough surfaces with asperities, by crawling on substrates of rocks, earth and vegetation over which runoff waters flow. Eels use undulations of the body axis whereas prawns walk on the substrate. In Tahiti, both eels and prawn juveniles are known to climb over earth dams, 15m to 20m in height. Therefore, as species they are still present and abundant upstream of dams built in the 1980s (Moirod & Trebaol, personal communication).

Table 7-4 presents locomotion behavior of identified fishes.

Table 7-4 Locomotion behavior

Locomotion behavior	
Ambassidae	
Ambassis interrupta	Strict swimmer
Ambassis miops	Strict swimmer
Anguillidae	
Anguilla mamorata	Crawler
Apoginidae	
Apogon hyalosoma	Strict swimmer
Apogon sp.	Strict swimmer
Carangidae	
Carangoides malabaricus	Strict swimmer
Caranx sp.	Strict swimmer
Caranx sexfasciatus	Strict swimmer
Scomberoides sp.	Strict swimmer
Scomberoids sp. Juveniles	Strict swimmer
Cichlidae	

Locomotion behavior	
Oreochromis mossambicus	Strict swimmer
Eleotridae	
Allamogurnda sp.	Strict swimmer
Belobranchus belobranchus	Strict swimmer
Butis sp.	Strict swimmer
Butis amboinensis	Strict swimmer
Eleotris fusca	Strict swimmer
Ophieleleotris hoedti	Strict swimmer
Ophieleotris margaritacea	Strict swimmer
Ophieleotris sp.1	Strict swimmer
Ophieleotris sp. 2	Strict swimmer
Ophiocara aporos	Strict swimmer
Bunaka gyrinoides (Eleotris gyrinoides)	Strict swimmer
Gerreidae	
Gerres sp.	Strict swimmer
Gobiidae	
Awaous guamensis	Climber
Awaous melanocephalus	Climber
Awaous ocellaris	Climber
Awaous sp.	Climber
Bathygobius andrei[42]	Data deficient
Glossogobius celebius	Data deficient
Glossogobius sp. 1	Data deficient
Glossogobius sp 2	Data deficient
Lentipes multiradiatus	Climber
Lentipes sp.1	Climber
Lentipes sp. 2	Climber
Redigobius bikolanus	Climber
Redigobius tambujon	Data deficient
Schismatogobius sp. cf. ampluvinculus[43]	Data deficient

[42] This identification is questionable, based on known range. Records are pending further identification.

[43] This identification is questionable, based on known range. Records are pending further identification.

Locomotion behavior	
Schismatogobius sp. cf. roxasi[44]	Data deficient
Schismatogobius sp.	Data deficient
Sicyopterus lagocephalus	Climber
Sicyopterus longifilis	Climber
Sicyopterus ouwensi	Climber
Sicyopterus sp.	Climber
Sicyopus discordipinnis	Climber
Sicyopus mystax	Climber
Sicyopus sp.1	Climber
Sicyopus sp.2	Climber
Sicyopus zosterophorum	Climber
Stenogobius hoesei	Climber
Stiphodon atratus	Climber
Stiphodon sp. cf. atropurpureus[45]	Climber
Stiphodon birdsong	Climber
Stiphodon sp. cf. multisquamus[46]	Climber
Stiphodon sp. cf. ornatus[47]	Climber
Stiphodon rutilaureus	Climber
Stiphodon semoni	Climber
Stiphodon sp.1	Climber
Stiphodon sp.2	Climber
Kuhliidae	
Kuhlia marginate	Strict swimmer
Kuhlia rupestris	Strict swimmer
Lutjanidae	
Lutjanus argentimaculatus	Strict swimmer
Lutjanus fuscescens	Strict swimmer

44 This identification is questionable, based on known range. Records are pending further identification.

45 This identification is questionable, based on known range. Records are pending further identification.

46 This identification is questionable, based on known range. Records are pending further identification.

47 This identification is questionable, based on known range. Records are pending further identification.

Locomotion behavior	
Lutjanus vitta	Strict swimmer
Mugilidae	
Liza tade	Strict swimmer
Liza vaigiensis	Strict swimmer
Muraenidae	
Gymnothorax polyuranodon	Data deficient
Ophichthidae	
Scolecenchelys macroptera (Muraenichthys macropterus)	Data deficient
Poeciliidae	
Gambusia holbrooki	Strict swimmer
Rhyacicththyidae	
Rhyacichthys aspro	Data deficient
Syngnatidae	
Chelon macrolepis	Data deficient
Microphis (Oosthetus) manadensis	Data deficient
Microphis sp.	Data deficient
Microphis leiaspis	Data deficient
Microphis(Doryichtys) retzi	Data deficient
Terapontidae	
Terapon jarbua	Strict swimmer
Mesopristes argenteus	Strict swimmer
Mesopristes cancellatus	Strict swimmer
Zenarchopteridae	
Zenarchopterus dispar	Strict swimmer
Zenarchopterus sp.	Strict swimmer

7.5.6 Habitat requirements

Together with locomotion behaviour, the use of habitat by species' present in the river will determine the impacts that hydro scheme operation will have on migration and life cycle.

There is little published information about the habitat types in which the Tina River species are found and no specific information on the water depths, velocities and substrates in which they are found. Gobies are usually found in riffles, where coarse substrate (boulders, cobbles and large gravels) provide both shelter from the current and a food resource. Pools provide habitat for large eels, grunters and jungle perch.

Measurements of fish species and number, water velocity and depth and substrate composition in small areas (2-4 m^2) were made on 11 March 2016 and 13-14 July 2016 to determine habitat suitability for common fish species in the Tina River.

Very little is known about the factors controlling fish populations in Solomon Islands. As in other island countries, most Solomon Island fish species have evolved to cope with the conditions they experience. Eels and most gobies are capable climbers and can penetrate to the headwaters of most rivers. The diadromous life history protects their early life stages from the vagaries of the riverine environment such as strong and variable currents caused by floods and freshets. The overwhelming influence of diadromy suggests that total fish numbers and diversity in a given reach will depend on access to the sea, with instream habitat controlling the density of fish within the reach.

7.5.6.1 Habitat modelling

Modelling of instream habitat availability for selected species, over a range of flows, is a valuable tool when assessing potential effects of flow changes and making decisions about environmental flow requirements. This method is one of the most commonly used methods of assessing flow requirements (Tharme 2003). The background to methods used here is discussed in Jowett et al. (2008).

Habitat modelling entails measuring water depths and velocities, as well as substrate composition, across a number of stream cross-sections at a given flow (referred to as the survey flow). Points on the banks, above water level, along the cross-sections are also surveyed to allow model predictions to be made at flows higher than the survey flow. Calibration data for fitting rating curves are obtained from additional measurements of water level at each cross-section, relative to flow, on subsequent visits. The stage (water level) with no flow in the river (stage of zero flow) is also estimated at each cross-section to help fit rating curves. These data allow calibration of a hydraulic model to predict how depths, velocities and the substrate types covered by the stream will vary with discharge in the surveyed reach.

The habitat suitability at each point in the reach is calculated from modelled depth, velocity and substrate from habitat suitability curves[48] (HSC). Habitat suitability weighted by the area represented by each point is summed over the reach to give area weighted suitability (AWS previously known as WUA weighted usable area) with units of m^2/m. The average habitat suitability of the reach is the AWS divided by the wetted area of the river and is a dimensionless number between 0 (totally unsuitable and 1 (ideal). Habitat modelling is undertaken over a range of flows to predict how habitat availability (AWS) and average habitat suitability will change with flow.

7.5.6.2 Habitat mapping

The first step in the process is to carry out habitat mapping along the length of the reach between the dam and tailrace locations. The habitat types are assessed in the field after traversing the affected reach; usually they would include riffle, run, pool, and rapid. The length and location of each habitat

[48] HSC describe the suitability of different depths, velocities and substrate sizes for given species of interest.

type is recorded. The habitat mapping between the Tina Village and dam site is presented in Table 7-5.

Table 7-5 - provides the percentage of habitat types between Tina Village, powerhouse site and dam site on 6 March 2016

Habitat Type	**1 km upstream of Tina Village to powerhouse site**	**Upstream of powerhouse to 1 km downstream of dam site**
Rapid	5%	5%
Riffle	31%	36%
Run	55%	46%
Pool	9%	13%

7.5.6.2.1 Cross-section selection

The number of cross-sections required depends on the morphological variability within the river. Studies have shown that relatively few cross-sections can reproduce the results from a survey with a large number of cross-sections (see Jowett et al. 2008 for details).

The total number of cross-sections needed to generate a robust result should be proportional to the complexity of the habitat hydraulics: 6-10 for simple reaches and 18-20 for diverse reaches.

Each cross-section is given a percentage weighting based on the proportion of the

habitat type in the reach that it represents. The underlying assumption is that the cross-sections measured provide a reasonable representation of the habitat throughout the reach. Reach results can be extended to longer sections of river, if the flows, river gradient and morphology do not change significantly.

Three cross-sections were surveyed - one in a pool, one in a run and one in a riffle. Water levels were measured at flows of 8.7 m^3/s and 19.7 m^3/s and these were used to develop rating curves at each cross-section[49].

7.5.6.2.2 Habitat suitability

It is the quality of the habitat that is provided by the flow that is important to density of stream biota, rather than the magnitude of the flow per se. In many streams, flows less than the naturally occurring low flow are able to provide good quality habitat and sustain stream ecosystems. The magnitude of this flow will vary with the requirements of the species and with the morphology of the stream.

Water velocity is probably the most important characteristic of a stream. Without it, the stream becomes a lake or pond. In gravel bed rivers, an average velocity of 0.2-0.3 m/s tends to provide for

[49] It would have been ideal to obtain calibration measurements at three flows, one as low as possible. However, experience has indicated that there is a probability (> 50%) that 3 cross-sections in the different habitats would give the same answer as a larger number of cross-sections. Although not ideal, these measurements can give some indication of the effects of a flow reduction on instream habitat.

most stream life, because velocities lower than this provide unsuitable habitat for a number of fish species and stream insects and allow deposition of sand and finer materials. In large rivers, water depth of more than 0.4 m provides habitat for swimming species, but benthic fish are often found in shallower water. Gobies feed either on algae or small invertebrates associated with algae growing on the stable cobbles and boulders.

The flow at which limiting conditions of depth and velocity occurs varies with stream morphology. Generally, minimum flow increases with stream size, because stream width increases with stream size. However, the relationship is not linear. In general, small streams require a higher proportion of the natural stream flow to maintain minimum habitat than do large rivers.

7.5.6.2.3 Method for determining habitat suitability

Fish densities were sampled across transects in the Toni River in a variety of habitat types (riffle, run and pool) on 11 March 2016. Thirteen quadrats of between 2 m^2 and 6 m^2 were sampled by electro-fishing using EFM300 (NIWA Instrument Systems, Christchurch, New Zealand) electro-fishing equipment. Flooding and turbidity prevented sampling in the Tina River

The quadrats were at regular intervals across each transect with a distance of at least 1 metre between quadrats to avoid fish disturbance. The quadrats were selected so that there was minimal variation in water depth, velocity and substrate composition within the quadrat.

Electro-fishing was conducted with a downstream stop net and a dip net to catch any fish that missed the stop net.

Water depths and velocities were measured across a diagonal of the area fished and matched to recorded species and lengths of fish caught. Afterwards, fish were released at their capture point.

A further 56 quadrats were sampled by snorkelling on the 13-14 July 2016; 23 in the Toni River and 33 in the Tina River. A total of 18 species were either caught or observed and 8 of these species were relatively common (present in more than 3 quadrats).

After fishing, water depth and velocity were measured (at 0.4 times depth) at 5-10 points in each quadrat usually on a diagonal. The percentage of five substrate size categories (bedrock, boulder, cobble, gravel, and fines) was estimated visually.

Potential cover such as banks with overhanging vegetation or large logs was also sampled. The average depth and velocity in each quadrat was calculated from the measurements taken within the quadrat. For substrate, a substrate index (s) was calculated from the visual percentage estimates using the formula (Jowett & Richardson, 1990)

s =0.08*bedrock + 0.07*boulder + 0.06*cobble + 0.05*gravel + 0.035*fines.

The most suitable habitat was be determined by the density of fish. For example, if the highest average density of fish was in riffles and the lowest in pools, riffles would be the most suitable habitat and pools the least. A similar procedure was followed to determine habitat suitability for depth, velocity and substrate. The methods used for determining habitat suitability are described in Jowett & Davey (2007) and Jowett & Richardson (2008).

Some size-related habitat selection was observed with smaller fish in low velocity water than the larger individuals of the same species.

During the first survey, the proportion of the different habitat types was measured and cross-sections were identified in each of the habitat types. A large flood that occurred on the second day of the survey, removed more than half of the temporary staff gauges that had been installed. This meant that only 3 cross-sections could be surveyed. One cross-section was a wide riffle at the proposed powerhouse location and the other two were in a pool and run further upstream. Water levels were measured at flows of 8.7 m^3/s and 19.7 m^3/s and these were used to develop rating curves at each cross-section. The cross-section at the powerhouse site was selected to evaluate the effect of flow on water level between the powerhouse and Tina Village where the valley is wider than between the dam and powerhouse. Because the powerhouse cross-section was unrepresentative of the habitat between the dam and powerhouse it was excluded from the habitat analyses.

The second survey (11-12 July 2016) comprised cross-sections in 2 pools, 5 runs, 5 riffles and 2 rapids; a total of 14 cross-sections. The flow was 9.91 m^3/s on the 11 July and 9.66 m^3/s on the 12 July. Water level and flow measurements were taken on 15 July and 25 July for rating calibration when the flows were 8.28 m^3/s and 5.39 m^3/s, respectively.

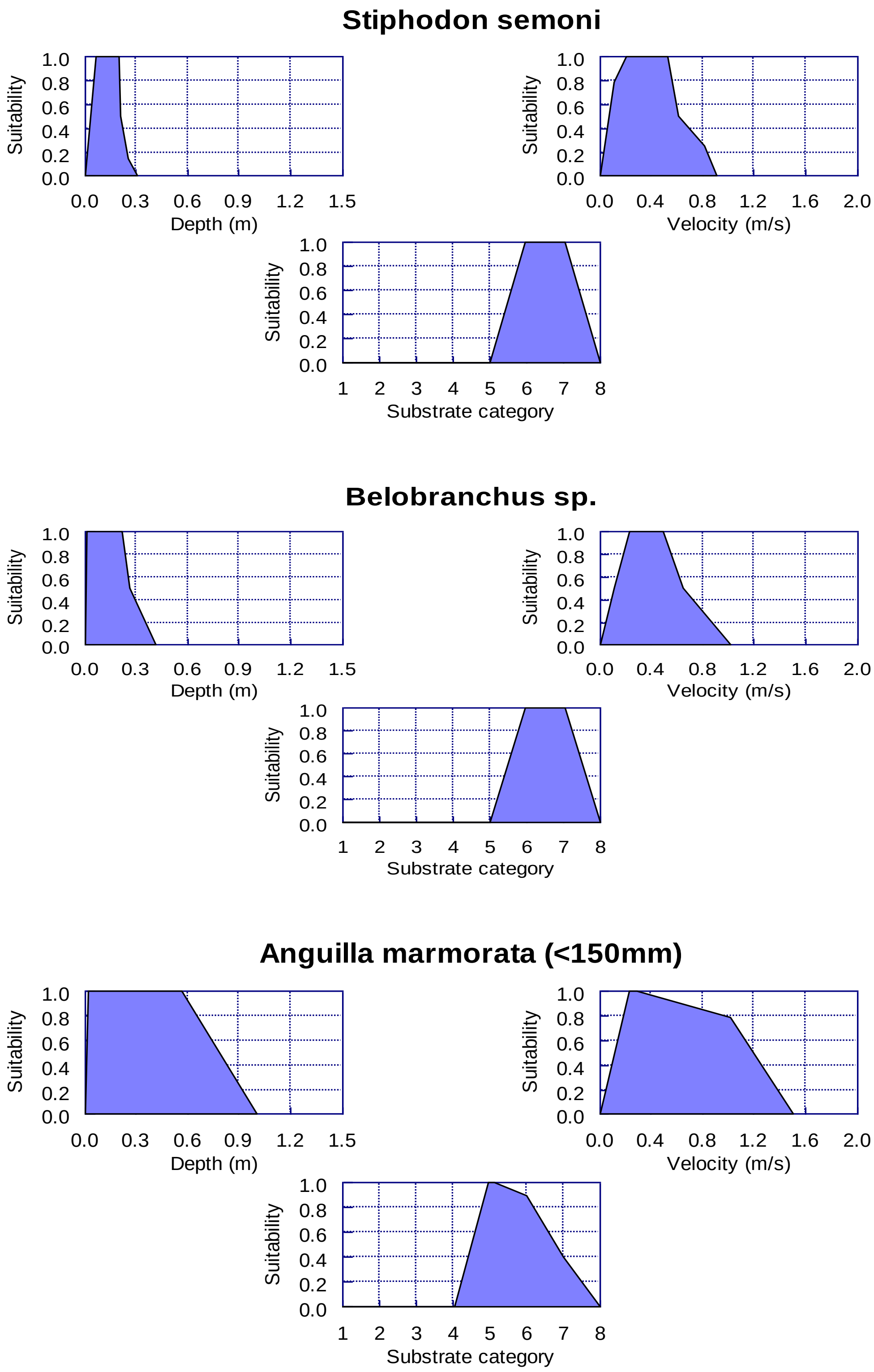
This sampling showed clearly that riffles were the preferred habitat of gobies and eels, with an average fish density in riffles of 7.2 fish/12 m^2 compared to an average density of 1.4 fish/12 m^2 in runs. We did not find any fish in association with log or bank cover.

Fish density and diversity was higher in the Toni River than in the Tina River (Mann-Whitney non-parametric test, $P<0.001$), with an average of 60.4±81.7 fish/12m^2 in the Toni River compared to 6.7±17.1 fish/12m^2 in the Tina River and an average number of species per quadrat of 2.61±1.44 in the Toni River compared to 1.17±1.09 in the Tina River. There were no significant differences between rivers in sampling depth or substrate composition (Mann-Whitney non-parametric test, $P>0.1$) but sampling velocities were higher in the Tina River than in the Toni River (Mann-Whitney non-parametric test, $P=0.001$).

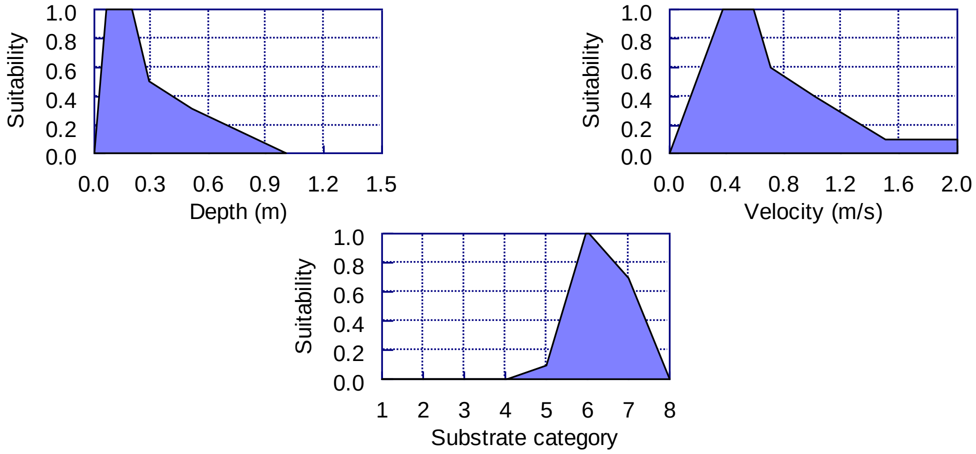
In general, the results were as expected with these goby species in shallow low-moderate velocity riffles and eels in a wider range of depths and velocities in the riffles. Shallow water (<0.3 m), a velocity of about 0.5 m/s, and cobble substrate tended to contain the greatest density of fish and the greatest number of species.

The preferred habitat of the goby species *Sicyopterus stimpsoni* in Hawaii (Figure. 7-4) was similar to the preferred habitat of the Solomon species in that they preferred low to moderate velocities and coarse substrate. However, the other Guam and Hawaii species seemed to prefer lower velocities than *Stiphodon semoni* and *Belobranchus* sp.

Figure 7-4 :Habitat suitability curves for Stiphodon semoni, Belobranchus sp., Anguilla marmorata, fish density and species richness. The substrate categories are 1= vegetation, 2=mud/silt, 3=sand,4=fine gravel, 5=gravel, 6=cobble,7=boulder, 8=bedrock.



Fish density



Species richness

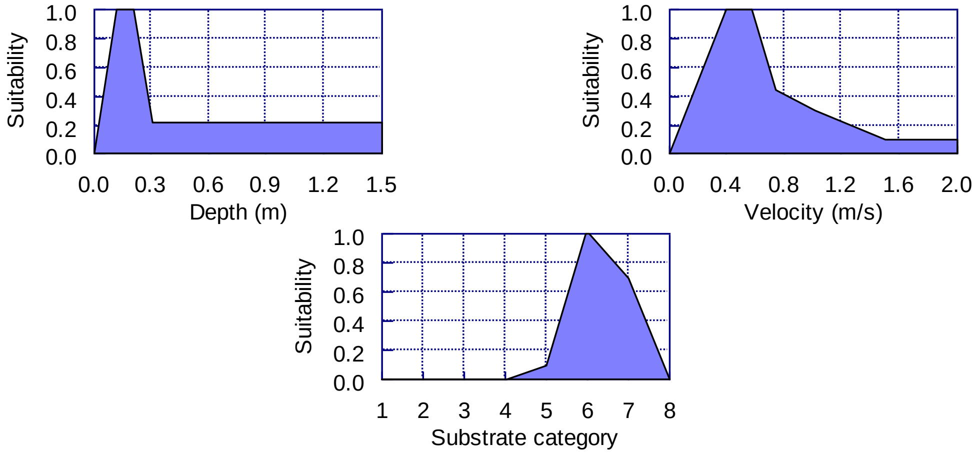
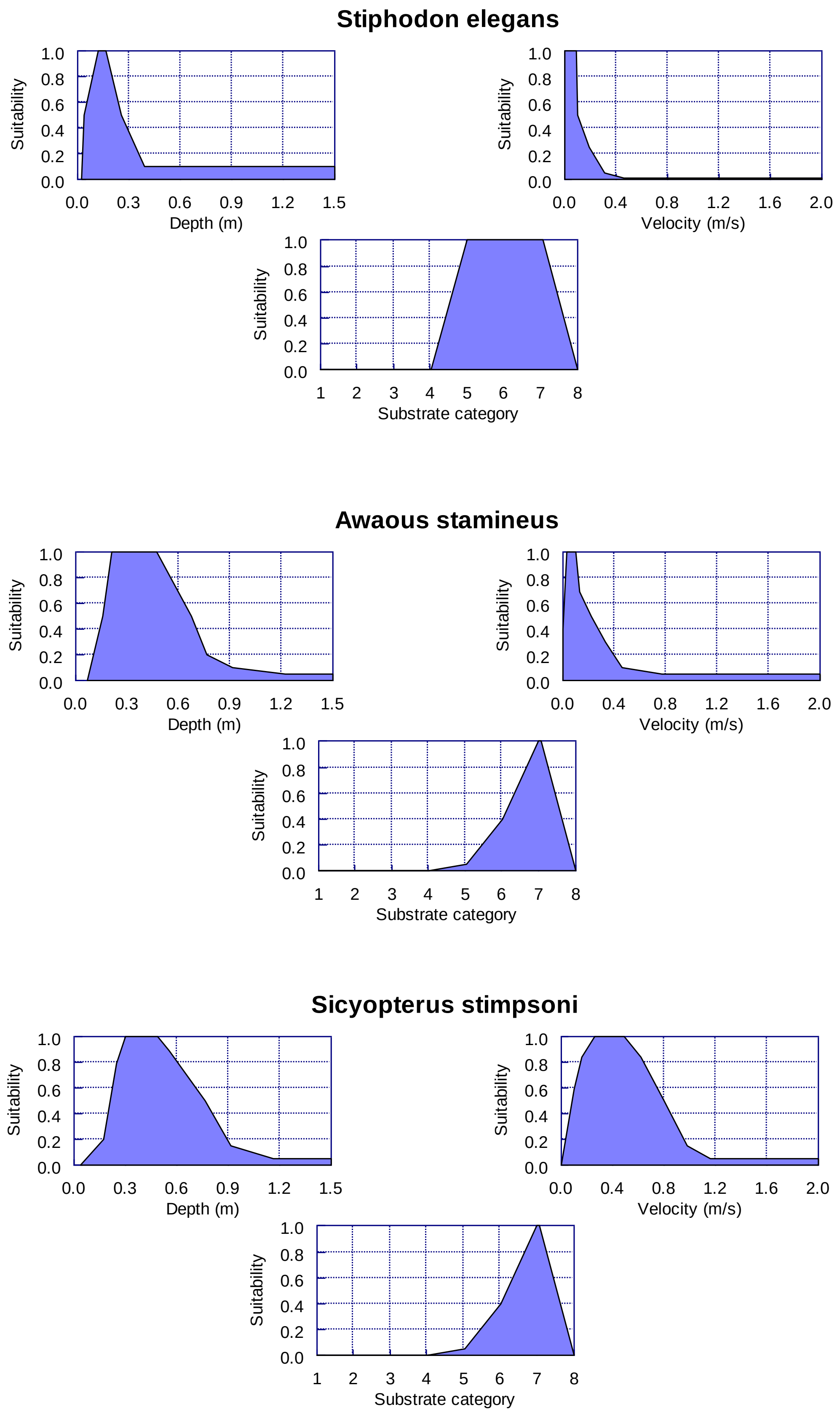


Figure 7-5: Habitat suitability curves for goby species from Guam and Hawaii from Thomas R Payne & associates. The substrate categories are 1= vegetation, 2=mud/silt, 3=sand,4=fine gravel, 5=gravel, 6=cobble,7=boulder, 8=bedrock.



7.6 Invasive, Rare, Endangered, Endemic and Threatened Species

This sub-section describes observed species that are deemed ecologically important because of their migratory patterns, endemic status, threatened and protected status, and water dependence. These include migratory species, Guadalcanal island endemics species, species included by IUCN as red listed (Vulnerable, Endangered or Critically Endangered), species protected by CITES, and those that are dependent on the river water system.

Although Polhemus, et al. (2008), surveyed many islands in the Solomon Islands archipelago for aquatic insects, and compiled results in the report entitled "Freshwater Biotas of the Solomon Islands: Analysis of Richness, Endemism and Threats", there is a lack of literature regarding specific life cycles, and breeding and feeding habits of most fauna in the Solomon Islands. Therefore, due to limited scientific data and limited previous surveys, there is only partial knowledge regarding the extent of impacts that TRHDP activities may have on terrestrial species.

7.6.1 Endemic Aquatic Insect Species

Guadalcanal is rich in aquatic insect diversity. Polhemus surveyed many islands in Solomon Islands for aquatic insects, including nine locations in Guadalcanal, four of which were in the TRHDP study area. These four stations are presented on the map in Figure 6-1. Surveys were carried out between 2004 and 2005. The table in Annex 7 of the Annex Report shows sampling results from Polhemus *et al.* (2008), aquatic insects observed by the ESIA team were added to the table.

Among the aquatic insect species of the Sub Order Heteroptera (true bugs), 12 species occur on Guadalcanal, 4 of which are endemic across Solomon Islands, and 8 of which are endemic to Guadalcanal.

Among the aquatic insect species of the Sub Order Odonata (dragonflies and damselflies), 15 species occur on Guadalcanal, 8 species of which are endemic across Solomon Islands, and 7 species of which are endemic to Guadalcanal.

Among the aquatic insect species of the Sub Order Coleoptera (beetles), 7 species occur on Guadalcanal, 1 species of which is endemic across Solomon Islands, and 6 species of which are endemic to Guadalcanal.

This richness in aquatic insect species is primarily threatened by logging activities, which can lead to stream degradation, obstruction and siltation from tree falling. Logging also creates openings in the canopy leading to an increase of stream temperatures, which affects habitat requirements of many aquatic species. Oil palm plantations also pose a threat to aquatic insects, due to runoff of water containing of fertilizers and pesticides. Finally, mining activities can cause siltation and introduce chemicals to the streams.

7.6.2 Invasive Aquatic Species

Two major invasive aquatic species, Mozambique tilapia (*Oreochromis mossambicus*) and mosquito fish (*Gambusia holbrooki*) can become very numerous in the lower reaches of Guadalcanal rivers. *O. mossambicus* was recorded at Ngalimbiu River bridge (Golder Associates, 2009) and in a billabong near the Tina Village during the scoping study (PHCG, 2010). The species was not observed during the 2013 fish survey, though its presence was confirmed by interviews with local fishermen, and by observations made during the rainy season.

The dynamics of these two invasive species are believed to be low in the Tina-Ngalimbiu River, due to dominant rheophilic conditions (fast moving water), and to the flow pulse in a short period of time. Tilapia is definitely not a species adapted to rheophilic conditions found in the middle/upper Tina River. This ESIA considers that this species will not colonize the upper Tina River catchment, and will not have consequences on local fish biodiversity. The species has already been present in the lentic environment of the Ngalimbiu River for many years, and has not invaded middle/upper Tina River.

7.6.3 Endemicity and IUCN Status

The endemicity rate of freshwater fish in Solomon Islands has been assumed to be low, compared to other taxa like aquatic insects (Polhemus et al, 2008), although recent detailed studies have revealed a level of freshwater fish endemism in the Solomon Islands that was not previously appreciated (Keith et al. 2017).

According to Polhemus et al (2008):

> . . . *interestingly, although freshwater fishes show notable endemism on both New Guinea and Fiji which bracket the SI region, there were no locally endemic genera or species of freshwater fishes previously recorded from the SI archipelago, nor were any unequivocally discovered during the present surveys, although there is a possibility that a few sicydiine gobies collected may prove to be regionally endemic*.

In contrast, the aquatic insect biota is represented by many endemic species often confined to single islands, with an endemic rate of 44% to 90%, depending on the taxa, and 32 species new to science.

Fish surveys on Tetepare Island, Western Province (Jenkins and Boseto, 2007) show that most species have a wide geographical distribution range in the Indo-Pacific area. Though, 15% of the fish fauna is either restricted to the Melanesian archipelagoes (5%) or only known from Solomon Islands (10%). Regarding the latter, five un-described species were identified.

The Tina River and other Guadalcanal rivers are likely to present the same range of species, with a few restricted range species, especially in genus *Schismatogobius, Stiphodon, Sicyopterus* and *Lentipes.* Endemicity at the Tina/Ngalimbiu watershed level is very unlikely, given the above mentioned scientific results.

For all recorded species, IUCN status is given as least concern or not evaluated / unknown. No native vulnerable, or near threatened, or endangered, fish species have been found in the Tina/Ngalimbiu River system. Some species are rare, according to local communities, and have been identified as such in Table 4-13.

7.7 FISHERIES IN THE TINA-NGALIMBIU RIVER

Along the river, fishing activities were recorded at all surveyed stations. The remote areas at and upstream of the dam location are fished very occasionally, and only on particular occasions, due to difficult access. Further downstream, in inhabited areas along the lower Tina River and upper Ngalimbiu River, subsistence fishing is a continuous activity, practiced either by adults or children, using mainly snorkelling and spear fishing gear. From interviews with local fishermen, fisheries activities have increased with growth of human population, especially for younger people. During the field survey conducted near Horohotu, a fisherman exhibited a catch of 6 specimens of considerable sizes (mullet and rock-sucker gobies) caught with a spear.

The shore along the mouth of the Ngalimbiu River is a very bountiful fishing location due to the concentration of adult and juvenile fish of different species entering into the lower river. About 30 fishermen from Komporo and other coastal villages are working at the mouth of the river during both daytime and night time, either for subsistence or commercial fishing, using canoe, gill nets, and mosquito seine nets. According to fishermen that were interviewed, a single fisherman can earn SBD 1,500 by selling the catch. Goby larvae are very appreciated and sell for SDB 5 per cup. The catch with 50-70 test fishing lines is very high (e.g., 40 fish per 20 minutes was mentioned) and even higher with 1” mesh gill nets.

At a monthly frequency, when full moon and sun meet at the dawning of a day, the fishers await massive migrations of juvenile fish entering into the river. In the upstream reach, increased catches have been observed during these periods. Apart from juveniles, migration of large specimens of marine forms and eels reaching maturity, are targeted in the upper reaches.

7.8 TINA RIVER UPPER CATCHMENT, A CRITICAL NATURAL HABITAT?

This sub-section discusses the significance of the upper Tina River catchment solely on an aquatic ecology basis, since it is the main upstream component that will be modified due to the Project. However, the upper Tina River catchment is also an important terrestrial habitat, since it is covered by a significant area of Montane forest and is the location for many high peaks of Guadalcanal.

7.8.1 Critical Habitat

As defined by World Bank Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources, critical habitats are “areas with high biodiversity value, including:

(i) habitat of significant importance to Critically Endangered and/or Endangered species (IUCN classification);

(ii) habitat of significant importance to endemic and/or restricted-range species;

(iii) habitat supporting globally significant concentrations of migratory species and/or congregating species;

(iv) highly threatened and/or unique ecosystems; and/or

(v) areas associated with key evolutionary processes”.

Unlike the forests in the upper catchment, the Tina River itself does not meet the critical habitat definition. It does not shelter endangered fish species (see table of fish species for definitions).. Although all fishes are migratory within the Tina River catchment, fishes in Solomon Islands do not show homing behaviour, meaning that juveniles can colonize any river, rather than just their natal stream, and do not depend on a particular river for support.

The upper Tina River also does not satisfy the definition with respect to endemic or range-restricted insect species in the groups that were sampled for the ESIA or in the literature. All identified endemic insect species have also been identified as present in a number of other river catchments within Guadalcanal outside of the study area and well outside of the area of impact for the Project.

Polhemus's account of the biogeography of Solomon Islands aquatic insects suggest that catchment-specific impacts of the Project are unlikely to have wider impacts on species populations.[50]

7.8.2 Value Of The Upper Tina River Catchment

7.8.2.1 Important in Fish Life Cycle

The upper Tina River and its tributaries are a significant spawning ground for most amphidromous species, and a rearing / maturing location for many catadromous species, due largely to the high water quality, the richness in habitats in tributary rivers, and food availability. In addition, the length of rivers within the catchment allows for many habitats to shelter a significant number of fishes. However, the length of rivers in the Tina River catchment is not a factor that increases fish lifespan or fertility, since these factors are determined genetically and environmentally. Some environmental signals trigger fish to migrate, to spawn and die, regardless of the length of the river system.

The absence of human settlement is the upper Tina River catchment also allows fish to thrive without significant harvest pressure. The large area of intact forest adds value to the river catchment, since leaf detritus, flowers and fallen fruits provide nutrients to the river system. In addition, the local topography, with its high peaks brings cool, rapid and well-oxygenated water to the catchment, attracts fish. The water temperature gradient found along the Tina River is an important environmental cue suspected of being a trigger for fish migration. Many Tina River tributaries originate at elevations of between 1000masl and 1600masl, bringing cool water to the system. Flash floods can be very powerful in the upper catchment, contributing rich nutrients that support biomass productivity, and provide connectivity for larvae to migrate to the ocean.

It is, however, important when comparing the value of habitat to mention that the mouth of the river is more "critical" to the life cycle of fishes, than the upper catchment. This is because the river mouth is the unique entry point for all migratory fishes when at the fragile juvenile stage of their lives. Disturbances at the mouth of the Tina/Ngalimbiu River can have greater adverse impacts on juveniles, than disturbances to the upper reaches of the river system have on adult fishes.

7.8.2.2 Tina River Uniqueness

Assessing the value of the upper Tina River catchment is rather difficult, since little scientific data exists regarding other river catchments with which to compare the Tina River. Prior to the Gold Ridge mine development, Chovohio River and Tinahulu River catchments (Matepono) were likely similar to the Tina River catchment, where 45 species of fish were identified (Golder and Associates, 2009). Likewise, the Tetepare catchment had 60 identified species of fish (Jenkins and Boseto, 2006). By looking at these two other catchments, the Tina River's fish biodiversity appears to follow the general trend in Guadalcanal. Other than its relatively large catchment area, based on the limited knowledge of its fish biodiversity, the, Tina River catchment does not appear to represent unique habitat within the Guadalcanal context. Moreover, within the South Pacific region, catadromous and anadromous

[50] Polhemus (2008) p. 105. Polhemus in discussing hydropower projects notes that "…their impacts would be confined to the mid- and terminal reaches of a few individual river catchments. Given the short, discrete nature of many Solomon Islands drainage basins, and the sharp topographical divides separating them, the environmental changes caused by any one dam, although locally dramatic, would have little overall effect on the aquatic biota of a given island, and would not serve to endanger any endemic species in a global sense."

fish do not present a homing behaviour. Juveniles are able to colonize any river, rather than just their natal stream.

Notwithstanding, all of the fish surveys conducted to date have been based on qualitative, rather than quantitative methodologies. Therefore, it is difficult to determine the quantity of fish that the Tina River system is able to produce, compared with other catchments. Several factors could be having a positive influence on fish biodiversity, productivity and abundance, and contribute to the uniqueness of the Tina River, including:

- Its large catchment area, the majority of which is undisturbed forest;
- It is among the few rivers that drain mountain peaks that reach to 2000masl in altitude. The topography also makes the area less accessible to human related disturbances.
- The length of the river network provides a variety of aquatic habitats for catadromous and amphidromous fishes, enabling them to thrive without human pressure.

The Tina River is among the few rivers that possess all these features, thereby making it a distinctive river in terms of its physical characteristics.

7.9 CONCLUSIONS ON FISH AND AQUATIC ENVIRONMENT

Although the upper Tina River catchment plays an important role in the life cycle of various fish species, it is not a critical role since:

- Fishes do not show homing behavior, meaning that juveniles will colonize any rivers, rather than only their natal stream;
- The mouth of the Ngalimbiu River is more critical to the life cycle of fish species found within the system, than upstream areas, as the mouth of the river is the only point between the river and the ocean that all species of fish must cross at some point in their live histories.

Based on current knowledge, the waters of the upper Tina River are a highly valued aquatic habitat, but not critical habitat.

8. SOCIO-ECONOMIC / SOCIO-COMMUNITY BASELINE

8.1 SOCIAL ENVIRONMENT

8.1.1 Meeting at Hill Top

Prior to commencing the social assessment, a meeting was held at Hill Top with Bahomea Chiefs, members of the TRHDP PO team and the ESIA team. The objective of the meeting was to present the ESIA process to the Chiefs, taking note of Chiefs' grievances, and to get their blessing prior to commencing fieldwork.

Table 8-1 lists the persons involved in the meeting:

Table 8-1 List of attendance at Hill top meeting

Name	Title	Name	Title
Timus Matthew	Chief	Aldin Roger	
Mahlon Dasi	Teller	Japan Chaku	
Kapini Sosimo	Chief	Deresa	Chief
Michael Meki	Chief	Riskiy Rongo	
Gilbert Avai	Elder	Zimiri Launi	
Daniel Garusi	Chief	Oscar Billy	
Alfred Ilala	Chief	Jonathan Beho	Chief
Adam Singi	Elder	Areson Handila	
Rex Ata	LOC	James kaputi	
Albert Ringo		Pastor Kedimiel Lauri	Pastor
Hudson Solo	Chief	Michael Litany	
Timothy Suigi		Peter Rocky	Paramount Chief
Richard Anisie	Chief	Mahlon Maeni	Chief
Masioth Rere		David Tapitoa	
Peter Lakale	Chief	Jabeth Lati	
Dohlan Gisi	Chief	Crystal Frenda	
Penuel Pore	Chief	Bethsaida Neka	
Enoch Mark	Chief	Dorcus Pesini	
Malcolm Rino		Eric Gorapava	TRHDP PO
Hipo Suhara		Brally Tavalia	TRHDP PO
Absuah Zapaniah		Julian Maka'a	TRHDP PO
Wickham Kesi		Daniel Una	Chief

Name	Title	Name	Title
Madrush Welmah		Eric Deneut	ESIA Team
Julia Jackie		Fred Patison Siho	ESIA Team
Lovelyn Hema			

Minutes of the meeting are included in Annex 4 of the Annex Report.

8.1.2 Social Assessment Methods

8.1.2.1 Staff Involved

The Social studies were led by Gerard Fitzgerald, Sociologist. He was accompanied by a team of National experts, including:

- **Lawrence Foana'ota, National Cultural Heritage consultant; and**
- **Kellington Simeon, National social assessment assistant.**

Additional assistance was provided by the following:

- Sharon Tabea-Para, an indigenous woman from the area, who also acted as a project Community Liaison Assistant (CLA). Ms. Tabea-Para is an independent Sociologist with independent local knowledge about local protocols, custom, village populations, kinship relations, natural resources, and the local environment. She facilitated culturally-safe access to local women and provided the team with local indigenous language translation skills.
- Zimri Laoni and Rex Ata, TRHDP office community liaison assistance (CLAs) from Bahomea, who provided liaison with local leaders and groups in the Bahomea communities.
- Community Liaison Assistants (CLAs) from Malango and Ghaobata.
- An officer of the Guadalcanal Provincial Government, who assisted in organising meetings with downstream communities.

Several observers attended village meetings during the fieldwork, including:

- Real Courcelles, an international expert in project benefits sharing, who attended at Marava
- Brally Tavalia, the TRHDP PO Community Liaison Officer.
- Fred Patison, who attended workshops at Mataruka and Ado villages in the Malango area.

8.1.2.2 Dates of Surveys

Field surveys were carried out from 29 August to 25 September 2013.

8.1.2.3 Location of Surveys

The program of fieldwork was developed by the ESIA team in consultation with Project officers, the project CLAs, and the environmental assessment team. The aim was to concentrate most of the fieldwork effort on the indigenous communities likely to be most directly affected by the proposed development options, while also allowing time and resources for input to be provided by communities, and stakeholders, not likely to be immediately or directly affected by the project's construction or operation.

Table 8-2 shows the extent of social science fieldwork carried out by the team.

Table 8-2 Village fieldwork schedule and locations

Date	Core Venue	Target hamlets/stakeholders	Grouping	Ward
2-Sep-13	Marava	Marava, Vatupaua, Rate CHS, Ngongoti	Bahomea	Malango
3-Sep-13	Haimane,	Vuramali, Haimane, Horohutu 2, Katihana	Bahomea	Malango
4-Sep-13	Tina	Tina, Valebebe, Valebarik, Valemaota, Tahurasa	Bahomea	Malango
5-Sep-13	Antioch	Antioch, Valesala, Komeo	Bahomea	Malango
9-Sep-13	Senge	Senge, Koropa, Choro	Bahomea upstream	Malango
10-Sep-13	Pachuki	Habusi, Pachuki, Veraloka	Bahomea	Malango
11-Sep-13	Office	Fieldwork team & assistants		
12-Sep-13	Verakuji	Mangakiki, Verakuji	Bahomea	Malango
13-Sep-13	Namopila	Namopila, Komureo, Valekocha, Vatunadi	Bahomea	Malango
17-Sep-13	Mataruka Ado	Malango (Mataruka 1, 2, 3, & 4) Belaha communities	Bahomea	Malango
18-Sep-13	Vera'ande Horohutu 1	Vera'ande, Verakweli, Niumahata, Horohutu 1(settlers)	Settlers	West Ghaobata
19-Sep-13	Ravu	Ravu area hamlets (Ghaobata plains communities)	Ghaobata - downstream	West Ghaobata
20-Sep-13	Verakabikabi Old Selwyn	Settler communities, lower roadside Ghaobata plains communities	Settlers Ghaobata - downstream	West Ghaobata West Ghaobata
23-Sep-13	Honiara	Team workshop with assistants & project team		
24-Sep-13	Honiara	Institutional stakeholders	Government and non-government organisations	

8.1.2.4 Community and Stakeholder Participation

International ESIA practice guidelines specify participation by project-affected persons (PAPs), and other stakeholders in the planning of a project, and in the social impact assessment process. Such participation provides the opportunity for project planners and assessors to learn directly about local social conditions, ways of life, and existing issues among local people and communities. It also provides the opportunity for people and communities to help shape proposals that directly affect their present and future social and economic conditions. Consultation and other activities for engaging people are, therefore, normally initiated in the early stages of a project, rather than after key decisions have been made.

Current good international industry practice (GIIP) attempts to move beyond simply providing information. Rather, GIIP requires two-way dialogue to develop partnerships and empower people and communities, to enable themselves to play an active role in shaping developments to meet their own needs[51]. There is a considerable body of literature on how to achieve participation in development projects, especially by vulnerable groups. Participatory methods (such as those offered by Participatory Learning and Action (PLA)) are increasingly used in developing countries for project and programme identification, planning, assessment, and implementation.

The TRHDP PO, which is embedded within MMERE, is a well-organized, and comparatively well-resourced organization, with an explicit mandate. The TRHDP PO has planned and implemented an ongoing program of stakeholder, community, and indigenous leader engagement. The program has included, among other things:

- awareness raising activities, including suitably crafted multi-channel information dissemination.
- the creation of appropriate forums for discussion and negotiation, including formulation of access agreements for the project investigations, memoranda of understanding between the TRHDP PO and customary land owners and their leaders and an agreement for the acquisition of the Core Land with the five landowning tribes.
- establishment of a network of trained community-based liaison assistants to aid communication between villagers and the project office.
- public meetings, conferences, participatory workshops, and small group and individual discussions.
- study tours to hydropower facilities elsewhere in the Pacific.

Ongoing consultation activities implemented by the TRHDP PO have been reported in project newsletters, media releases, and on the project website *http://tina-hydro.com.*

8.1.2.5 Methods

GIIP recognises that community and stakeholder participation is integral to ESIA, and most professional organisations, such as the International Association for Impact Assessment (IAIA)[52], stress that the outcomes of consultation/participation should be incorporated into the project design, and into the assessment, management, mitigation and monitoring of social and other impacts.

The TRHDP ESIA work itself was specifically designed and implemented to achieve active participation by project affected people (PAPs), local residents, downstream, residents, other

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51 See a recent (2014) description of landholder involvement in the TRHDP by Roughan, at http://www.stakeholderforum.org/sf/outreach/index.php/previous-editions/sids/sids-day-7-water-food-and-waste/11724-the-tina-river-experience-power-only-through-partnership

52 The international professional body for impact assessment professionals: See www.iaia.org.

stakeholders, project planners, and environmental technical specialists. The participatory focus workshop process, combined with face-to-face interviews and direct observation with local communities was chosen to enable active participation and interaction between the assessment team and the stakeholders. The details are outlined below in the description of the ESIA fieldwork.

Prior to conducting field visits, information was gathered from various stakeholders, including the MECDM, MHMS, Guadalcanal Provincial Office, and the Census Office. Information was obtained from personal communications with these sources. The main stakeholders consulted during the course of the assignment included the TRHDP PO, MECDM, MHMS, Guadalcanal Provincial Office, National Census Office, other international consultants and TRHDP CLAs and environmental experts working on the ESIA. Issues pertaining to the project location and settings were discussed with the TRHDP PO and its CLAs. Governance issues relating to the Project, were discussed with the MECDM and Guadalcanal Province. Health issues were discussed with the MHMS. Other relevant topics of discussion, such as benefit sharing, were discussed with other international consultants engaged by the World Bank as advisors to the Project.

A key output of the planning stage was a program schedule for the village workshops. The schedule took into consideration the amount of time available for the social studies, the size of the project area, and the impact of weather on accessibility. As part of the schedule, key focal villages were identified as optimum locations for conducting workshops and face-to-face interviews, since it was recognized that it would be difficult to carry out workshops in each and every village within the project area.

The social research fieldwork required 4 weeks to obtain primary data for the social profile and for the assessment of impacts. All members of the social assessment team were involved in the detailed planning of the fieldwork program and selection of methods, assisted by TRHDP PO project officers and CLAs - the latter serving as the main points of contact and logistics organizers within the study communities.

The social scope for the assessment, as specified by the study terms of reference (TOR), covered:

- the above geographical areas, and within them the:
  - Teha speaking customary landowning residents, including leaders, general public, groups, kinship groups, women, and youth.
  - The ”settler” residents (that is, people originating from elsewhere in Guadalcanal, but residing locally as ”guests” of the landowners.
- users of the Tina River in general.
- other stakeholders, including customary landowners who do not regularly reside within the project area, and environmental and community NGOs.

To ensure that the various stakeholders specified in the TOR were covered by the fieldwork investigations, the Tina River catchment area_was divided into four areas or zones, based on the proposed project, - each with a different set of issues to be investigated, as follows:

1. Any communities located in the *Direct Impact Area*, that is, the lands required for the construction and operation of the proposed dam, storage reservoir, headrace tunnel, and powerhouse, as well as any borrow areas, set down areas, and yards, etc (Core Area) and any communities located in the 50 metre wide access road and transmission line corridor (Infrastructure Corridor). No communities or residences were identified in this area or in the Upstream Area above the reservoir.

2. The people and communities likely to be mainly affected by changes in the river water quality, volume, or availability during the construction or operation of the hydro scheme –downstream of the power station site. This area was designated as the *Downstream Area.* Within this group, the Senge Community are the villages located closest to the Direct Impact Area.

3. The people and communities likely to be mainly affected by modifications to, and use of, the existing or new access road/s, and transmission line corridor but who are not located within the *Direct Impact Area*. These areas were designated as the *Infrastructure Area*.

4. The people and communities who use or have ownership rights to land and resources in the project area and downstream, but do not necessarily reside in the Tina-Ngalimbiu River valley. These were designated as belonging to the *Wider Impact Area* (WIA).

These various groupings are generally consistent with the communities' geographical distance from the Core Area. Groups 1 to 3 could also be affected by loss of access to livelihoods and resources upstream of the proposed dam, and by the potential presence of a construction workforce. All groups could benefit from employment or contracting opportunities during construction and operation of the scheme.

Using this classification, the villages and hamlets in each of the different project impact areas were identified, as shown in Table 8-3.

Table 8-3 Classification of Tina Catchment settlements by potential project affect

Impact area	**Customary landowning communities**	**Non-customary communities**
Direct Impact Area (DIA) and Upstream Area Settlements	*None.*	
Downstream Area Settlements	*In Bahomea district:* ***Senge Community (proximate to the reduced flow reach):*** Choro, Koropa, Senge ***Other Bahomea:*** Habusi, Pachuki, Namopila, Komureo, Vatunadi, Tahaurasa, Tina, Valebebe 1 & 2, Vuramali, Haimane, Valebariki, Horohutu2 *In Ghaobata area (plains):* Popolo 1 & 2, Old Selwyn, Ngalimera, Selaghoghoro, Pokasou, Siroigha, Kadavu, Ravu area, villages on Tenakaro Road, and riverside road to Tetere between main road and the mouth of Ngalimbiu River .	Horohutu1 New Birao GPPOL village,

Impact area	Customary landowning communities	Non-customary communities
Infrastructure Area settlements	*Bahomea District* Mangakiki/Verakuji, Pachuki, Marava area, Vera'ande/Grassy	Verakabikabi, Namanu area
Wider Impact Area (WIA) settlements	*In Malango district* Communities of Malango area and Belaha area	

The social studies in the communities consisted of the following:

- Structured community workshops designed to collect information in each village area about a) the local way of life, social organization, history of settlement, resources, and livelihoods, and b) views on potential project impacts. Each meeting brought together several associated hamlets. The meetings typically took approximately 4 hours and followed a standard format. Discussions were conducted in Solomon Islands pidgin and occasionally in the local indigenous language (Teha) and were aided by the use of large format maps, printed satellite imagery, and sketched diagrams. Where necessary, additional explanation of the hydro scheme components and operation (as known at the time) was provided by the team. Attendance sheets were completed for each meeting. Fifteen such village workshops were held covering the residents of 40 villages and hamlets. Total attendance was at least 511 men, woman, youths, and children.
- A questionnaire survey of a random selection of female householders from each of the hamlets represented at the community meeting. This questionnaire covered household nutrition, health, gender and age division of labour, resources and income, and anticipated project impacts. Approximately 50 such interviews were conducted, each taking approximately 30 minutes.
- Individual interviews with village and tribal chiefs and older men about sacred and important cultural sites and issues. These were conducted by the team's national cultural impact specialist.
- Where time permitted, transect walks were carried out through village and garden areas, complemented by photography and recording.

The social baseline studies were carried out by both on-site social surveys and bibliographical data. Photographs in Figures 8-1 and 8-2 illustrate engagement activities at three of the villages located within the project area. The methods used to undertake the social surveys are presented in the following sections.

Figure 8-1 Verakambikambi Village; men, women and children participating in the discussion

Figure 8-2 Discussion at Segue and Tina Village

8.1.2.6 Recording People's Responses

The members of these communities were given the opportunity to inform the ESIA team of their specific communities' interests, and concerns regarding the construction and operation impacts of the proposed hydropower project. These were recorded on a white board, and detailed notes were also made. The responses to the questions and the concerns raised are presented in this report (also see Annex 15 in the Annex Report).

Time was provided in the fieldwork program for consolidation of fieldwork notes and photographs between the team members, and for reviewing and completing questionnaire forms, when necessary.

8.1.3 Summary of Results

Using the fieldwork program schedule as the reference, and with the aid of the local field assistant and CLAs, the Social research workshops were conducted in 15 focal villages, within four main districts (Bahomea/Tina, Malango/Belaha, Mid-Catchment and Roadside, and Plains).

Residents of more than 45 village communities attended the focus workshop meetings. Participants included tribal chiefs, village chiefs, youth, men, women and children. Overall, a total of 511 people attended the meetings.

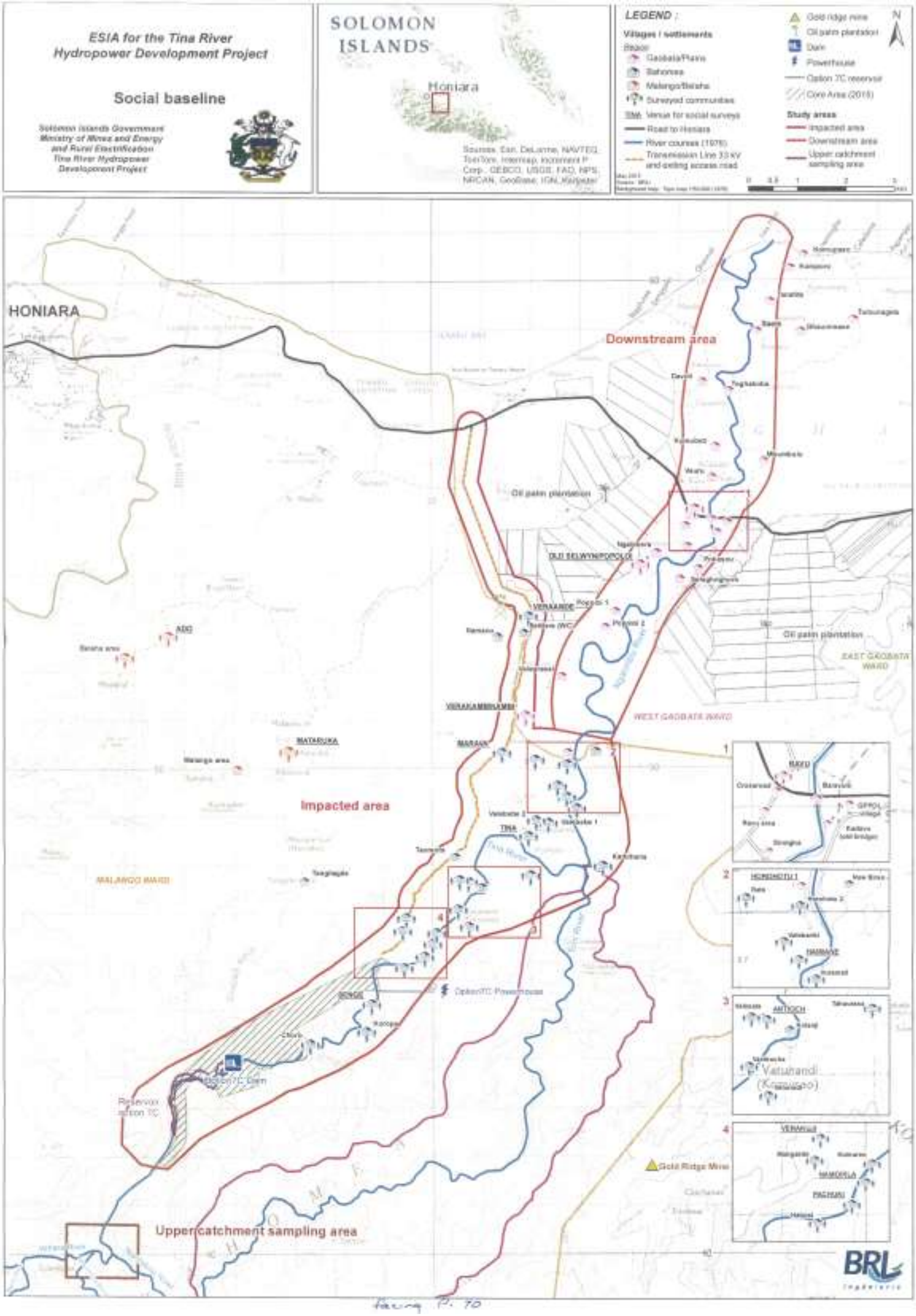
Table 8-4 lists the focal villages and some of the communities that attended the workshops, including the number of participants. Figure 8-3 is a map that identifies the surveyed communities.

Results of the social assessment studies are discussed in the next sections.

Table 8-4 Surveyed communities

Date	**Venue**	**Communities**	**Approx. number of Participants**	**District**
2-Sep-13	Marava	Marava, Vatupaua, Rate CHS, Ngongoti	31	Bahomea (Upstream Communities)
3-Sep-13	Haimane	Horohotu 2, Vuramali, Haimane, Katihana	44	
4-Sep-13	Tina	Tina, Valebebe, Valebarik, Valemaota, Tahurasa	38	
5-Sep-13	Antioch	Antioch, Valesala, Komeo	41	
9-Sep-13	Senge	Senge, Koropo, Choro	22	
10-Sep-13	Pachuki	Habusi, Pachuki, Veraloka	43	
12-Sep-13	Verakuji	Mangakiki & Verakuji	80	
13-Sep-13	Namopila	Namopila, Komureo, Valekocha, & Vatunadi	28	
17-Sep-13	Mataruka and Ado	Mataruka 1, 2, 3, 4, Belaha, More than ten villages (2 separate meetings held)	83	Malango/Belaha
18-Sep-13	Veraande & Horohotu 1	Veraande, Verakwele, Konga Horohotu 1, Niumahata (NB: Two separate meetings held)	24	Bahomea Settlements Communities
19-Sep-13	Ravu	(at least 5 communities represented)	19	Gaobata/Plains (Downstream Communites)
20-Sep-13	Verakambikambi Old Selwyn	Verakambikambi Old Selwyn (Popoloi) (NB: Two separate meetings held)	58	

Figure 8-3 Map of communities surveyed within the project area



facing P. 70

8.1.4 Post August 2017 Community Engagement and Consultations

Following completion of the August 2017 version of the ESIA, the Project Office continued to undertake regular community awareness visits from September to December 2017 to provide updates on Project activities.

During 2018, the main workstream for the Project Office was the ongoing negotiation of the Power Purchase Agreement, Implementation Agreement and other Project Documents. During this year, as there were fewer activities on which to provide updates, community and landowner engagement focused on smaller group meetings in the Project Office.

Following the signing of the Power Purchase Agreement (PPA) in December 2018, community engagement will enter the next phase in 2019. From April 2019 the Project Office will engage an additional Community Liaison Officer (CLO), who will also act as a Gender Focal Point for the Project, to join the existing CLO. The two CLOs, together with a Communications Officer, will conduct monthly awareness sessions in the Project communities to ensure communities are kept informed of events and progress during the PPA closing period, targeted for completion in August 2019, and throughout the construction and early operations phase of the Project.

In addition to the community engagement work undertaken by the Project Office, in 2019 Tina Hydropower Limited (as the Special Purpose Company) will prepare and implement P-3 Stakeholder Engagement and Communications Plan (see section 12.5.6), governing the community engagement activities of Tina Hydropower Limited (THL) and their contractors. THL environmental and social team is responsible for the implementation and overseeing of the Stakeholder Engagement and Communications Plan.

8.1.5 Social Organization

8.1.5.1 Key Contextual Factors

Based on a review of reports and other secondary information, and fieldwork conducted in Guadalcanal, the following points seem to be crucial considerations for the planning of the TRHDP and the social assessment:

- the system of clan-based customary collective land ownership, coupled with shifting settlement patterns and leadership, and inter-tribal marriage, gives rise to complex claims and conflicts over resource and land rights;
- lack of services and infrastructure, underdevelopment, isolation, and poverty in Guale indigenous rural communities despite their proximity to Honiara;
- the historic settlement, agricultural development, and alienation of large areas of the Guadalcanal plains by colonial administrators and corporations, and their use of migrant labour from Malaita;
- the post-World War II development of Honiara as the modern day capital of the Solomon Islands with its associated multi-island and multi ethnic population located on Guadalcanal, and its on-going sprawl onto adjacent Guale customary land;

- on-going large-scale and unsustainable logging of Guadalcanal's indigenous forests by foreign logging companies with high level political patronage, that provides little apparent material benefit to the majority of indigenous land owners;
- the establishment of the Gold Ridge mine, with on-going grievances regarding distribution of benefits and royalties;
- the recent history of Guale rising up against the central government, the cause of which was a sense of inequity in the distribution of benefits and costs of development, and the associated violent conflict between indigenous people and "settlers" from Malaita, and other islands and regions. This ethnic tension, and associated civil unrest, was present in the project area and has abated under the authority of the Regional Assistance Mission to Solomon Islands (RAMSI), but has not necessarily been resolved[53].

At the local level, Pacific Horizon Consulting Group (PHCG) note the following are also important to the context for the TRHDP:

- The emergence of the Project Office as the primary identity for the TRHDP, rather than MMERE and its officials.
- The emergence of various groups and organizations for interacting with the Project and government, including the Bahomea House of Chiefs, the Malango House of Chiefs, the more recently formed Tina River Hydro Landowner Council (with 27 representative groups "purporting to represent a district clan within the Ghaobata and Malango areas"), along with area-based groupings of villages within the project affected area (e.g., the Upper River Catchment Community centered on Namopila)

The following sections provide a detailed description of the people and communities of the proposed project area and their socio-economic condition.

8.1.5.2 Settlement Patterns

The TRHDP study area consists of over 30 villages and hamlets of mainly indigenous people originating from the central Guadalcanal mountain lands, and several official "settler" villages made up of people originating from South Guadalcanal/Weather Coast.

The Bahomea villages and their component hamlets are mainly distributed adjacent to the Ngalimbiu River and lower-mid sections of the Tina River, and are often only hundreds of meters apart. In some cases it is hard to distinguish where one hamlet ends and another begins (e.g. Antioch and Valesala). Most hamlets in the study area are connected together by walking tracks and in some cases by dirt roads, which are prone to becoming impassable during wet weather. In recent years, settlements have been established along the main Bahomea access road and logging track that run up the ridge that marks the left side of the Tina Valley.

Settlements range in size from two-house hamlets with one extended family, up to villages with dozens of houses and over a hundred residents. These larger villages tend to be arranged around a

[53] For example, during the ESIA fieldwork in September 2013, a group of intoxicated Malango youths from the Tina village area attacked a Weather Coast settler and destroyed their roadside stall/shop at the corner of the Namanu Road in the hope of evicting them. Some of the settlers are occupying "alienated"/government land.

village square/green with a substantial church, and perhaps a meeting-house and other facilities. The details of the various villages are provided in subsequent sections.

Roughan et al (2011) and Entura (2012) both provide a history of the settlement of the Tina River area, and while the accounts differ in some respects, they agree on the following key aspects:

- the present-day indigenous inhabitants of Malango Ward, and in particular the proposed project area, are closely related and have common ancestors.
- the originating communities lay at the base of Mount Popomanaseu, and were variously named Sasahakama, Belana, Tuhurutolu, and Malukuna.
- Since World War II and the establishment of Honiara city, there have been successive waves (or chains) of migration down from the villages of the central mountains to the foothills to the north, so that people could be closer to modern services and employment, to be safer from landslides and other natural disasters, and to protect clan lands from intrusion inland by squatters and others.
- In these moves, people from different originating Malango villages stayed together and settled in different areas. The people from Belana and Tuhurutolu settled in the Tina river/Bahomea area. The people from Malukuna settled in the Malango area, and people from Sasahakama settled in the Gold Ridge area and on the Toni River.
- There has been some subsequent movement from the north back up the main ridges of Malango Ward, as areas have been opened up by logging roads, and possibly to avoid exposure to ethnic conflict.
- Mixed in with the indigenous Malango-speaking communities are more recent arrivals of people from the Weather Coast who sought refuge locally from natural disasters, poverty, and conflict, and who moved to find employment in the plantations and foreign owned resource industries.
- Since the 1980s there has also been unauthorised settlement on Malango lands by migrants from Malaita, and elsewhere, that were drawn to Honiara for employment.
- The ethnic tensions of the late 1990s and early 2000's displaced the non-indigenous settlers, including many hundreds working in the (now GPPOL) palm plantation, and squatters, resulting in a major reduction in the population of the Malango and West Ghaobata wards.
- With the subsidence of the ethnic tensions, people from the Weather Coast have returned to the Bahomea area, and squatters are again moving onto the government and alienated lands within Malango Ward.

At present, the mountainous interior of Malango Ward is essentially unpopulated, apart from periodic expeditions by the traditional owners for hunting and camping, and to reconnect with customary 'homelands". The indigenous people of the Tina River area are, therefore, aware of the locations of their key originating villages and important cultural sites. Since membership of particular clans is claimed through kinship connection with people from successive historic settlements and originating places, knowledge of such places is crucially important for establishing identity and land and resource rights.

Original migrants from these upland villages can be still found among the older residents of the TRHDP study area, and they have knowledge of the sequence of migration and village creation within the Tina catchment. A number of stories of such movements were recorded during the social impact assessment fieldwork. The sequence of movement is represented in Table 8-5.

Table 8-5 The settlement history of villages in the TRHDP area

Villages/ hamlets	Impact area	Year of establishment (approx.)	Origin notes
Senge Choro Koropa	Downstream	1970 1990s 2003	Originating place was Reiloto. Senge originally started in 1930s. In 1940s-50s moved to Marava, Vuramali, Mangakiki and Koropa. Some stayed. Senge destroyed by Cyclone Namu in 1986. Reoccupied and rebuilt in 1990s.
Verakuji Mangakiki	Infrastructure	c1984 c1987	Originally from Tangilagila/Hamilake, then Marava, then Mangakiki, and Verakuji and Verakila (1990s). From Turutolu/Malukuna, then to Tangikala, then Mangakiki.
Pachuki Habusi	Downstream	1996 Post 1986	Originally from Turutolu. Villagers moved in 1966 to Vatunandi & Valebungana, then Valekocha , then Valesala after Cyclone Namu in 1986, then Pachuki and Habusi
Namopila Komureo Vatunadi Valekocha	Downstream	2007 2004 1990 2008	Originally from Valevungana (est 1967). Cyclone Namu (1986) moved to Valekocha, then Valesala. Then dispersed to Choro, Vatunadi, Koropa, Komureo, and Valekocha
Antioch Valesala Kolanji Komeo	Downstream	c 1970 1986	Movement from the hill & forests began in 1960s. Came from Kolohaji, then Talamu and Turutolu, then Vatunandi, Valekocha, and then Antioch etc
Tina Valebarik Valebebe Tahurasa Valemaota	Downstream	1950 1980 1998 1999 2006	The first village in the lower part of the Tina River valley. Originally from Belana and Vurutolu. The other villages in the community were established to cope with local population growth
Marava Ngongoti Vatupaua Rate school	Infrastructure	1962	Moved from hills & forest. Other villages are spin off communities. Rate established by government as a district school campus, with teacher housing.
Vuramali	Downstream	1986	

Villages/ hamlets	Impact area	Year of establishment (approx.)	Origin notes
Haimane Horohutu 2 Vuvamali		c 1970 c 1960 -	
Horohutu 1	Downstream	c1980	Moved from Weather Coast of Guadalcanal to Konga in 1974 while founding family working for Foxwood Timber Milling Co. Started the settlement at Horohotu 1. Cyclone Namu struck in 1986. Other villages established subsequently.
Vera'ande Verakweli New Mahata	Infrastructure	2000 1968	Moved from Tina to Vera'ande in 2000 to take up a cocoa blocks on clan land left by Levers. Verakweli established by families from Veravolia. New Mahata established by families from the Weather Coast
Verakabikabi	Infrastructure	c1965	From Weather Coast. More settlers in 1970. Acquired custom rights to occupancy and use from indigenous land owners.

Traditionally, Guadalcanal villages were periodically moved so they could be located closer to newly cleared gardens, to move away from bad spiritual influences, or because of natural disasters. Such natural disasters feature prominently in the history of settlement of the Tina River Valley. Cyclone Namu, which hit the region in 1986, is probably the most significant event in terms of destruction and relocation of villages. Settlers from the Weather Coast also came north as refugees from floods, earthquakes, and landslides. Some of the early upland settlement areas of the Malango people were also badly affected by natural disasters[54]. Nowadays, various factors encourage villages to be permanently located, such as the building of permanent churches and houses using more durable building materials, the availability of services, roads and other infrastructure, and perennial cash crops. Reasons for relocation given by villagers who participated in the community workshops include:

- as resettlement after landslides, flooding and cyclones, especially Cyclone Namu in 1986;
- better access to employment and, therefore, the opportunity to improve living standards;
- better access to services and facilities, including health, education, transport, markets, and churches;
- to get better access to quality gardening land;

[54] Note that in early April 2014, subsequent to the ESIA fieldwork and reporting, a major flood in north and Central Guadalcanal appears to have damaged the villages of Habusi, Pachuki and Namophila. The local effects of the flood are unknown.

- over-crowding and shortage of resources, for example, land for a house or water supply;
- to escape influence of the Moro Movement (see description of Moro Movement in Section 8.2.5);
- to provide greater protection to clan land, especially from migrant labour squatters; and
- family disagreements or feuds.

Internal migration and the formation of new village communities are only possible because of kinship networks and clan membership, which provides access to land and livelihoods throughout the Bahomea/Malango area.

Downstream of the Tina River, where the Ngalimbu River joins the Guadalcanal plains, there are larger villages and hamlets made up of the indigenous coastal people, referred to as the Ghaobata. The plains and coastal area also contain hamlets of settlers from elsewhere, including "squatters" who have (re) occupied "vacant" marginal, or abandoned plantation land on the plains, which had been vacated during the Ethnic Tensions. The current makeup of the squatter hamlets is said to be predominantly Malaitan peoples drawn to the Honiara area for work, but this was not confirmed. It is clear from village discussions that the Bahomea and Ghaobata peoples regard the presence of these non-indigenous outsiders as a threat to their land and resource rights and is an ongoing potential source of conflict.

8.1.5.3 The People of the Project Area

LANGUAGE GROUP

The indigenous people of the TRHDP area are often referred to as the Malango and speak the Malango language (also known as Teha). They are hill peoples who once occupied hamlets around the central mountains of Guadalcanal, including Mt Popomanaseu, the highest point in the Solomon Islands. Up to the 1950s or so, the hill people of central-north Guadalcanal largely lived in isolated hamlets, rather than centralized larger villages that are evident today.

According to Lynch, Ross, & Crowley (2002), the Malango language belongs in the Bugotu–Gela–Guadalcanal family of languages within the overall Southeast Solomonic group, itself part of the Oceanic group within the larger Malayo-Polynesian set of languages. Other languages in Guadalcanal family of languages are Birao, Ghari, and Talise. According to Ethnologue (the Internet reference site for the world's languages), in 1999 there were an estimated 4,140 native speakers of Malango/Teha. The downstream neighbours of the Bahomea-Malango people of the Tina River valley, the Ghaobata people, are indigenous speakers of the Longgu language.

The Malango people are largely resident in the modern-day administrative Malango Ward of central-northern Guadalcanal, and have a population of 10,500, 95% of whom are Melanesian. The proposed TRHDP lies within the Bahomea district, and is centered on the Tina River and associated ridge/s running from the mountainous interior north towards the Guadalcanal Plains. The people of Bahomea district are kinsmen of the peoples of Malango to the west, and to those of the Gold Ridge area to the east. The Ghaobata people live on the plains, and are largely located in two administrative Wards – West Ghaobata and East Ghaobata. The Ngalimbiu River runs through West Ghaobata Ward to the sea (see the map in Figure 5-3).

KINSHIP AND TRIBAL STRUCTURE

Guadalcanal societies are known for their matrilineal descent systems, that is, where descent and inheritance are traced through the mother's line. Normally in matrilineal systems women marry outside their own kin group into a nearby community and reside with their husband's people after marriage. A woman's sons take up land from their mother's brother upon reaching adulthood. Adoption may also be used to provide matrilineages with heirs to land (Schoeffel, Fitzgerald et al, 1994). The most common pattern is for marriage partners to be chosen from a different clan, so in matrilineal systems one may not marry one's mother's kin, because they are members of the same descent group as oneself. However, one might be able to marry one's father's kin, since they are not of one's own descent group. Several matrilineal kinship systems are found on Guadalcanal.

Hogbin, in his 1930s studies of Guadalcanal societies[55], found that that the hill tribes of North Central Guadalcanal (Including the Malango people) are organized into a pair of exogenous matrilineal moieties, each with their respective custom origin stories. These moieties are known as the Manulava [56](the eagle or "big bird") and Manukiki (the hawk, or "small bird"). Every indigenous person belongs to one or other of these moieties. Hogbin also records that each moiety consists of a number of matrilineal clans/sub-tribes each of which carries the name of a different species of bird, and each clan has primary rights over blocks of land scattered /patch-worked across the tribal landscape, "with no piece of ground un-owned" (1964:17). That is, land and resource ownership is based on clan membership. This remains the situation today among the Malango people of the TRHDP area. In their review of the "Indigenous Terrain", Roughan et al (2011) confirmed that the matrilineal clans (mamata) of the study area "are the sole authorities vested with authority over territory" (p. 29).

Previous studies have noted that regardless of the decent system, in the Solomon Islands women tend to move to their husband's village after marriage (known as virilocal residence). In a matrilineal descent system, this means that women will be living away from their own land, which will be under the control of their brothers. As people living in villages where they are not members of its land-owning groups, they are, therefore, outsiders when it comes to local-level decision-making, particularly about land and resource use[57]. Women are far more likely to be in this situation than men. This tends to be the case in the communities of the TRHDP area, although there is a degree of variation in marital residence.

Figure 8-4 represents the kinship structure of Malango society as revealed by an informant in the Bahomea area. Note that terminology varies for the types of groupings at different levels, and there is a range of spelling for names of the different groups/units. This diagram suggests that there are 29 clans within the Tribe, though the exact number is contentious. For example, Roughan et al (2011), in their work on indigenous terrain mapping, identified 13 named clans in Bahomea, and 14 in Malango (27 in all), along with their chiefly representatives (see Table 8-6).

In 2010, SIG, through intermediaries, identified 27 tribal sub groups as having a stake in the TRHDP, and they became signatories to the original access agreement with SIG to allow the project feasibility studies to proceed. Subsequently, in consultation with local leaders, the TRHDP PO identified 10 "communities" and their component villages, along with the list of clans found in each community - giving a total of 21 locally resident clans.

Not all of the clans identified by our informant are present in the project area, or necessarily represented by either of the Houses of Chiefs (HOCs) as described in project documents. Further clarification on clans in the area is provided by the 'land identification' process undertaken by the

55 For example, Hogbin, I. 1964 A *Guadalcanal society: the kaoka speakers*. London, Holt,. Rinehart and. Winston.

56 Known to the Malango/Teha speaking people of the Project area *Manukama*

57 Schoeffel, P., Fitzgerald, G, and Loveridge, A. 1994. Solomon Islands Forestry Inventory Project Working paper 19: Forest utilisation in the Solomon Islands: social aspects and issues

Bahomea Land Identification Committee comprised of Bahomea story tellers, a Paramount Chief, a church leader and tribal chiefs (TRHDP, 2013).

Figure 8-4 Tribal Structure of the Malango people

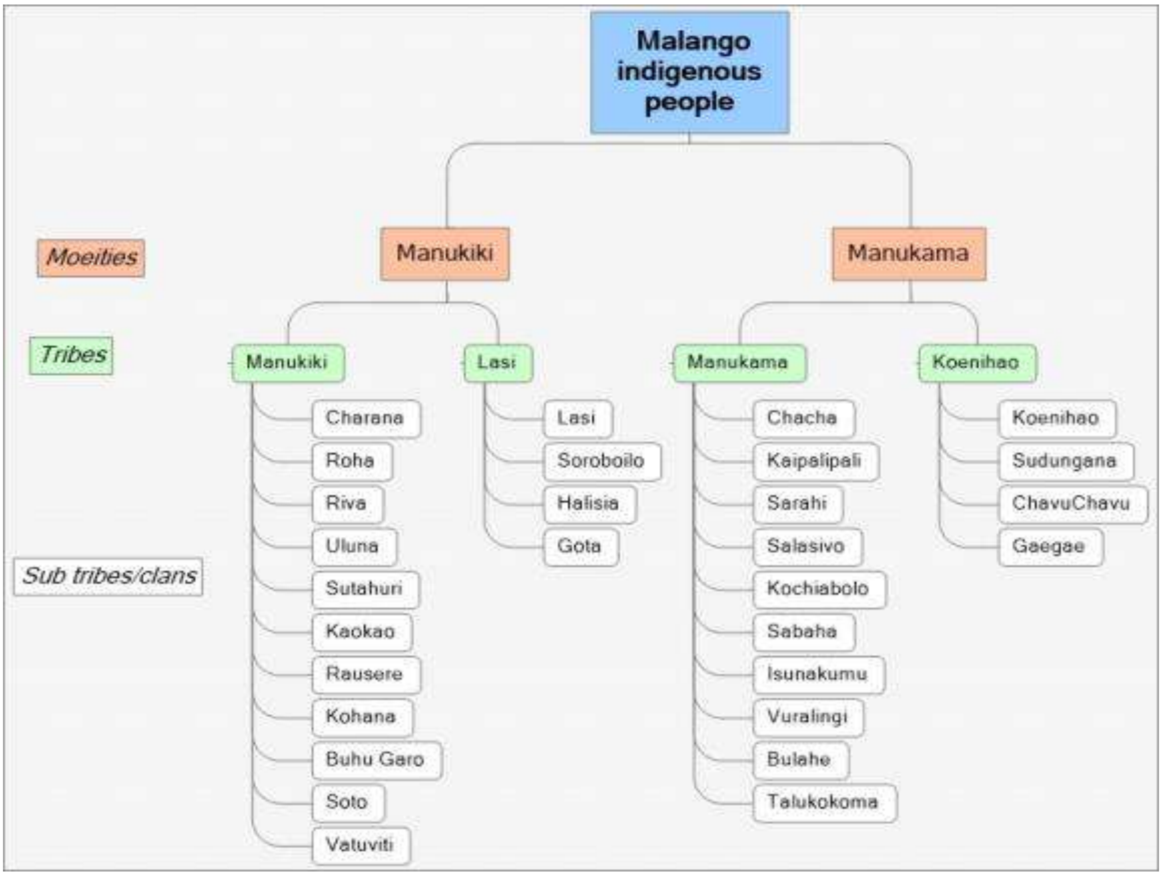


Table 8-6 Clans/sub-tribes represented in Houses of Chiefs (Roughan et al, 2011)

Clans in the Bahomea House of Chiefs	Clans in the Malango House of Chiefs
Charana	Barahau
Chavuchavu	Bolahe
Kaipalipali	Buhu/Garo
Kochiabolo	Chacha
Lango	Halisia
Rausere	Kaokao
Salasivo	Koenihao
Sarahi	Kohana
Soroboilo	Ngaengae
Sudungana	Riva
Sunakomu	Roha
Sutahuri	Sabaha

Clans in the Bahomea House of Chiefs	Clans in the Malango House of Chiefs
Uluna	Soto
	Vuraligi

According to Hogbin (1964), the tribes occupying the northern and eastern coastal area of Guadalcanal, between Point Cruz and Longgu, including the Ghaobata people who neighbour the project area, are divided into five exogamous matrilineal tribes named Hambata, Lasi Naokama, Thimbo, and Thonggo. Of these, Hogbin noted in the 1960s that:

> The chief importance of the clan organisation is its application to land rights… Land is cut into named blocks of varying acreage, some 2 or 3, others 50 or 60 acres large. These are grouped into series each of which is bound up with a clan. By virtue of his birth into a clan, an individual acquires the inalienable right to select sites for his house and cultivation on the territory of that clan (1964:5- emphasis added).

Roughan et al (2011)[58] suggest that the tribal structure of the people of the Bahomea area is similar to that for the Ghaobata and other coastal people. They suggest there are 5 named tribes (or kema) in the project area, that is, Lathi, Thimbo, Negama, Thongo, and Gaobata (also known as Garavu and Hambata), and these are divided into land owning and rights-holding subunits called mamata (clans). However, this is not quite consistent with what local informants have suggested is the situation for the Malango people, and what Hogbin noted during his anthropological studies.

LOCAL COMMUNITIES

As noted above, the TRHDP PO identified various "communities" and their associated clans. The basis for "community", which according to Roughan et al (2011), is one of the key elements of the cultural landscape and is dynamic, is not clear from the Table 8-6. However, the available information indicates that there is a mix of clans present in any particular village or geographical community. In practice, Guadalcanal communities are dynamic, and sometimes ephemeral.

As noted above, new villages are formed in response to the need for services, as a new start after natural disasters, resource scarcity and availability, spiritual threat, and internal conflict. Overlapping with communities of place, communities of interest may be formed or dissolve according to peoples' affiliation with particular interest or group (e.g., religion or issues-based grouping). Again, overlapping with both place and interest, communities of identity are based around kinship and ethnic affiliation, which can shift or be reinvented over time, e.g., the assertion of an "Isatabu" (indigenous Guadalcanal) identity by the Moro movement in the post-war period, at the time of independence in the 1970s, and during The Ethnic Tensions.

From the social assessment fieldwork data it would seem that the groupings are based on a combination of geographical location, kinship, and religious affiliation, although this is not entirely consistent. For example, Senge Village is said to be associated with Namopila Village, but in practice the families located at Senge are closely related to those at Marava, from whom they split in the 1970s, or so. The extended family at Koropa (founded in 2003) is closely affiliated to Namopila through kinship.

58 in the PHCG "Indigenous Terrain Mapping Report" prepared for the project

During the fieldwork, it was common to hear people say that all of the people in the Malango area are related to one another, and that "we are all really one family". It is not clear, however, to what extent these bonds extend to resource or residential rights.

Table 8-7 lists the communities in the TRHDP study area and their tribal affiliations.

Table 8-7 Communities of the TRHDP study area and their tribal composition

Communities	Villages	Est. Pop. 2010	Paramount Chiefs	Subtribe / clan Chiefs	Village leaders/ chiefs	Sub tribes/clans In the community
Namopila community	Namopila, Choro, Senge, Habusi, Pachuki, Komureo,	300+			5	Sutahuri, Kaokao, Uluna, Koenihao, Kochiabolo, Sabaha
Antioch community	Antioch, Valesala, Valekocha, Vatunandi	150+		3	2	Kochiabolo, Lasi, Kaipalipali, Kaokao, Charana, Roha, Koenihao, Sutahuri, Uluna
Verakuchi community	Mangakiki, Verakuji, Hanilake	200+		3	3	Kochiabolo, Charana, Kaipalipali, Roha, Sarahi
Tina community	Tina, Valebarik, Valebebe, Tahurasa, Valemaota,	300+	1	6	3	Sarahi, Riva, Chavuchavu, Rausere, Sudungana,
Marava community	Marava, Ngongati, Rate CHS, Vera'ande, Verakwele, New Mahata	200+		1	3	Charana, Kochiabolo, Kaipalipali, Sabaha
Katihana community	Katihana	150+	1	*	2	Chavuchavu, Uluna, Kaokao, Halisia, Rausere, Chacha, Kochiabolo
Vuramali community	Vuramali	100+	1	1	2	Kochiabolo, Koenihao, Charana, Uluna, Soroboilo, Salasivo
Haimane community	Haimane	150+	1		2	Koenihao, Lango, Sutahuri, Uluna
Horohotu	Horohutu 2 & 3, Valele'e	100+			2	Chavuchavu, Salasivo, Kaipalipali, Charana, Sarahi, Koenihao

Communities	Villages	Est. Pop. 2010	Paramount Chiefs	Subtribe / clan Chiefs	Village leaders/ chiefs	Sub tribes/clans In the community
Settler communities	Horohutu 1, Verakabikabi, New Birao, Namanu, Vatupaua	120+			4	from Guadalcanal Weather Coast clans

Source: TRHDP PO community liaison team

Political organization

The Malango people are divided into two administrative groups: the Bahomea House of Chiefs (BHOC) and the Malango. According to a local informant (a member of the Bahomea House of Chiefs) the BHOC is a legally constituted body, and consists of the four Paramount (tribal) Chiefs plus the subtribe/clan chiefs and local village chiefs, along with other representatives and elected officers (see Figure 8-5). The chairman is elected by and from the members. The Houses of Chiefs seem to exist primarily to determine resource and land rights, resolve disputes, settle matters of custom and breaches thereof, and to represent local indigenous people in dealings with outside organisations. Houses of Chiefs are a relatively new institution, and while their internal governance is unregulated modern government has given them a role in providing an initial determination of land disputes under the *Local Courts Act*.

Much has been written about the process by which leaders[59] emerge from within Melanesian societies. As elsewhere, local leaders /chiefs do not acquire their positions or authority by inheritance, although they do draw on their relationships with kin, neighbours, and fellow churchmen and with other networks (i.e., local social capital) to build a base for leadership. Despite fieldwork and the available project reports, it is unclear how the leaders are selected within the Bahomea area. From observation, clan leaders appear mainly to be elderly males who have the best knowledge of the history and customs of their clan, including the land and resources to which they have primary rights. This is crucial, since the clan is the primary land-owning group. Village leaders /chiefs appear often to be younger and show more of the characteristics of “Big Men”, i.e., they appear to have above average ability, seem able to organise and sponsor projects and events, are active in various economic and church activities and can rally both human networks and natural resources for economic and sociocultural purposes. For example, a paramount chief is also the Pastor of the South Seas Evangelical Church (SSEC) church at Tina Village; the village chief at Verakuchi is the sponsor/funder of the new local SSEC church; and a chief at Marava was the sponsor/funder of a new pre-school at Verakuchi.

More traditional “big men” activities still occur in local communities. For example, a traditional pig feast gathering took place in September 2013 at Habusi, which involved large numbers of local people and featured the distribution of pigs and other produce among the participating clans and communities.

Regarding modern politics and leadership, Malango Ward is a political unit of the Guadalcanal Provincial Government and is currently represented on the Provincial Assembly by Mr. Amaziah Robo. It also lies within the national Parliament’s Central Guadalcanal constituency, currently represented by Hon. Peter Shanel Agovaka.

[59] most often referred to as "big men".

VILLAGE AND COMMUNITY ORGANIZATIONS

Kinship is the most important basis for community formation and action among the people of the TRHDP area. After kinship, church membership is the next most important. As noted, villages in the TRHDP area are often made up of several related hamlets, and sometimes these have different religious affiliations. As observed above, local clan and village leaders may also be religious leaders.

Some villages have formally structured administrations. For example, at Marava, which has a population of 180 or so, there is a central community board which has six committees covering different areas of community life and development, including: education and training; women, children and youth; culture tourism; health and sanitation; agriculture and forestry; and projects.

There are also five church groups represented locally, and each church has its own groups, such as a woman's groups, sports groups, singing bands, and youth clubs. Also located at Marava is a community house belonging to the Malango Council of Women (MCOW), one of a network of groups organised by the Guadalcanal provincial government. MCOW has a woman's community house which is used as a meeting and educational centre (see Figure 8-5).

Figure 8-5 Women's centre at Marava

Most villages in the project area, especially the smaller ones, do not have this level of organisation or formal structure, hence most activity is organised through the churches and in association with village chiefs.

8.1.5.4 Ethnic Tension

Roughan et al (2011) note that Guadalcanal has been structured and patterned more than any other island in the Solomons, by the location of national projects, and the reactions to them. These projects have led to a broad discourse of grievance in which TRHDP specific concerns need to be understood.[60] This experience has been politically articulated by the people of Guadalcanal through

[60] Roughan et al (2011)

various textual and bureaucratic means since the 1970s[61], with the main elements of this narrative centering on:[62]

- The widespread and longstanding alienation of lands from the late 19th century onwards, exacerbated by their subsequent continuous habitation and evident employment in significant articles of national infrastructure, most notable of which is the capital city of Honiara

- The economic productivity of major investment projects emplaced on Guadalcanal, and their historically perceived lack of lasting positive effect on either the peoples whose territory has been host, or on the people of Guadalcanal as a whole. Chief amongst these have been SIPL (now GPPOL) and the Gold Ridge mine.

- Invasion of cultural and social space of the Guadalcanal people by settlers from other islands and provinces. This has been recognised as a form of structural violence, taking the form of disregard and disrespect for Guadalcanal cultural forms and norms, and actual violence perpetrated on indigenous Guadalcanal persons in the shape of murder and physical assaults.

Over time, a lack of comprehensive action in relation to these concerns has been apprehended as structural unresponsiveness, something which has itself been additional basis for grievance.

These grievances took most obvious shape in the initiation and evolution of the 'ethnic tension' of 1998-2003 characterised by widespread violence and militancy across Guadalcanal and other provinces and the eventual functional collapse of major state institutions including those mandated with ensuring law and order.[63]

During this time the northern plains area incorporating GPPOL, and central Guadalcanal, including the Gold Ridge area, witnessed extensive fighting involving armed militants, police and civilians.

The initial stage of the unrest generally consisted of intimidation and violence against Malaitian settlers in Guadalcanal, including those working on Gold Ridge and oil palm plantations in Central Guadalcanal (Evans)[64]. The placement of a (largely Malaitan) police force to secure Gold Ridge mine may have escalated the violence. According to Evans the fighting was linked largely to Malaitan–Guadalcanal differences related to issues of cultural respect, perceived inequitable revenue distributions, and Malaitans securing jobs on Guadalcanal. By May 2000, Malaitans working on the Gold Ridge mine were evacuated. It is estimated that by the end of 1999, 24,000 largely malaitan settlers had been evicted from Guadalcanal.[65]

Fighting was initially centered between the Isatabu Freedom Movement (also known as the Guadalcanal Revolutionary Army) and later the Malaita Eagle Force (as well as the Marau Eagle Force). In October 2000 the Solomon Islands Government signed a peace agreement with these

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61 See Kabutaulaka, T.T. (2002) A weak state and the Solomon Islands Peace Process. East-West Center Working Paper No. 14. Honolulu: East-West Center and Bennett, J (2002) Roots of conflict in Solomon Islands. RSPAS Discussion Paper 2002/5. Canberra: Australian National University for overviews of this history.

62 Roughan et al (2011)

63 Roughan et al (2011)

64 Evans, D, 'Tensions at the Gold Ridge mine, Guadalcanal, Solomon Islands', Pacific Economic Bulletin

Volume 25 Number 3 © 2010 The Australian National University

65 Fraenkel, J, The Manipulation of Custom: from uprising to intervention in the Solomon Islands, 2004,

Victoria University Press/Pandanus Books, Canberra groups or elements of these groups, known as the Townsville Peace Agreement. The Agreement led to a fracturing of Guadalcanal militants between those that supported the peace process and those that did not. This fracture led to an era of intra-ethnic warfare including further fighting in the Central Guadalcanal area, and with fighting spreading to the Weather Coast.

Warfare largely ceased after the arrival of Australian and Pacific Island police and soldiers under the Regional Assistance Mission to Solomon Islands (RAMSI) in July 2003.

8.1.6 Socio-Economic Profile of the Communities of the Project Areas

8.1.6.1 Data Sources

The most reliable data for assembling a profile of communities associated with a proposed development usually comes from an official Census of population and dwellings. However, this is not always available. For the most part, the only statistical data that are available for constructing a profile of the TRHDP study area are population estimates for the various villages, made by local chiefs for the TRHDP PO, and those data gathered in the community workshops and from householder interviews conducted by the ESIA field team.

8.1.6.2 Population

The communities potentially affected by the TRHDP all fall within the Malango and West Ghaobata Wards. The population counts of the TRHDP areas and villages within Bahomea made during the ESIA field studies in 2013 are presented in Table 8-8, along with the available census data.

Previous local estimates put the population of the TRHDP area at approximately 2000, with half of these having “direct access” to the Tina/Ngalimbu River (Entura, 2012:32). The counts made during the ESIA fieldwork put the Bahomea/Tina population at about 1800, divided among approximately 362 households.

The villages of the project area have an average population of approximately 56 people, and an average of 11 households. Settlement sizes vary from 4 persons for Choro (the isolated occupation site in the upper Tina River), to 219 for the settler community of Verakabikabi. Nearly half the surveyed settlements had 5 households or fewer, and only 11 of the 32 villages had 20 households or more. The largest indigenous villages (with 100 people or more) are Tina, Antioch, Valebebe, Haimane, Mangakiki, and Marava. Komeo near Antioch, was abandoned at the time of the survey, while the settlement at Choro appeared to be occupied sporadically by an elderly couple, and seems mainly used as a shelter during times of garden cultivation of clan lands in the upper Tina River catchment.

The average household size in the TRHDP area is 5 persons, compared with 5.9 for the whole of Malango Ward in 2009. Households of the Senge Community average 5.1 persons, 4.6 in the other Bahomea downstream villages, and 5.6 in the households in the infrastructure impacts area. Based on the limited data available, the downstream Ghaobata households are of a similar size to those in the Bahomea area and to the rest of West Ghaobata Ward. In 2009, Solomon Islands households had an average of 5.3 persons.

While having a significantly larger population than its coastal neighbours, at 19 persons per km^2 Malango Ward has a low settlement density compared to West Ghaobata (60 persons per km^2) – reflecting the very different terrain of each group of people. West Ghaobata and East Ghaobata wards have the highest settlement densities of all wards in Guadalcanal Province.

Table 8-8 Population counts of the TRHDP areas and villages within Bahomea

Communities & affiliation	**Villages/ hamlets**	**Impact area**	**2013 households (approx.)**	**2013 population (approx.)**	**2009 census**	**1999 census**	**1986 census**
Senge Community - Bahomea							
Senge community	Senge	Direct	3	16			
Bahomea	Choro		1	4			
	Koropa		3	19			
Total			7	39			
Downstream Area - Bahomea							
Pachuki community	Pachuki	Downstream	14	65			
Bahomea	Habusi		6	33			
Namopila comm.	Namopila	Downstream	5	27			
Bahomea	Komureo		6	28			
	Vatunadi		1	5			
	Valekocha		5	26			49
Antioch community	Antioch	Downstream	23	110			
Bahomea	Valesala		20	105			
	Kolanji		2	10			
	Komeo		0	0			
Tina community	Tina	Downstream	23	104			109
Bahomea	Valebarik		6	22			
	Valebebe		22	104			
	Tahurasa		5	15			
	Valemaota		4	12			
Vuramali comm.	Vuramali	Downstream	18	70			18
Bahomea	Haimane		26	111			
	Horohotu 2		17	84			46
	Vuvamali		16	77			
Horohutu comm.	Horohotu 1	Downstream	12	60			51

Communities & affiliation	Villages/ hamlets	Impact area	2013 households (approx.)	2013 population (approx.)	2009 census	1999 census	1986 census
Settlers							
Total			231	1068			
Infrastructure Area (area affected by Infrastructure Corridor) – Bahomea							
Verakuji community	Verakuji	Infrastructure	11	56			
Bahomea	Mangakiki		21	111			5
Marava community	Marava	Infrastructure	28	168			54
Bahomea	Ngongoti		1	20			
	Vatupaua		5	50			31
	Rate school		?	?			4
Vera'ande community	Vera'ande	Infrastructure	6	30			78
Bahomea	Verakweli		6	24			
	New Mahata		2	15			51
Verakabikabi	Verakabikabi	Infrastructure	44	219			54
Settlers							
Total			124	693			
Bahomea Total			362	1800			
Malango Ward					10532	4105	6094
West Ghaobata Ward					4515	2601	4239*

* Did not exist in 1986 – Was part of the former West Tasimboko Ward

8.1.6.3 Population Trends

Little reliable data is available from which to determine population trends for the TRHDP area. Even where village level figures from 1986 are available, it is almost impossible to interpret the data without access to the census boundary maps of the time.

From the available data, it seems that Tina village has about the same population as in 1986, Marava's population has trebled, Horohutu 2 has almost doubled, and Vera'ande has decreased by more than half. The populations of the Weather Coast settler communities of Horohutu 1 and

Verakabikabi have increased after having been significantly depopulated during the Ethnic Tensions. Verakabikabi appears to be about 4 times larger than in 1986. This may be because the villagers, being settlers residing in the area under a customary arrangement with the local indigenous chiefs, do not have their own local land rights outside of this area, which might enable them to spread out and establish new hamlets.

On a broader scale, census counts for Malango Ward show the socially disruptive depopulation effects of the Ethnic Tensions, and the post-tension rapid repopulation and growth: that is, from 6,094 people in 1986, to 4,105 in 1999 at the height of the tensions, and 10,532 in 2009. The population of Malango Ward is now 2.5 larger than it was in 1999. Over the same 10-year period, the population of neighbouring West Ghaobata (downstream of Bahomea) went from 2,601 to 4,962, making it almost twice the size it was in 1999.

By comparison, the population of Guadalcanal Province (excluding Honiara City) increased by 55% between 1999 and 2009, while the population of the Solomon Islands as a whole increased by 26%. Guadalcanal Province has the fastest growing population of all the provinces. Natural growth is high due to high birth rates and declining death rates, but this has been obscured in recent years by internal migration.

Fraenkel (2004), drawing on results of the 1999 census, records that 4,098 people (or 16.7% of the population at the time) were evicted or fled from Malango Ward and became displaced persons in 1998-99, as a result of the Guale uprising. In West Ghaobata 2,808 people were displaced (11.4% of the population), and in East Ghaobata 1,549 people (6.5% of the population were displaced). Most of those driven out the district were Malaitan and fled initially to Honiara.

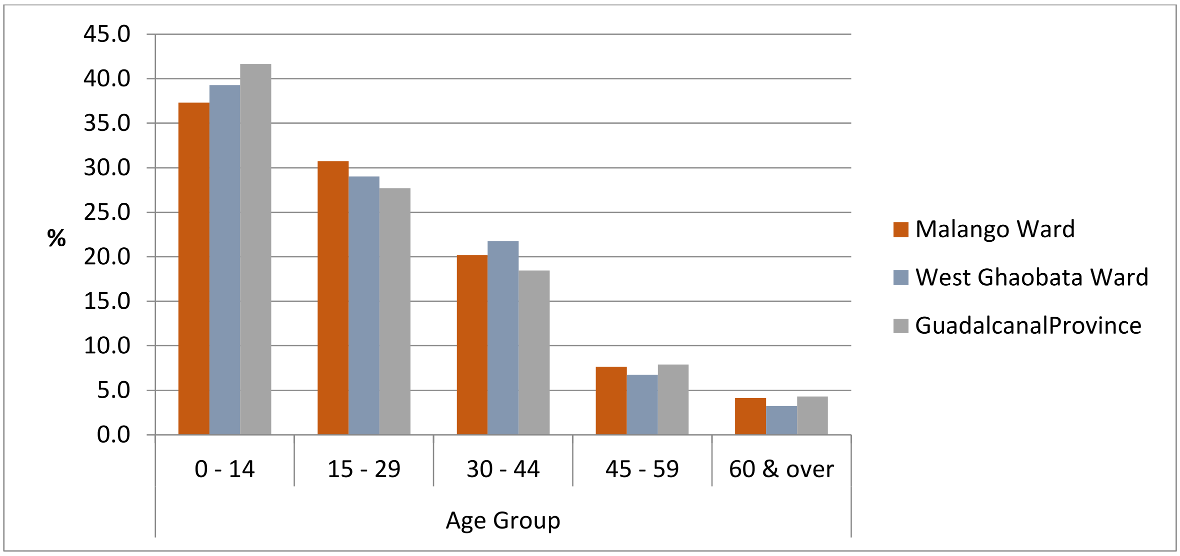
The project is therefore taking place in a local context of considerable former social disruption and post-conflict population growth – with its associated demand for residential and garden land, natural resources, and social services.

8.1.6.4 Sex and Age Structure

Figure 8-6 shows the age structure of the population of the relevant wards compared with Guadalcanal Province in 2009. The populations of Malango and West Ghaobata have very similar age structures and are generally consistent with the rest of the Province. That is, they have very large proportions and numbers of infants and young children (aged 0-14 years), and very few elderly people, the latter of which are the repositories of traditional knowledge and customs. The high proportion of children is consistent with observations in the villages surveyed for this study, where the large number of potentially vulnerable teenage mothers and infants is very evident. However, there is some evidence that the Malango population is aging. For example in 2009, 37% of the population was aged 14 and under, compared with 45% in 1986.

Across each of the groups in the Malango and West Ghaobata ward populations, males outnumber females. Males make up 53% of the total Malango population, and 52% of West Ghaobata. In Malango Ward the gender imbalance is most evident in the 45-59 year old group, and may reflect a greater longevity among local males, compared with women.

Figure 8-6 Age Structure of Malango Population, 2009



8.1.6.5 Ethnicity

The population of Malango Ward is 95.4% Melanesian, although the available census data does not distinguish between people who are from Malango, and those from elsewhere in the Solomon Islands. This compares with 97.8% Melanesian in West Ghaobata, and 98.5% for Guadalcanal as a whole.

As noted elsewhere, there are groups of Weather Coast settlers residing legitimately in the Tina-Ngalimbiu area. In these cases, the settlers have formal customary agreements with the land owning clan and its chiefs. Through exchanges of pigs, produce and custom money (chupu), they have been granted rights to use local land for residences and gardens, but ownership is retained by the customary landowning clan. These agreements reportedly need to be renewed periodically. One of the challenges for the customary landowning peoples of North-central Guadalcanal, since the 1970s, has been the unsanctioned occupation of their land by people from Malaita and elsewhere, who have come to Guadalcanal to work in the city, in the plantations, and the resource extraction industries.

The main ethnic minorities in Malango Ward are Polynesians and Micronesians (relocated Gilbertese), possibly associated with the St Joseph's boarding school at Tenaru, and with settlements along the main road and/or close to Henderson.

The Project needs to comply with the WB Performance Standards as previously mentioned. Based on discussions with the World Bank about Performance Standard 7 and Operational Policy 4.10, both of which address Indigenous Peoples, all groups resident in the area are considered Indigenous people regardless of their status and origin in the Solomon Islands (landowner, squatters, settlers, people from Guadalcanal, Malaita or other islands), which ensures that all communities are consulted in compliance with this standard and Policy. More information on this is provided in Section 3.6 WB Performance Standards.

8.1.7 Local Peoples' Sources of Livelihood

8.1.7.1 Framework

The proposed TRHDP could have a significant effect on local people's livelihoods. Therefore, both the ESIA and householder surveys gathered background information on current livelihoods in each of the communities. This is presented below in terms of the elements of the Department for International Development's (DFID) 'sustainable livelihoods framework': that is, the range of livelihood strategies employed by local people, the livelihood capitals they deploy or utilize, the various constraining and enabling factors at play, and the various risks and vulnerabilities that people must manage to obtain the things they need to make a living, are outlined.

8.1.7.2 Livelihoods Strategies

The main livelihood goals of the people and households of the project area appear to be daily food security, and protection of the family from risks of climate and loss of resources. With a paucity of financial capital, local people use a range of strategies, including a mix of the following:

- traditional garden cultivation and gathering of staple foods for subsistence needs, combined with occasional hunting
- Cash-earning activities to raise money to pay for imported food, shop goods, school fees, technology, community obligations, and household needs. Such activities typically include one or several of the following:
  - household-scale cash crop production, with the produce sold in the central market in Honiara
  - small-scale timber milling for local and Honiara markets
  - local day laboring, for example in timber milling, garden clearing, house building, etc.
  - running a small home-based business, such as home baking, natural materials handicrafts, a local shop-canteen selling small items, vehicle hire, etc.
  - full or part time employment for a government agency or large company – typically the Gold Ridge Mining Company (GRMC) (when operational), GPPOL, Earthmovers Logging Company, market gardens.
  - Fishery at the River mouth.

These strategies, therefore, mostly rely on having good access to:

- local natural capital such as land, forests, river, gravel and forest products
- household human capital, including traditional and formal skills and knowledge, and labour power
- physical capital in the form of tools, equipment, and transport infrastructure, and social capital in the form of assistance from neighbours, relatives, and fellow church members.

The following sections outline the situation regarding livelihoods in households and communities of the TRHDP area.

8.1.7.3 Household Income and Expenditures

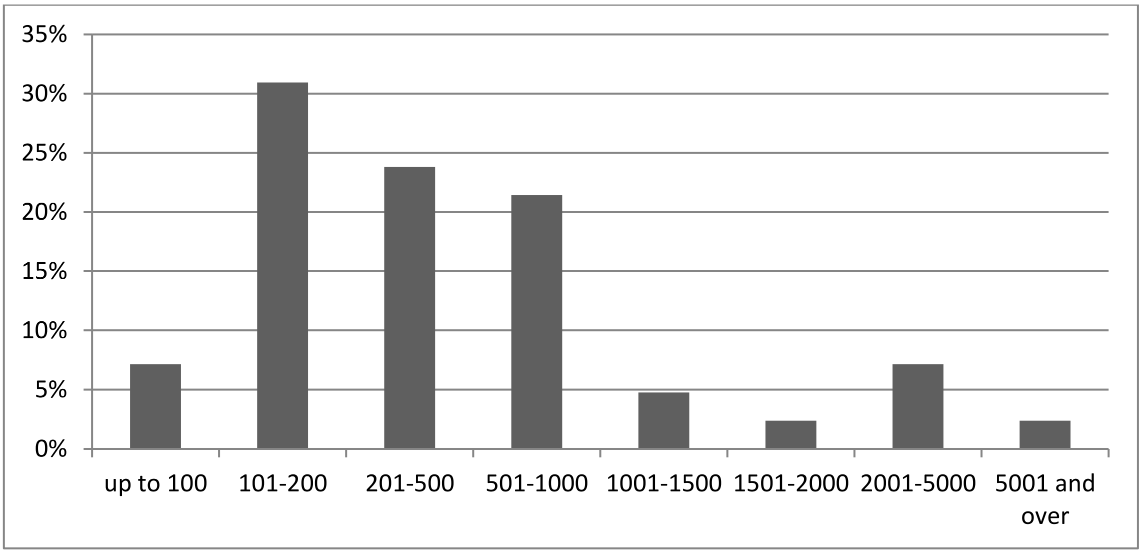
The 2006 National Household Income and Expenditure Survey (HIES) calculated that 56% of all income to rural households in the Solomon Islands (and to households in Guadalcanal province) comes from home production of goods and services. That is, they are produced by the household and predominantly consumed by the same household. Next most important for Guadalcanal households is self-employment (13.5% cf 9% nationally), and wages and salaries (12%, both provincially and nationally).

People in the TRHDP area rely on both cash and non-cash income and, increasingly, they are being drawn into the cash economy to meet their needs. Most households have some level of subsistence production, though the current annual value of this subsistence production is not known.

The survey of householders in the project area indicates that the average weekly cash income for households is approximately SBD 870 [66], and the median income is SBD 500. However, the range of weekly cash incomes as reported to the social team (Figure 8-7) is very wide, ranging from SBD 100 to SBD 6000.

In addition to income generating activities of various kinds, some members of the communities of the project area received periodic payments of royalties from the Gold Ridge Mine when it was operational and/or receive royalties from logging on customary land. This tends to be treated as windfall income and is used to purchase major items, if possible. Hence, it is not surprising that only a weak correlation was found between the number of appliances and pieces of equipment that a household owns, and the weekly income of that household.

Figure 8-7 Weekly cash incomes in Solomon Islands Dollars (SBD) for the sampled households in the study area



No data on local household expenditure were collected in the social survey. National data from the 2006 HIES indicates that average annual household expenditure in rural areas of Solomon Islands was SBD 23,366 for an average household of 6.0 persons, giving an average per capita expenditure of SBD 3,894. On average, 66% of this expenditure was on food, 11% on housing, 5% on transport, and 14.5% on miscellaneous goods and services.

8.1.8 Human Capital

8.1.8.1 Introduction

Human capital refers to the knowledge, skills, and experience on which individuals and households can draw to generate a livelihood, and the labour/work power or energy available to them. The latter depends on peoples' overall health and well-being. These various aspects of human capital are discussed below.

The people of the project area rely heavily on specialist, customary, and detailed technical knowledge, skills and abilities in a number of areas:

[66] Approximately $121 US.

- knowledge of the land and geography of the Tina River catchment, including the location of particular natural resources, natural hazards, tracks, and places where they have ownership and use rights;
- knowledge of the trees, plants and animals found in the catchment, along with their characteristics, uses, and seasonal availability;
- knowledge of garden plants and other domesticated species and the skills to manage them;
- marketing and selling skills;
- carpentry and house building skills;
- numeracy and literacy; and
- knowledge and skills in hand and power tool and machinery use.

They also require the ability to resist a range of endemic diseases, which could reduce their ability to support themselves, and knowledge of basic health care necessary for family wellbeing. All of these are complemented by knowledge of local customs and social mores and, increasingly, knowledge of how to deal with bureaucracies and commercial organisations.

An important strength of the residents of the project area is the depth of their traditional knowledge and skills and ability to live in a largely natural environment, and to acquire a livelihood from it. Such skills, abilities, and qualities are acquired in the course of growing up in rural areas and participating in village life, where traditional knowledge is passed down by parents and elders through "learning by doing". This is complemented by formal education in the government and/or private school system, if it is accessible and affordable. Increasingly, people are required to interact with urban communities and conditions, and with a monetised economy that requires a different range of skills and experience, which are not always locally available.

These various aspects of human capital are dealt with separately in the following discussion on work, employment, education and health, using the official and survey data that was available.

8.1.8.2 Work

The Solomon Islands Census gathers information for each person aged 12 and over on whether they worked during the previous week, and the "type of work/activity they usually do". Respondents are offered a choice of one of the following:

- Work for pay as an employee of government or private sector, as an employer, or as self-employed;
- Producing goods for sale;
- Producing goods for own consumption;
- Voluntary work; and
- Unpaid family work.

The implied assumption in the Census question is that people have one main or dominant kind of "work", rather than being involved in perhaps equally important multiple activities. Taking the data for Malango Ward at face value, almost 35% of the 4,266 people of working age recorded in the 2009 census for Malango Ward were in paid employment, 10% were self-employed or employing other people, and a further 15% were producing goods for sale, for example, garden produce. This implies that 59% or so were engaged in the cash economy in some way.

The level of participation in the cash economy among people in West Ghaobata is similar (55%), but somewhat higher than for Guadalcanal as a whole (41%).

The 2009 census records that only 17% in Malango, and 24% in West Ghaobata, were engaged principally in subsistence food production, which is low in comparison to the whole of Guadalcanal province (38%). Malango and West Ghaobata may be at an advantage compared to other rural residents of Guadalcanal, since they are both located relatively close to Honiara city. Honiara has an active labour market and several large produce markets, including the Honiara central market, where most produce is sold and bought.

Importantly, the Census data show that there is a major difference in work between males and females in Malango Ward. For example, in 2009 only 471 of the 1,872 (i.e., 25%) involved in paid jobs were woman, whereas women made up 64% of those engaged in subsistence production, 53% of those producing goods for sale, and 72% of those doing unpaid family work. Apart from income from selling small volumes of cash food crops, home baking, and craft items locally and at the Honiara market, women typically have little direct access to cash.

8.1.8.3 Paid Employment

The village workshops attempted to gather information on the extent of paid employment in the communities of the TRHDP area. Table 8-9 summarizes the data.

Table 8-9 Employment in the communities of the TRHDP area

Community & affiliation	**Villages/ hamlets**	**In paid employment**	**Types/sources of paid employment**	**Main types of self-employment**
Downstream Area - Senge Community				
Senge community	Senge Choro Koropa	1?	Public service	Chainsaw timber milling, ecotourism, market gardening
Total		**1?**		
Downstream Area – Other Bahomea				
Pachuki community	Pachuki Habusi	2	GRML, Earthmovers	Timber milling, market gardening, livestock, equipment hire
Namopila comm.	Namopila Komureo Vatunadi Valekocha	0		Timber milling, market gardening, gravel extraction
Antioch community	Antioch Valesala Kolanji	11	Public service, Earthmovers, GRML, GPPOL, church	

Community & affiliation	Villages/ hamlets	In paid employment	Types/sources of paid employment	Main types of self-employment
	Komeo			Timber milling, firewood, market gardening, crafts, bush food marketing
Tina community	Tina Valebarik Valebebe Tahurasa Valemaota	20	GRML, GPPOL, Public Service,	Timber milling, market gardening,
Vuramali comm.	Vuramali Haimane Horohotu 2 Vuvamali	15	GRML, Public service, CBSI, Ports Company, Fisheries,	Timber milling, market gardening, copra, cocoa, canteen, handcrafts,
Horohutu (settlers) Settlers	Horohotu 1	12	GPPOL, GRML, NGO, public service, logging company	Vehicle hire, market gardening,
Total		**60+**		
Infrastructure impacts area				
Verakuji community	Verakuji Mangakiki	6	Public service, GRML, Earthmovers, Church,	Timber milling, market gardening, bush products marketing, vehicle hire
Marava community	Marava Ngongoti Vatupaua Rate school	4	GRML	Timber milling & marketing, handicrafts, market gardening, canteen, firewood
Vera’ande community	Vera'ande Verakweli	19	GRML, GPPOL, QQQ farms,	

Community & affiliation	Villages/ hamlets	In paid employment	Types/sources of paid employment	Main types of self-employment
	New Mahata			Timber milling, market gardening, bakery, bush products,
Verakabikabi (settlers)	Verakabikabi	?	GRML,	Gold panning (artisanal mining), market gardening, vehicle hire
Total		**29+**		
Downstream Ghaobata communities		?		

8.1.8.4 Household Production and Self-Employment

The importance of multiple activities as a livelihoods strategy among the people of the greater TRHDP area is evident in the 2009, Census data on "household money earning activities" (see Table 8-10). For example, while 646 Malango residents said in 2009 that their main economic activity was producing goods for sale, 77% of households reported that they earned some money from the production and sale of crops and/or other products, such as vegetables and fruits, betel and other edible nuts, coconuts and related products, cocoa, cut flowers and wild plants, milled timber, and craft items (Table 8-11). Compared with their Ghaobata neighbours, the people of Malango are more involved in the production of flowers and timber but much less involved in coconut products and cocoa. This reflects the accessibility to Ghaobata people of established (and perhaps abandoned) commercial plantations on the Guadalcanal plains, downstream of the Tina River.

Table 8-10 Households earning cash from sale of produce, 2009

	Number of households			**Percentage of households**		
	Guadalcanal Province	**Malango Ward**	**West Ghaobata ward**	**Guadalcanal Province**	**Malango Ward**	**West Ghaobata Ward**
Food crops	12088	1110	686	70.4%	63.5%	70.3%
Coco./Copra	4518	50	203	26.3%	2.9%	20.8%
Betel Nut	7574	152	215	44.1%	8.7%	22.0%
Cocoa	6392	309	280	37.2%	17.7%	28.7%
Tobacco	1045	35	5	6.1%	2.0%	0.5%
Timber	569	52	6	3.3%	3.0%	0.6%
Flowers	1428	189	52	8.3%	10.8%	5.3%

Other products	816	78	11	4.8%	4.5%	1.1%
none	1977	401	157	11.5%	22.9%	16.1%
Households involved	15186	1348	819	88.5%	77.1%	83.9%
Total households	17163	1749	976			

* Note that households could indicate more than one product type

The 2006 Household Income and Expenditure Survey (HIES) reported that of the Guadalcanal households that were involved in some kind of self-employment, 34% were producing root crops for sale, 31% were producing other vegetables and fruits, 6% were doing livestock farming, 6% were catching and selling fish, 5% were in handicraft production, and 16% were engaged in some other kind of self-employment or small business activity.

In our householder survey, 100% of the respondents indicated their household grew crops of some kind for home consumption, while 70% said they grew or collected produce for sale. This is reasonably consistent with the 2009 Census findings for Malango Ward.

Women of the study area tend to group together to make the weekly trip to Honiara to sell their produce, and to make any necessary household purchases. Different villages seem to favour different days for marketing, though Saturday seems to be the busiest day for the Honiara Central Market. Transport typically costs at least SBD $50 per person each way, plus a market stall fee.

The range of crops grown for consumption and sale is presented in Table 8-11. Relatively few respondents mentioned producing and selling betel nut and tobacco, despite there being an apparent abundance of betel nut in the villages of the study area, and plenty of betel nut chewers. Many indigenous village households are involved in some capacity in sawn timber production. This is discussed below.

Table 8-11 Crops produced for consumption and for sale by the surveyed households

Product	**% of households growing for consumption**	**% of households growing for sale**
Banana	90%	31%
Kasava (Manihot *esculenta*)	74%	19%
Kumara (*Ipomoea batatas*)	69%	26%
Beans	57%	31%
Cabbage	57%	19%
Tomato	55%	24%
Sugar cane	50%	10%
Slippery cabbage (*Abelmoschus manihot*)	43%	14%
Taro (*Colocasia sp*)	38%	7%

Product	% of households growing for consumption	% of households growing for sale
Yam (*Dioscorea sp*.)	38%	10%
Eggplant	36%	14%
Capsicum	29%	17%
Pana-yam	23%	7%
Potato (*Solanum sp*)	17%	14%
Pumpkin	17%	10%
Shallot	14%	12%
Pawpaw	12%	14%
Garlic	12%	7%
Pineapple	7%	-
Chinese cabbage (*Brassica rapa var.)*	9%	9%
Cucumber	7%	7%
Coconut	7%	7%
Lemons/citrus	5%	2%
Kangkong (*Ipomoea aquatic*)	5%	0%
Betelnut (*Areca catechu*)	2%	5%
Melon	2%	2%
Cutnut (*Barringtonia procera*)	2%	2%
Corn	2%	2%
Cocoa		5%
Jackfruit (*Artocarpus heterophyllus*)		2%
Sago palm (*Metroxylon sp*)		2%

In his guide to Solomon Island food crops, French (2011) describes the diversity of crops produced in local gardens, and notes that having a range of cultivated and wild foods available is a proven food security strategy in an uncertain environment. Table 8-11 reveals that that the variety of food produce offered for sale is greater than reportedly produced for home consumption. With home consumption there is a much greater emphasis on staples such as root crops, banana, and cooking vegetables, whereas the cash crops are more likely to include salad (green leaf) vegetables and exotic items. This suggests that there is an established pattern of growing specifically for the market and targeting more high-value food products. Importantly, some domestically and commercially important green vegetables are collected from wetland areas adjacent to the Tina River, and in some cases areas that may be required for the Hydro development.

8.1.8.5 Occupations

Among the 1,872 paid workers in Malango Ward in 2009, the most important occupations are crafts and trades (20%), service and sales (19%), professions (15%), and plant and machinery operation (13%). By comparison the most important occupational groups among those in West Ghaobata are elementary workers or labourers (34%), followed by skilled agricultural and fishing work (23%) – both probably associated with employment at GPPOL, and other nearby plantation operations. No occupational data is available at the village level.

8.1.8.6 Education

Formal education provides a means of building “human capital”, and especially the skills and knowledge necessary to participate effectively in the modern economy and society.

Nowadays, all children in Solomon Islands are expected to at least attend primary school where it is available. Primary school in Solomon Islands is free, but not compulsory. In the project area and nearby, schools are provided by both central government and by established churches.

Government statistics indicate that the majority of Solomon Islands children attend school between ages 8 and 13, after which attendance rates decline. Nation-wide, 64.5% of rural children aged 6-12 attend school. In general, the levels of female and male educational attainment in rural communities in Solomon Islands are similar.

Census data on educational participation and achievement is only available for the whole of Guadalcanal Province. These data suggests that there are problems of poor school attendance by primary school aged children. For example, in 2009 only 69% of 5-9 years olds were attending school or preschool, 85% of 10-14 year olds were attending, and 61% of 15-19 year olds were attending some kind of schooling/or training. School attendance reportedly falls off from age 13 onwards. The main differences between boys and girls in educational participation emerges in the 15 and over age group, possibly due to the relatively high cost of high school fees for ordinary rural families, which means families favour advancement of sons over daughters in the education system.

From observation in the villages of the TRHDP area, school attendance is relatively low. Interviewees indicated that this was due to the labour needs of the household, low accessibility of the local schools due to lack of school transport, and poor attendance by teachers due to low salaries and/or failure of the government to regularly pay the teachers’ salaries. Some local villagers volunteered that their young people/teenagers had poor literacy skills and were not easily employable as a result. This, in turn, leads to early marriage and child bearing among girls, and antisocial activities among boys.

At present, there are approximately seven schools within the TRHDP area (the closest ones shown on the map in Figure 8-9). Local people aspire to have greater access to schools to make it easier and safer for their children to get an education. As a result, communities sometimes use church buildings as alternative classrooms, or resort to building their own classroom using local materials. For example, in Valesala/Antioch, the community has a barely serviceable building that houses the kindergarten (see Figure 8-8) as well as Grades 1-3. However, a new permanent building, located at the intersection of Antioch and Valesala villages, was under construction and will take students from Grades 4-6. This new permanent building, like that constructed at Rate, was being funded by the Ministry of Education as part of a bundle of benefits provided to local communities through the TRHDP planning process. Construction was being done by a builder from the local community. The new school classrooms at Valesala will eliminate the need for local children to walk several kilometers to Rate School. However, high school students will still need to attend Rate Community High School. There is also a school run by the Seventh Day Adventist Church at Namanu.

Children who want to attend higher levels of secondary school often need to leave the area and attend boarding school. The closest such school is at Tenaru (St Josephs). Selwyn College was formerly located near the river in West Ghaobata, but was relocated to West Guadalcanal following massive damage by Cyclone Namu. Tertiary level trade training is available in Henderson at the Don Bosco academy, and in Honiara.

Kindergartens are located at Marava, Ngongoti and Valesala. These take children aged 3 to 5 years old, and are run by local community groups with volunteer help. At the time the social surveys were being conducted, a new community kindergarten was nearing completion at Verakuji. Students from the downstream communities such as Ravu, Popolo, the GPPOL workers village, and other plains communities adjacent to the Ngalimbiu River, attend Ngalimbiu Primary and the High School at Nguvia.

Figure 8-8 Valesala kindergarten and grades 1-3 (left) and grades 4-6 (right)

8.1.8.7 Health and Health Services

Health and wellbeing underpin personal human capital and one's ability to secure the means of existence, and to participate fully in one's society. Depending on location, Solomon Islanders face significant threats to their health and wellbeing, especially:

- diseases associated with the environment and unimproved living conditions, such as: malaria, pneumonia, diarrhea, asthma, and skin diseases; and
- increasingly common diseases and conditions associated with inadequate or modern diets, nutrition, and lifestyle, such as: diabetes, high blood pressure, anemia, (in children) wasting and malnutrition, stress, and problems of protein deficiency.

Based on village workshops and interviews with local people, the principle diseases of concern to residents of the project area are malaria, pneumonia, diarrhea, stress, flu and other respiratory conditions, diabetes, and STDs. Hernia seems to be a problem, especially among men, and is put down to the physically demanding types of work and carrying of heavy loads (e.g., timber). In several village workshops people reported incidences of gonorrhea and dengue fever. Cuts and fractures to limbs appear to be relatively common and relate to peoples' living environment and their way of life, though no data is available on the incidence of serious injuries.

In some communities, people reported that malaria and diarrhea cases are slowly reducing, but pneumonia incidence appears to be increasing. Some of the improvements in sanitation related illnesses have resulted from environmental and sanitation improvement drives within communities (e.g., Tina Village). Respiratory conditions appear to be common among both children and adults, and may be associated with cooking cover open wood fires in closed spaces, and with damp living conditions.

The people who live in the vicinity of the Tina River are constantly interacting with it in the course of their daily lives, especially women and children. Several of the villages in the project area (e.g., Koropa, Choro, Habusi, and Vuramali) are located on the right bank of the Tina/Ngalimbiu River and their residents have to ford the river to access most facilities, and to catch transport to Honiara. This can sometimes be very dangerous, since river conditions are subject to change, sometimes rapidly. Consequently, there are occasional drownings or near drownings of children, reportedly about one every two years. The rainy season also brings the threat of major destructive floods which, in the past, have caused many deaths.

The overall rate of accidents and accidental deaths in the communities of the project area is not known.

For women, the main diseases and health issues for which they most often suffer include stress giving birth to premature babies, miscarriage, or death of either the mother, or baby, or both, during the time of delivery. Since there are no health facilities, including no clinics nearby any of these villages, death may occur when women encounter such problems. The other hardship women currently encounter is the lack of easy access to transportation to take them to the clinics in Honiara or the Central Referral Hospital at No. 9 (downtown Honiara) if they encounter problems when giving birth.

According to women, the main causes of stress are husbands spending all the money on alcohol and other women, husbands becoming involved in extramarital affairs, husbands not contributing enough to support the needs at home, young people taking drugs, disobeying their mothers, not doing well in schools and unwanted pregnancy among young girls.

According to the ESIA Scoping Report, in Pachuki, Habusi, Namopila, Tina Village and Antioch, the most common ailments reported were pneumonia, malaria and an observed high incidence of skin conditions, especially among children (Entura, 2012).

8.1.8.8 Child Health

In the 2007 Demographic and Health Survey (DHS), the most common health issues for young children in rural Guadalcanal were associated with poor nutrition and hygiene. These include anemia (55%), stunting of growth (34% nationally), and diarrhea. Poor nutritional status is related to maternal malnutrition, low birth weight, inadequate breastfeeding and weaning diets, and childhood diseases. For children under five years of age, 17% were reported to have had a fever in the two weeks preceding the survey, with children aged 6 to 23 months being the most vulnerable. On Guadalcanal, only 46% of those children who were reported to have had a fever were taken to a health facility for treatment. This is the lowest level of treatment of all of the provinces. In the two weeks preceding the survey, nationally 9% of all children aged less than five years were reported to have had diarrhea. However, 93% received some form of treatment. Poor children's health and lack of access to healthcare represent significant threats to the future availability of human capital for rural Guadalcanal communities.

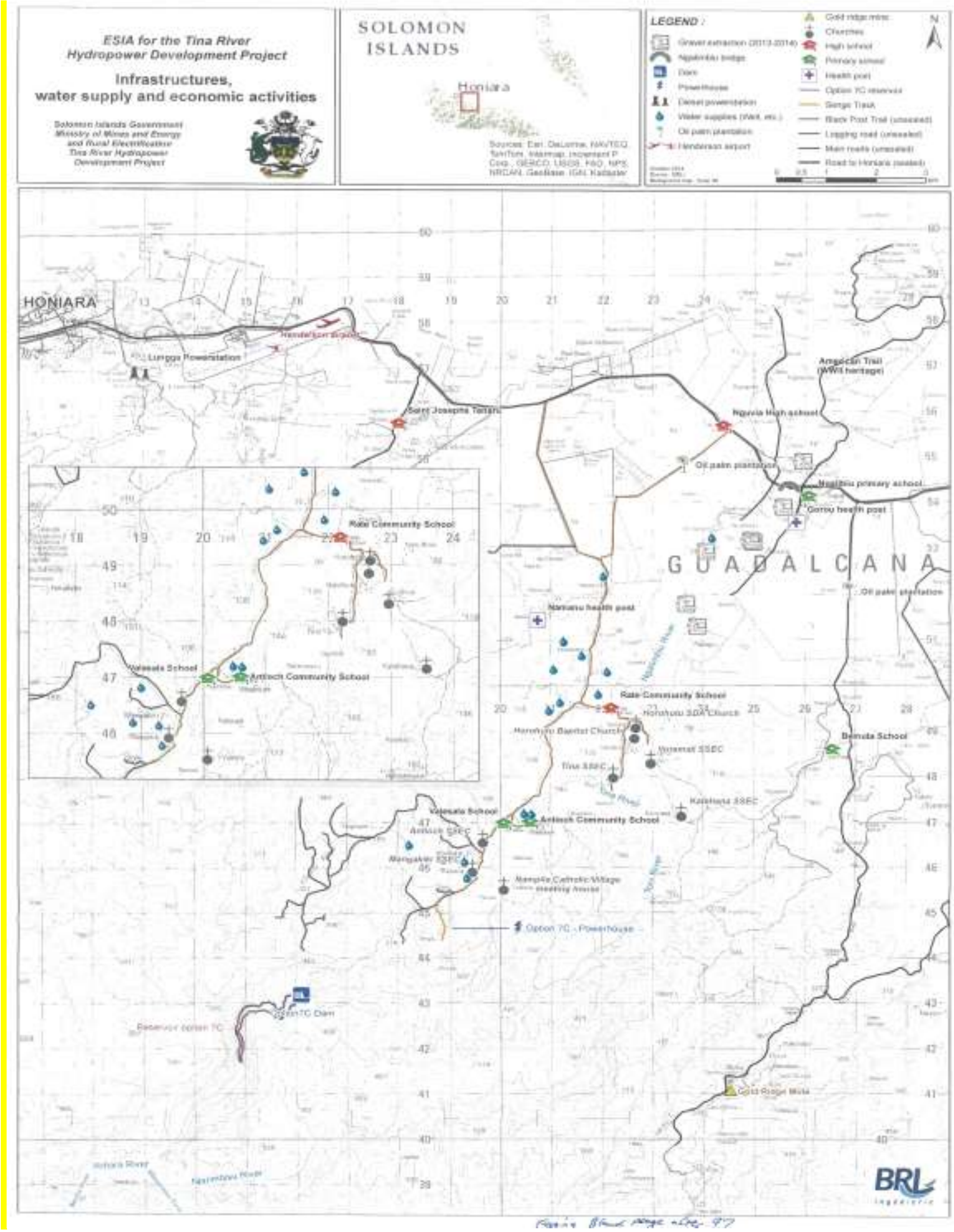
8.1.8.9 Access to Health Services

The accessibility of health services is a significant issue for communities of the project area. This is particularly problematic in cases of accidents, complications of childbirth, and child diarrhea and fever. The national 2007 DHS showed that in rural areas only 37% of children less than five years of age with diarrhea in the previous two weeks had access to oral rehydration, and 58% had been taken to a health facility. The incidence of seeking health support for sick children in the project area is not known, although it is not likely to be any better than elsewhere, since the majority of the residents of the project area have to travel considerable distances over rough roads, often on foot, to attend the basic provincial government provided health clinic at Namanu or the health post at GPPOL (Gorou health post). Even when they are able to attend the clinic, local people may not be able to obtain the drugs or treatment necessary. The main national hospital ("Number 9") in Honiara is not easily accessible by local communities.

Local villagers consider health services within and adjacent to the project area to be inadequate. Given the prevalence of illness and disease, there is clearly a need for a nursing station or a part-time attended health outpost in the Tina River area, possibly at Rate or Antioch.

The infrastructure map in Figure 8-9 indicates the location of schools and health services.

Figure 8-9 Map of local infrastructure



8.1.8.10 Household Nutrition

The householder survey included a 24-hour meal recall, for which respondents were asked to recall what they had eaten during the previous 24-hour period. It showed that over the previous 24 hours all the surveyed households in the TRHDP area had eaten breakfast, 90% had eaten lunch of some sort, and 97% had eaten an evening meal. The details of the foods eaten are provided in Annex 6 of the Annex Report.

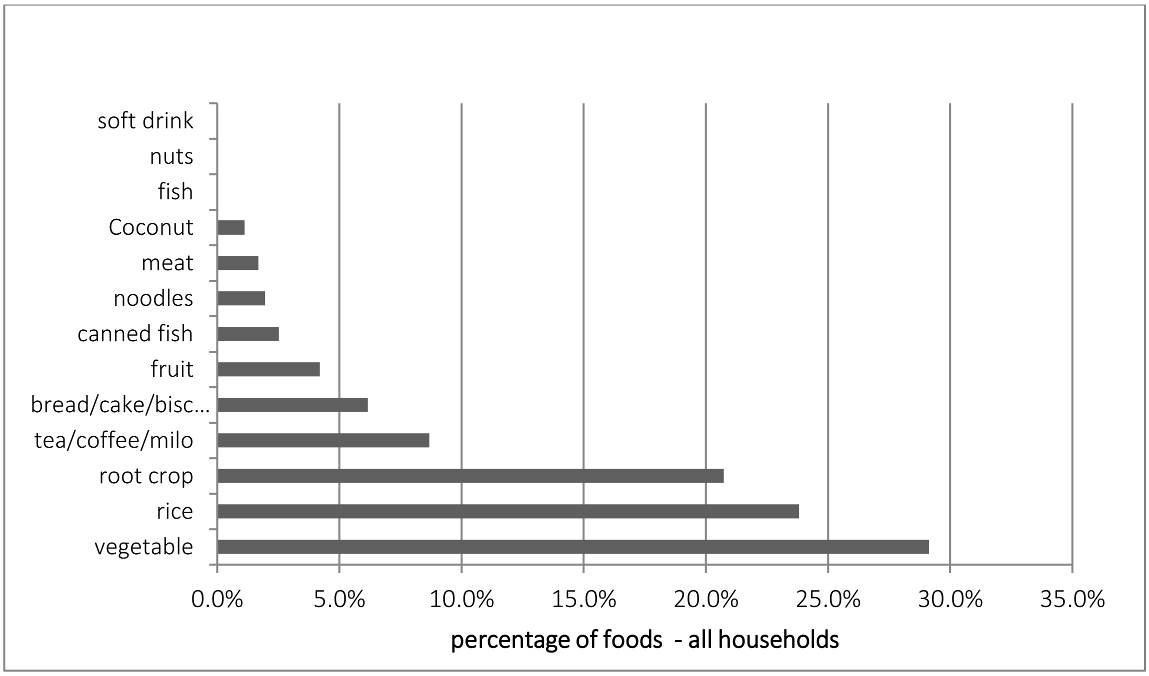
Rice is taking over as a staple food of the Solomon Islands, and for those people of the TRHDP area who can afford it, it is displacing traditional root crops in their diet:

- 43% of households eat rice as part of their breakfast, 41% in their midday meal, and 77% in their evening meal.
- 36% of households eat root crops as part of their morning meal, 42% in their midday meal, and 50% in the evening. These include mainly kumara, cassava, and potato, and occasionally taro or yam.

Figure 8-10 presents the overall picture of foods eaten by households in the project area. Local diets consist primarily of rice and/or root crops, and are eaten with a variety of vegetables, especially green leaves and ferns that are collectively referred to as “cabbage”. The main source of protein is canned tuna (domestically produced), and occasionally pork or fresh fish. Meat or fish was eaten in only 12% of meals, mainly in the evening meal. Fruit, mainly banana and pawpaw, is generally eaten at breakfast and as a snack food. While not a major feature, instant noodles are an increasing component of local households’ diets and are commonly found in local canteen shops.

Based on the limited information available, it appears that the diets of Ghaobata people are generally similar to the people of Bahomea, although, as coastal people, they have greater access to and knowledge of seafood.

Figure 8-10 Foods consumed over 24 hours



Given that subsistence gardening is still the main source for root crops and vegetables for local households in the TRHDP area, changes in work/employment and access to horticultural land and areas where wild foods can be found will have a direct effect on diets and householders’ nutritional status. Past commercial scale logging is reported by local villagers to have had a negative effect on the availability of wild foods, both plant and animal. Also, green leafed food-plants and ferns that are collected from wetlands, and moist areas located adjacent to streams and the river, are negatively affected by drought and floods.

While not recorded as part of the household diets, homegrown tobacco smoking and beer drinking are common among males, and betel nut chewing is common to both males and females. The area is known for its high quality betelnuts, which fetch good prices in the Honiara market.

8.1.9 Physical Capital

Physical capital refers to the equipment, tools, infrastructure, and physical structures used in securing a livelihood. Data was gathered in the TRHDP area householder survey on the goods and equipment owned by the household. This is summarized on Figure 8-11.

8.1.9.1 Household Equipment and Facilities

Regarding the use of toilets, the vast majority of households rely on pit latrines or simply going into the bush. People cite this as one of the reasons for the relatively high incidence of diarrhea, especially among children.

In terms of transport equipment, very few people have their own motor vehicle: 14% reported they had a car and 7% a van or truck, but this appears to be somewhat high given that there are entire villages that have no vehicles. Therefore, the results may be due to sampling bias in the survey.

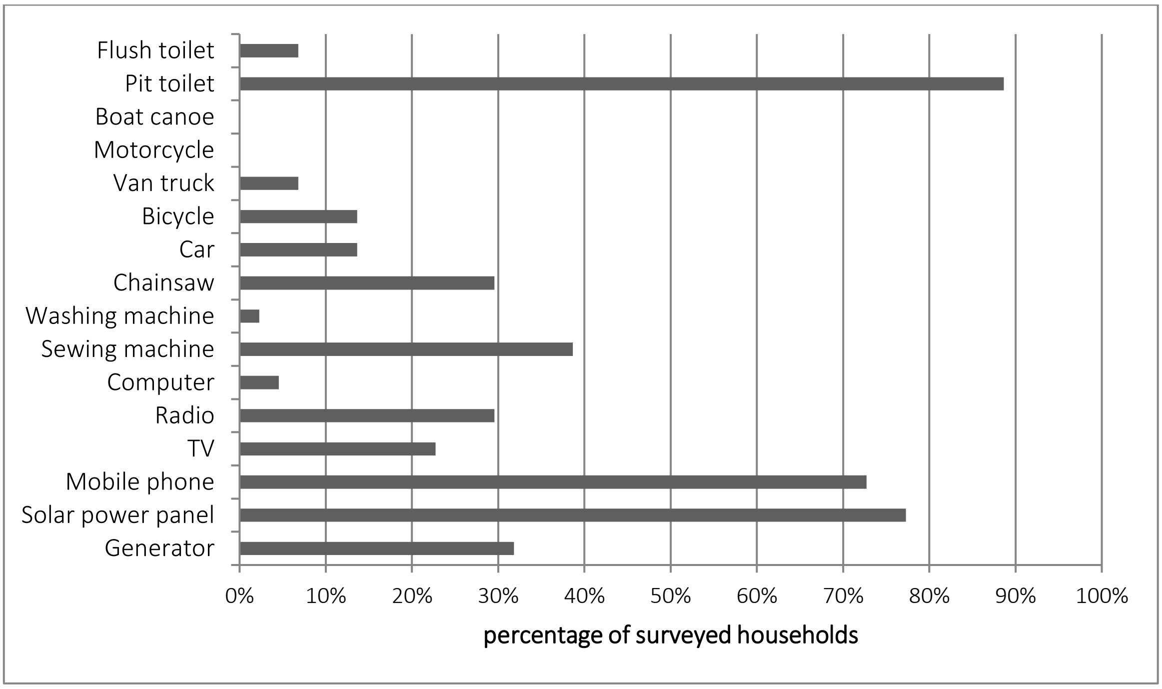
The majority of households have a small solar panel that makes it possible to have a mobile phone. This, in turn, facilitates communication both within the area and with town-based services, suppliers, and family members, and represents a major change for residents of the project area, especially since telephones were completely absent prior to mobile communications technology. Having a solar panel also enables a household to have lighting, albeit at very low power, and small appliances such as a television set, a radio and a computer. However, ownership of each of these items is relatively low. Approximately a third of households' report that they have a generator but, again, based on direct observation, this appears to be somewhat high. Generators are typically used for events, such as church and community meetings, rather than for everyday use.

Nowadays, a chainsaw is one of the most important items of physical capital a household within the project area can possess. A chainsaw enables the owner, providing they have resource ownership rights in the area, to fell trees in the forest and, with the addition of a frame, break them down into merchantable timber according to customer need. As noted previously in relation to income, timber milling appears to have become the most important source of income for local households. Being able to produce timber also enables local people to build more durable, modern style houses. However, chainsaws are expensive to buy and, therefore, tend to be owned by people who have access to capital, perhaps derived from logging or mining royalties. Marketing of timber also requires having access to a truck, which few local villagers do. At present, those producing timber rely on timber merchants and hire vehicles to come out from Honiara to collect the materials.

Just less than 40% of households have sewing machines, which are mostly hand powered. These enable women to make clothes and handcrafts for home use and for sale. While not included in the survey, it is apparent that households in the project area lack refrigerators, and, therefore, are unable to store perishable foods, such as meat.

In general, the data indicate that local people lack significant equipment for supporting their livelihoods, in particular, motor vehicles able to transport goods and produce to Honiara for sale. Day to day domestic work could also be made significantly easier with reliable access to power from the main electricity grid, sufficient to run a washing machine, water pump, cooling fan, refrigerator, and household lighting.

Figure 8-11 Household Physical Capital



8.1.9.2 Housing

Local people of the project area live in extended family households, accommodated in several leaf houses depending on household size. Several types of local houses are evident in the villages of the project area:

- traditional one or two room "leaf houses" made of woven plant material walls, wooden poles, and dirt floors, and sago palm thatched roofs. In some cases these houses are raised on wooden poles. These houses are almost completely made of local materials collected from the forest. They appear to be declining in number.
- traditional style thatched houses with dirt floors or raised on piles, with floors and walls made of sawn timber. These houses are also made of local materials, and appear to be the most common style.
- larger permanent houses with multiple rooms, made of sawn timber, with concrete piles and corrugated iron roofs. Some examples include balconies. These houses incorporate both local and imported materials. It appears that these are a relatively recent introduction into the project area.

Figure 8-12 shows typical house structures observed in the TRHDP study aera at Verakuji (leaf house), Haimane, Habusi, and Marava, the latter of which illustrates the use of more durable building materials.

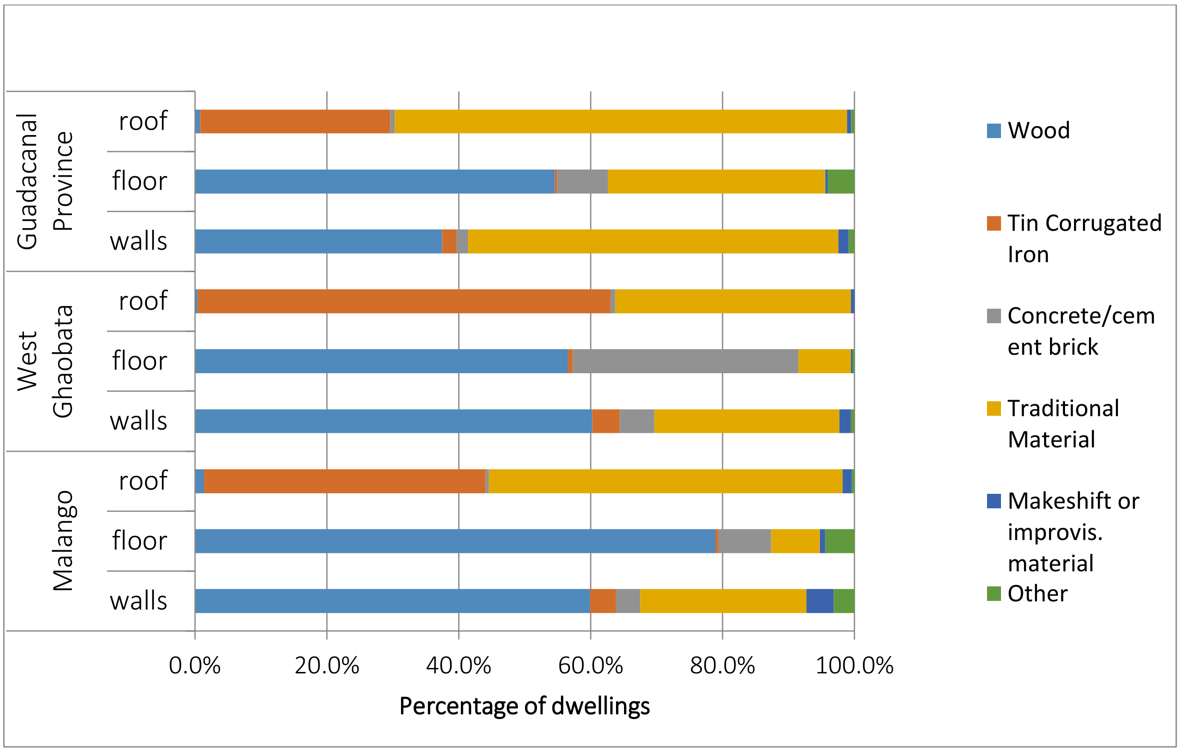
Figure 8-12 Typical house structures in the TRHDP area

The 2009 census recorded 1749 dwellings in Malango ward and 976 and West Ghaobata. Most contained a single household, although 49 of those in Malango ward and 204 in West Ghaobata contained two or more households. This suggests a shortage of housing in the lower part of the catchment.

The Census also records the material used in houses (see Figure 8-13). For the most part Malango houses are constructed of wood or leaf material walls, wooden floors, and leaf-thatch (sago palm) or corrugated iron roofs. This is consistent with field observations made in the project area. Houses in West Ghaobata are generally similar, though they tend to have concrete, rather than wooden, floors.

Malango houses are slightly above average in size for the province, with an average 2.5 rooms each, compared with 2.2 in West Ghaobata and the Province as a whole.

Figure 8-13 House construction materials in Malango & West Ghaobata Wards, 2009



8.1.9.3 Infrastructure

Roads

Physical capital includes local infrastructure. Roads and bush tracks are the most important infrastructure in the project area. These are vital for people and communities to be able to access natural resources, to transport people, goods, and produce to the marketplace, to access services within and outside the area, and to bring home the goods they need. The roads in the area have become vital for people's livelihoods. There are regular minibus services from Honiara right through the project area, wherever there are adequate roads, and they appear to be well patronised. People from the Senge, Pachuki, and Namopila areas who wish to travel to Honiara must ascend out of the river valley along bush tracks. Most villagers in the Tina area have to walk out to the main road to catch the bus.

Unfortunately, all of the local roads are unsealed, lack an adequate or durable surface, are inadequately drained, poorly formed, and badly located in some places. The main road from Black Post (GPPOL plantation) to Marava is a government road, and is only infrequently maintained. Consequently, it is very hard on vehicle undercarriages and suspension problems are common. During periods of heavy rain the roads become deeply rutted, and sometimes impassable. The village side roads are generally poor, and mostly require a 4WD vehicle, and a lot of driving skill. The road from Marava to Mangakiki appears to have been formed as a logging road and is now only maintained as far as Verakuji. Beyond this point, it has reverted to an overgrown track and is not used by local vehicles. The road has a number of culverts that appear to be deteriorating and are likely to fail in the future. In some places, run-off from the roads during heavy rain pollutes local streams and water supplies.

In 2013, some attempts were by the Project to improve the surface of sections of the main Bahomea/Tina Road, as part of its initial development efforts in the area. However, a more serious effort is required. Upgrading of the main road into the area and preparation for the project development was due to begin in October-November 2013, involving correcting creating a proper alignment, improving drainage, and creating a more durable carriageway. If adequately rebuilt, the new road will contribute positively to local people's livelihoods, way of life, and general wellbeing.

Water Supply and Use

Despite reports of many promises made by politicians and various agencies, the landowner and settler communities of the project area, and downstream Ghaobata, still have no formal water supplies or water treatment systems, and there is no water or sewerage infrastructure in the villages. This is seen locally as seriously unjust, given that in the nearby capital city of Honiara these services are available to most residents. Popolo/Old Selwyn has a borehole and infrastructure for water conveyance throughout the village, but this is currently inoperative. Several villages in the project area have their own fresh water wells (see Figure 8-14), but most people rely on the Tina River.

Figure 8-14 Covered village wells at Vera'ande- for washing & laundry

Lack of formal water supply systems is not uncommon in Malango Ward. With respect to drinking water, in 2009 the Census recorded that 38% (i.e. 525) of all Malango houses relied on rivers and streams, and 27% relied on a communal standpipe/well, while only 6% had metered supply from the Solomon Islands Water Authority (SIWA). However, in West Ghaobata 35% of houses had a metered supply, 29% had a communal standpipe, and 23% relied on rivers and streams. For washing water, 57% of houses in Malango Ward (i.e., 1004 houses) in 2009 used rivers and lakes, 17% used a well without a pump, 11% used a well with a pump, and 7% used a private piped supply. The pattern is quite different in West Ghaobata where only 20% use rivers and lakes, 44% used wells, and 26% used either a community standpipe or a shared piped system.

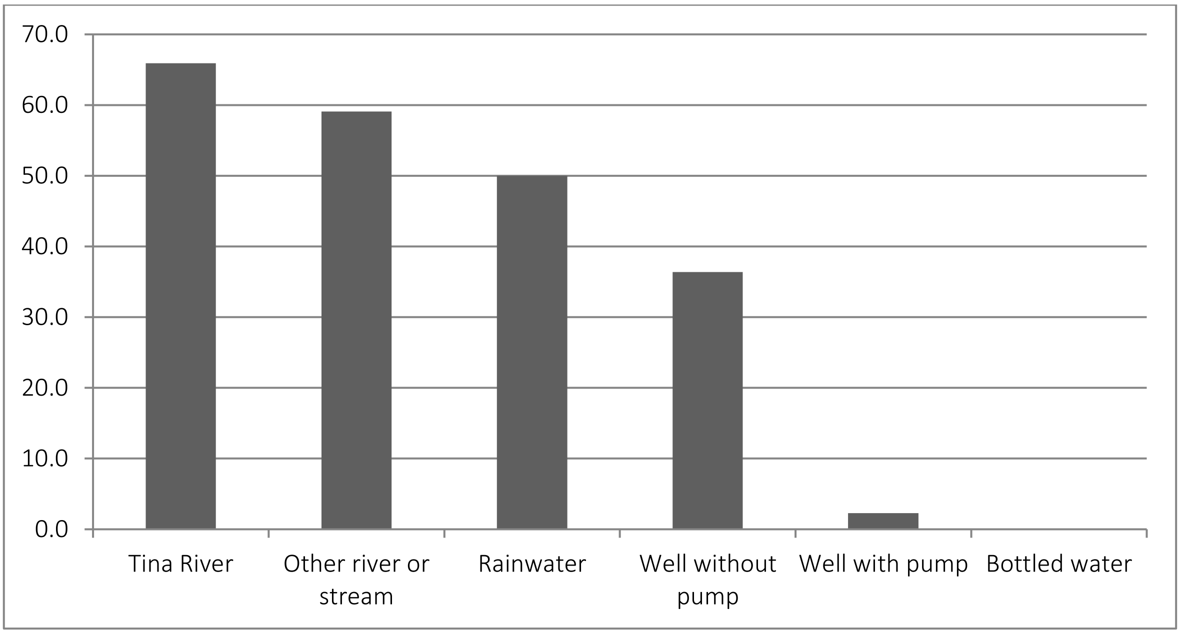
The village workshops and the household survey both enquired into local water supplies. Figure 8-16 presents the household survey findings. Households typically listed two sources of freshwater for drinking and cooking, typically the Tina River or an adjacent stream, and rainwater. Half the respondents said that their household used rainwater. However, there were relatively few rainwater tanks in evidence throughout the villages. Another 39% of households said that they obtained their water from a local well.

Those who take their drinking water from the river use a natural filtration method for ensuring clean water: they dig a hole in the gravel and sand immediately beside the river channel, and water seeps through the sand into the whole from where it is collected (see Figure 8-15). At Senge and the other upstream communities, people take their water directly from the river channel without filtering it. During wet periods or flood events when the rivers and streams are high and discoloured, most villagers collect and store water in anticipation of such conditions, and also collect rainwater in buckets and basins. Only 2% of householders in the survey reported that they used any kind of treatment for their drinking water. This suggests that, generally, the Tina River is of sufficient quality to drink, and most do. As the main source of water for households located in the vicinity, local people and communities are extremely vulnerable to any significant changes in the quality of the water in the Tina River.

Hevalao (2013) has surveyed village water sources in the project area, and provides details of the locations, flow rates and conditions of the Nembo source and Mangakiki, the Rate source for the villages of the Tina River area, and the Antioch source for Antioch and Valesala. In some cases villages have installed small dams and piping to make it easier to access the water.

At Mangakiki, Marava, and Verakabikabi, householders have to walk some distance, sometimes up and down steep hills, to fetch water from local springs or small streams. Several sources are used at Mangakiki, and some villages further down in the valley have proposed that these could be the basis of a piped supply in the valley. Villages at Vera'ande have several wells close by which are used for different purposes. Villages located on the downstream flood plains tend to have greater access to wells and communal taps, and generally don't use the Ngalimbiu River for drinking water.

Figure 8-15 Main sources of drinking and cooking water in the surveyed households



The majority (i.e. 73%) of the surveyed households in the project area do their laundry in the Tina River and 77% use it for bathing.

The people of Malango Ward clearly are at a disadvantage compared with their neighbours, with respect to both drinking water supply and washing water. This disadvantage in lack of basic infrastructure and service availability, which is exacerbated by the additional labour required for collecting water, and in poorer sanitation and health.

Figure 8-16 A water collection hole in the river bed near Tina Village

Sewerage

The lack of sewerage infrastructure and basic toilet facilities in the villages of the project area has been previously discussed. The reliance on pit latrines is common throughout Malango Ward, according to the Census. In 2009 45% of households in Malango used private or shared pit latrines, 13% used a private water seal toilet, 11% had their own flush toilet and 24% had “other” or no toilet facilities, that is, they use the bush. The pattern in West Ghaobata is slightly different, where 29% used a pit latrine, 30% used a private or shared flush toilet, and 33% had other or no facilities, i.e., they use the beach, sea, or bush.

Energy for cooking and lighting

While the 2009 census recorded that 12% of houses in Malango were connected to the main electricity grid, there is no such electricity supply to the villages in the project area, notwithstanding that this is very much desired by local people. For lighting, the Census records that the vast majority (77%) use kerosene lamps and a small proportion (4%) use solar/PV power. Cooking is almost exclusively done using wood fires (90% of households), with a minority of 8% using gas from compressed gas cylinders. In West Ghaobata, Popolo village was connected to the main electricity supply grid that also serves Honiara, but the overhead power lines were stolen during the period of Ethnic Tension. Other villages in West Ghaobata are connected to the mail electricity supply. The 2009 Census records that 27% of houses were connected to the main electricity grid. However, the majority of households still rely on kerosene lamps for lighting, and almost every household (i.e., 96%) cooks using heat produced from burning wood or coconut shells.

8.1.10 Social Capital

8.1.10.1 Introduction

Social capital refers to the relationships or connections that people and communities have with each other and upon which they can draw while seeking their livelihoods. Being able to access the resources and knowledge of other people and communities requires relationships of trust and reciprocity. Along with natural capital and human capital, social capital is an essential part of local people's portfolio of livelihoods assets.

8.1.10.2 Wantoks

Within the project area, kinship or family connection is the most important form of relationship for accessing the resources necessary for life. As mentioned, the indigenous people in the project area see themselves as being part of a 'family', with a special identity, language, culture and environment. Local people generally live quite close to their extended family members and are able to call upon them to assist with a wide range of tasks necessary to achieve their livelihoods. Likewise they are expected to contribute to other members of the family, clan and community. Those connected by kinship and who are members of the same community are often referred to as "Wantoks", and there are strong customary mutual social obligations associated with this relationship. In the project area, it is common for people to call upon relatives and neighbours to help with major tasks such as clearing land for cultivation, house building, transporting produce materials and goods, and assisting in special events such as traditional clan pig feasts. Those who aspire to leadership, draw heavily on their available social capital for the resources and support necessary to succeed.

In addition to kinship and membership in the same community, people use connections with former boarding school mates, workmates, and sports team members to gain access to livelihoods resources that they need.

8.1.10.3 Religion

The second most important basis for social relationships is through membership of the same church.

Most people in villages of the project area are Christians, and actively practice their religion. In some cases, people are also affiliated with the Moro/Gaena'alu movement. Religious affiliation is a very important basis for community formation and for providing social capital for local livelihoods and activities. The main religious or denominational groups in the communities along the Tina River are the South Sea Evangelical Church, Roman Catholic, Anglican/Church of Melanesia, Seventh Day Adventist, Assembles of God, Bible Way and the Baptist Church. There are also smaller churches such as the Church of the Living Word and Christian Mission Fellowship that are located in communities in the downstream areas. Several villages also have followers of the Moro Movement, centered mainly on Koropa and Namopila. There are twelve Church buildings across the various communities, varying in size, style, and construction.

Church buildings are usually located at one end of the village compound, acting as an "anchor site" and important meeting place for a village. They are also the most substantial buildings in the village, and represent considerable investment by the community, in terms of natural resources and materials, labour, and cash. Apart from kinship and clan affiliation, church membership is the main basis for social organisation and action.

Ward-level 2009 Census data show that the South Seas Evangelical Church (SSEC) has the greatest number of adherents in Malango Ward (33%), followed equally by the Church of Melanesia (Anglican) and the Roman Catholic Church (approximately 20% each), and then the Seventh Day Adventist Church (SDA) with 16% of the population. In West Ghaobata Ward, the predominant religion is the Church of Melanesia (with 52% of the population) followed by the Catholic Church (18%). Taken as a whole, Guadalcanal is predominantly Catholic (36%) and Anglican (23%), followed by the SSEC and the SDA.

As noted earlier, day-to-day activities often involve church membership, and along with sports groups, church groups make up the majority of social organisations in the villages of the TRHDP area. The surveyed villages typically have church-focused mothers' clubs and youth groups, Sunday school, and a local soccer, netball or volleyball team. All the larger villages have a church building, and in some cases the church is supported or led by a paid clergyman, religious instructor, and/or youth worker. These churches are also the conduit for church-based aid project work by overseas religious organisations, such as World Vision, Charitas, and others.

Additional details regarding religion, and the Moro Movement, are provided in the Cultural Heritage sections.

8.1.11 Financial Capital

In the context of livelihoods, financial capital refers to the stocks and flows of money or equivalent assets. This includes credit that might be available to the household.

It is clear from the general profile of incomes, work, and other livelihoods assets that the people of the project area are not well endowed with financial capital, although they may have periods where they receive relatively large payments of money from the sale of goods and from royalties. There are no data available on the extent to which local people have bank accounts, loans, or access to credit. Land tenure data from the 2009 Census for Malango Ward suggests that bank mortgages are rare, since 42% of householders were listed as having freehold ownership of their homes, 39% were leasing from a customary or a private owner, 7% were leasing from government, and 12% had some other arrangements.

With customary collective land ownership, and high levels of self-employment and subsistence, it is difficult for indigenous people to get loans for business or other developments from the commercial banks. It is, therefore, easy to see how selling off logging or mineral rights on one’s customary land to foreign companies may be tempting for those wanting to accumulate a block of financial capital. This seems to be the main means by which capital accumulation among indigenous people has occurred, and why logging and mineral exploration appear an appealing alternative for people of the project area and the wider Malango Ward.

8.1.12 Natural Capital

8.1.12.1 Introduction

Natural capital refers to all the “goods and services” of the natural environment that people use for their livelihoods. This includes materials and goods that are used directly (e.g., wild foods, and fresh water) or require processing or preparation before they can be used (e.g., forest trees, minerals, and wildlife). In the context of the TRHDP, the most important natural resources for local indigenous people are the land, forests, rivers and streams, sunlight and the cycles of the seasons.

8.1.12.2 Land and Land Use

Land Ownership and Occupation

As described earlier, land is central to the Malango people's identity, wellbeing, and culture. Prior to the colonial period the land, including the forests and the living things within them, provided all of the peoples' physical needs, i.e., food, drink, shelter, weapons, fuel, decoration, and medicine, and the materials required to transform or process products from the land. In modern times, this total dependence on the land and environment has been weakened through participation in the wider economy, including the use of imported food, materials, and technology.

Simultaneously, the land and its resources have been opened up to outsiders and multinational interests for large-scale exploitation. For example, much of the accessible area in Malango Ward has been logged over time, by a number of different companies[67]. This has generated royalty payments for some of the indigenous landowners, and provided roads, but the scale of the forest destruction has meant negative impacts on traditional subsistence uses of the land and forest. Commonly mentioned problems include erosion and sedimentation of streams and rivers, unnecessary destruction of important resources such as sago palm, medicinal plants and food trees, introduction of unwanted exotic plants and animals (e.g., the invasive Giant African Snail), and disturbance to or loss of wildlife habitat, which among other things, has displaced wild pigs into villages garden areas.

To the indigenous people, no land is un-owned or is not connected with a clan, even if it is does not appear to be occupied or utilised. The most important land to local indigenous people is the land that belongs to their particular clan, and the clan can have land in many locations. Sometimes the land is shared with other clans, for example, upland forest where people hunt and gather wild foods and materials. Within the tribal and clan domain, several types of land are particularly important:

- gardening land with soil and conditions suitable for sustained production of a range of crops for both household consumption and for sale in the market;
- well-drained safe flat areas for villages, houses, churches, meeting areas, and recreation, and which have access to fresh water;
- forest land for obtaining both timber and non-timber products (such as thatching, posts, vines, canes, materials for cordage, medicinal plants, decorative plants, fruits, nuts, edible leaves and roots), and for hunting wildlife;
- land that has been formerly occupied and been a home to clan members; and
- land which may contain important cultural sites, graves, or signs of occupation (such as planted food trees).

Full rights to occupy land and use its resources are acquired from membership of one's mother's clan, the matrilineal clan being the land-owing unit in Malango society. As Roughan et al (2011) have outlined in relation to the "indigenous terrain", clan ownership of particular blocks of land or whole areas depends on having knowledge of the history of that land, its use, and the location of culturally important sites and features to be able prove the connection to others. This knowledge tends to reside with the oldest members of the clan. Over time this knowledge can become lost or uncertain, especially if the knowledge holders and their descendants relocate to other areas, or become deceased, as has occurred throughout Bahomea and Malango.

[67] In mid-late 2013, Earthmovers Ltd, who are based at Foxwood on the Guadalcanal plains, were operating elsewhere in Malango Ward, and were seeking to return to Bahomea for more logging. In 2011, Pacific Timbers were logging on the ridges above Choro.

Since the vast majority of local people occupy, and use unregistered, customarily owned land, it is not always clear today which parts of the landscape belong to which sub-tribe or clan. Hence, there may be claims and counterclaims over particular areas, especially if there are material benefits to be had in the form of royalties or compensation.

With respect to the land in the upper catchment that may be occupied for a hydroelectric dam site and water storage reservoir, it appears that many Malango speaking clans may feel they have a land ownership or land use right over the potential project area since all originate from the hinterland at the top of each of the river catchments of central North Guadalcanal. A the time of this report, detailed clan ownership was being investigated by the clan leaders of Bahomea[68].

As noted previously, land use rights may be obtained by outsiders, through customary arrangements with the traditional land owning clan, involving the presentation of shell money and pigs. In this way, the original settlers from the Weather Coast were able to take up residence at Verakabikabi. Such arrangement has to be re-established or reinforced when there is a change of leadership among the landowners.

Garden Land

Attempts were made in the village workshops and the household survey to gather information about the location and size of peoples' garden lands. However, this proved to be difficult. Based on field observations, most garden land is located within relatively close distance to the village, typically within 10-15 minutes walk. Proximity is important for protecting crops from wild pigs and theft, and for convenience. In some cases people cultivate gardens some distance away from their residence, usually in areas and villages where they have land ownership rights. This seems to occur right through the Tina River valley and it is common to see people walking up or down the river or the road to and from their gardens. In some cases such as Choro, where clan land that is suitable for gardens is some distance away, people may build a hut on the land and stay for periods tending their seasonal crops.

The total amount of area used for household gardens depends on the size and needs of the household, the energy of the gardeners, and the extent of their involvement in cash cropping. Also some households may have several plots for different purposes. At Antioch it was said that, nowadays, some households have only small gardens because they are not so dependent on home produced food. At Senge, people said that households typically had two plots under cultivation at one time, each plot being approximately 1600m^2 in size. At Namopila and Pachuki, where people have access to highly fertile river flats (prior to the serious flood of April 2014), plot sizes were also approximately 1600m^2, although people may only have one plot under cultivation. At Tina and Haimane, garden plots were said to be typically of a similar size, though there is considerable variation. Householders at Vera'ande have a large area of cultivated garden land adjacent to the main Tina road, some of which may be encroaching into the road reserve. This garden land, which is also adjacent to a wetland that produces useful plants, and from which groundwater is drawn, also has several pigsties. Generally, pigsties are located on garden land on the edge of the village. Pig keeping is quite common, and is sometimes a community enterprise (such as at Tina). Relatively few households appear to keep chickens and geese. Domestic fowl are usually kept on a free-range system.

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[68] This process was subsequently described in a media statement on 24 June 2014 by the "Core Land Tribes of Tina Hydro Project" as the Bhamoea Land Identification Committee (BLIC) process, It involved investigations and consultations on land ownership by "all the recognised elders and storytellers holding traditional land knowledge".

8.1.12.3 Water Rights

In Solomon Islands, there are no formal allocations of water rights. Unlike, for example, rights to fish in an area or collect shells, which can be closely held under custom (and recognised by law), the High Court[69] has held that flowing water is a public right, unowned by the owners of the land over which it passes. In making this determination the Court found that the English common law position also reflected customary understandings of water rights:

> In spite of what we may say, it is common knowledge that water is essentially or necessity of the human being. It is always advocated by health officials in public talks and media etc that "water is life". This sum(s) up what I would say on the qualifications as local circumstances render necessary… on applying this common law on water.
>
> And I am satisfied that the common law principles of nobody own(ing) flowing water is not inconsistent with any law or Acts and; its applicability or appropriateness in the circumstances of Solomon Islands is not inconsistent with the Schedule 3 of the Constitution and therefore make a ruling that it is the law in Solomon Islands on the flowing water.

The conclusion in the case also reflects the findings of the 1959 Alan Report that noted that customary rights holders do not ordinarily assert control of water supplies.[70]

8.1.12.4 Crops

The earlier Figure on local people's food and nutrition lists the range of food produced from their gardens and adjacent forest areas. As noted, the focus of garden production throughout the villages of the project area is on root crops, especially cassava and kumara, green leafed vegetables, cucumber, pumpkin, tomato, corn, spices, tobacco, fruits (such as bananas, guava, mango, Malay Apple, and citrus), sugar cane, nuts (especially coconut and betelnut), and flowers. Local gardens and nearby areas may also contain small plantations of highly valuable timber tree species such as mahogany, and sago palm. French (2011) provides a comprehensive description of the plants that are frequently grown and/or utilised in the Solomon Islands.

8.1.12.5 Forest Resources

The range of timber and non-timber forest plants to be found on Guadalcanal has been documented in the Solomon Islands National Forest Resources Inventory Project in the 1990s. Google Earth provides a 2010 satellite view of the landscape of the project area. This reveals that the settled areas of the Tina River valley and adjacent hills remain forested, although not as densely as the areas in the catchment upstream of Senge.

The village workshops confirmed that Malango's forests are essential to the livelihoods and wellbeing of Malango people, providing:

- timber and non-timber materials for housing (i.e., timber, loya cane, thatch, bamboo, and bark):
- game wildlife for hunting, such as wild pigs, possums, flying foxes, lizards, skinks, frogs, hornbill, pigeons, and ducks ducks):

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[69] *Solomon Islands Water Authority v Commissioner of Lands* SBHC 58

[70] Allan, C. H. 'Customary Land Tenure in the British Solomon Islands Protectorate' *Report of the Special Lands Commission* Honiara, Western Pacific High Commission, 1957. Considering customary rights to water the report found 'In general, the principle can be stated that the tenure of water supplies is subject to little control'. This was found to be in contrast to strictly held rights to fishing areas along the rivers in Northern Guadalcanal.

- plants used for medicinal purposes and magic;
- wild foods such as fruits, wild palm, wild yam, various nuts, and ferns, megapode eggs, and emergency foods when required;
- materials for handcrafts, such as baskets;
- regulation of run-off from the heavy rains that occur on Guadalcanal especially around the high mountains, and climate regulation; and
- and aesthetic appeal, and places for recreation and relaxation.

The full range of fauna and flora in the Tina Hydro study area, especially that in the upper parts of the catchment where TRHDP is planned, is presented in Section 6 – Biological Environment Baseline - Terrestrial.

8.1.12.6 Timber extraction

Apart from materials for their own homes, people in the Bahomea district use the forests in the upper catchment, including the areas proposed for the hydro scheme options, as a source of timber for sale to the construction sector in Honiara. The main species targeted by locals are vitex (*Vitex cofassus*), kwila (*Intsia bijuga*), *Calophyllum* species, and rosewood (*Pterocarpus indicus*). Parties of 2 to 3 men work with a chainsaw to fell selected trees, and then mill them on site into timber according to required sizes. The cut timber is then carried to the river, made into rafts,and floated downstream to pick up points with road access, for example, near Tina village. As discussed previously, most villages are involved in timber extraction. Some of the timber extraction is focused on the Toni River and others on forest areas adjacent to the upper parts of the Tina River, especially around Koropa and upstream as far as Choro. The river is, therefore, integral to local landowners' timber extraction operations.

8.1.12.7 Hunting and Fishing

Most hunting by people of the TRHDP area appears to take place in the uppermost parts of the Tina River catchment, upstream of Choro, and especially around and upstream of the old settlement areas of Tulongu, Tulambirua, and Namoradina on the northern slopes of Mt Popomanaseu. Hunting mostly takes place as "expeditions" lasting several days to a week and focuses on wild pigs. Hunting and fishing parties commonly base themselves at Njarimbisu at the confluence of the Mbicho and Mbeambea Rivers. Pig hunting is done with dogs, and tends to be the domain of young men, and is mostly done to raise funds for church and other events, as well as when people feel like a "feed of wild meat".

Fishing is carried out along the length of the Tina River, though nowadays it is focused on the river holes and pools in the upper catchment, upstream of Choro and as far as the Mbicho and Mbeambea Rivers. The main mode of fishing is by spearfishing with mask, snorkel and spear gun, and is sometimes carried out at night. Participants in the village workshops provided long lists of species they said they were catching and eating. The main fish being targeted are eels, helu (Silver fish), valu (Freshwater snapper *Lutjanus fuscescenus*), kola (Mullets, *Cestraeus sp.*), and tilapia (in the Ngalimbiu River). People also take prawns (Ura) and a range of small fish. At Senge, villagers named more than 19 species of fish which they said they caught and ate; at Valesala they named 12 species; and at Marava 7 species.

According to PHCG in 2011, some fish species that used to be common in the lower and mid reaches of the Tina River can now only be found in the pools of the upper reaches. Despite the claims made in the workshops, the householder survey shows that fresh river fish only infreaquently feature in people's diets, if at all, and canned tuna ("taiyo") is now the main source of fish protein. Despite local people's obvious knowledge of the fish species found in the river, from a livelihoods point of view, it seems that fishing is, nowdays, a minor activity along the Tina River. However, fishing is a significant source of livelihood at the mouth of the Ngalimbiu River, where semi-commercial fishing occurs using mosquito seine net, and gill net gear. Additional information on fishes, and their ecological and economic importance, is provided in Section 7 – Biological Environment Baseline - Aquatic.

8.1.12.8 The River

The Tina River is an important natural resource and feature in the lives of people of the project area. For example it is:

- the main source of drinking and cooking water for the whole district;
- a source of irrigation water;
- a place to bathe, wash clothes, clean vegetables , and recreate;
- a transport corridor and mode of transport;
- a source of food, including fish, crustaceans, and a range of plants found in and around the river and tributary streams;
- a fence and boundary marker (e.g. in some villages pigs are kept on the opposite bank of the river);
- a source of rocks and gravel used in local house building, and sold under royalty by the villages in the West Ghaobata area; and
- a car wash - in its lowest reaches.

Among the Ghaobata people residing in the lower catchment, sale of river gravel to construction companies is a very important source of income, and a significant component of people's livelihoods. Villagers receive royalties for each cubic meter of material extracted from the riverbed. This material originates from the upper reaches of the river, from where it has been washed downstream during periods of high flow, and then deposited in the inside meander bends in the lower reaches of the river, on the Guadalcanal plains.

Importantly, the Tina River is a source of risk to those who live near it or are required to ford it to get to their home villages or gardens. The main risk comes from flooding associated with storms and cyclones, when the river can rapidly swell in volume and, in extreme circumstances, spreade out to inundate and destroy infrastructure, villages, gardens, animals and human life.

Central to people's experience of living in the Tina River area is the unprecedented storms and floods that came with Cyclone Namu in 1986. As noted in relation to the settlement pattern of villages in the Project area, the destruction by the Cyclone Namu floods resulted in a major relocation of many villages to their present-day sites.

8.1.13 Conclusions

In conclusion, the Social survey fieldwork was conducted successfully and in the expected timeframes, covering all of the settled area within the Area of Impact. A high level of participation by the village communities was achieved, with all levels of community members attending focus community workshops and follow up consultations, including adults, youth, women and children. Valuable baseline data and information was collected during the course of the Social field surveys from the village communities, householders, and culturally knowledgeable elders, as well as from various stakeholders, including government ministries and provincial offices, and civil society groups / NGOs.

8.2 CULTURAL HERITAGE AND GENDER ASPECTS

Cultural heritage and gender aspects fieldwork was carried out by Lawrence Foana'ota, a member of the ESIA team.

8.2.1 Survey Methodology

Cultural heritage and gender baseline and assessment data were gathered as part of the social workshops and survey process.

As outlined previously, meetings were held at 'core centres' either in community buildings or out in the open with members of the participating villages. The meetings generally began and closed with prayers, welcome remarks, introductions and explanation of the purposes of the visits by community representatives and ESIA team members.

During these workshops specific questions were asked about community health, cultural heritage and the role of women, as well women's as their views and feelings about the benefits and effects of the project.

In addition to the workshops and the householder interviews, interviews and discussions were conducted with individual chiefs, elders, leaders of youth and women's groups regarding cultural heritage matters, and gender aspects of life in the district.

People's responses to questions concerning cultural heritage, and the lives of women and children, were recorded in writing during social surveys (see previous section).

Additional information on cultural heritage, gender aspect and vulnerable people was gathered from secondary sources (such as published articles) and from the personal knowledge of Lawrence Foana'ota, who is a former Director of the National Museum.

8.2.2 Indigenous People

In traditional communities of the Solomon Islands, having specific names for tribes and sub-tribes or clans is by far the most important single factor in the identification of one's affiliation in society. Sometimes these names may be used to refer to a particular language group, a people or their geographical location within an island or province. The members of a particular group also use the names to distinguish themselves from other nearby groups of people.

People of Guadalcanal, like all the other communities in different parts of the country, have special names for specific groups of people. The groups of people in the Project area are called the Bahomea People within Malango Ward 20 in Central Guadalcanal**.**

As far as the whole of Guadalcanal Province is concerned, they have four main descendant groups. As already mentioned earlier in this chapter, they are Manukama, Manukiki, Koinahao and Lasi. The Bahomea people who live in the Tina Hydropower Development Project areas are descendants from the two exogamous moieties known as the Manukama or also known as Garavu and Manukiki. These are big lines and small lines as the people always refer to them.

Manukama or Garave is the big line, which is symbolized by the eagle or *Chacha* totem, while the small line or Manukiki is represented by the hawk or *Roha* totem. Sometimes they refer to themselves as big bird or small bird. The name for tribe in the local indigenous *Teha* language is Vunguvungu. There are reportedly twenty-seven sub-tribes living within the TRHDP area.

According to their custom, men and women of any sub-tribe belonging to these two main tribes can marry each other but not from sub-tribes of the same main tribe. For example, **A** of a sub-tribe from

Manukama is allowed to marry **B** of a sub-tribe from Manukiki but **X** of a sub-tribe from Manukama, cannot marry **Y** of another sub-tribe from Manukama. This also applies to members of other sub-tribes from Manukiki.

8.2.3 Cultural Heritage Sites

In parts of the Solomon Islands, some communities do not impart information or knowledge about their cultural heritage easily, especially when it comes to dealing with cultural and historical sites. There are some sites that are sacred or still considered to have powers that people no longer want to talk about, because they fear of getting sick or dying prematurely. This appeared to be the case in some of the communities the ESIA team visited. Prior to construction of the Project, a culturally accepted protocol has been developed to implement for identifying sacred sites (Tambu sites) (see ESMP).

Cultural heritage is a subject that many communities are not interested in discussing publically. It depends very much on the importance placed on it by the people. During the visits and meetings held with the communities, it was observed that, unlike in the past, members of the Bahomea communities were not always in agreement about what they regard as important cultural heritage. In Tina Village, for example, those interviewed no longer placed much importance on tradition, due to the influence of the Christian religions. Many people have turned to Christianity, and as a result, their cultural practices, sacred sites, and various rituals have lost much of their significance and meaning, including information associated with them.

Throughout the Solomon Islands, these types of sites are usually located either along the coast or high up in the mountains where they are sometimes hard to access on foot. As a result, persons interested in any of the sites may have to walk for a few days to get to them. In some cases, no one is allowed to visit or take pictures of them. This was also the case in the communities along the Tina River.

According to the information provided to date, the main sacred sites, also called tambu sites, located within or near the project area are Tulahi opposite to Koropa Hamlet, Namuloha sacred pool, Aho stream, Vatukotiti and Vatumosa sacred stones (the latter representing a pig), Makara Tavukea (2 stones - one representing a Helu Fish), Babaruhuvia (a cave used before for sleeping when people had no built shelters), Bela hill, Chanjo, Tovu, Choga and Kabi. These sacred sites were all used by the founding families in the past, when they first settled on the land, and are located between Senge and Choro Hamlets. No details of sites upstream of the damsite were obtained.

Some of the sacred sites and objects could be affected by the Project. The Namoloha sacred pool will be affected by flow changes in the by-passed reach of the river**.** The customary houses built in Koropa where two boxes containing a number of heirlooms are kept will not be affected. Most of the sacred, fishing, hunting and timber milling sites are located within the areas in the upstream catchment.

It was not possible to physically visit these upper catchment sites because they are located in places that are inaccessible by road. The ESIA team only ventured as far as Senge and Koropa

One of the reasons for not speaking about or providing information on these cultural sites, including the whereabouts of grave-sites, during village gatherings is because they are associated with landownership. This kind of response to questions regarding cultural or historical sites is common to many communities throughout Solomon Islands. Chiefs, or those who have the knowledge, fear revealing information in public because someone might use it to claim ownership of land, or use the information in court against them. People from Marava, Vatupaua, Rate CHS, and Ngongoti communities noted that several burial places may be affected if the existing Tina-Black Post Road is enlarged to facilitate construction of the dam.

According to the ESIA Scoping Report, the Njarimbisu River area (upper catchment area) is known to be of significance to local tribes. It is believed that, prior to WWII, Tina Village was located near this site. During the war it is believed that it was attacked and that lives were lost (Entura, 2012).

There are no cultural heritage sites within the project study areas that are formally protected under the Guadalcanal Historic Places Ordinance 1985. So far, based on information gathered by the ESIA team, there are no "critical" cultural sites or relics to be found within the area that cannot be relocated, or compensated for, if disturbed or destroyed.

There are no WWII sites in the proposed project area. However, some sites were noticed in the downstream area, such as bunkers along the "American Trail" (see Figure 8-17). These WWII sites will remain unaffected by the Project.

Figure 8-17 WWII Bunker along the American Trail

8.2.4 Christianity

As mentioned in a previous section, there are a total of twelve Church buildings in each of the communities. These structures vary in size and method of construction, using both local and imported materials. An example of the use of modern building materials, are the SSE Churches at Antioch and in Mataruka in the Malango district. Figure 8-18 shows a photograph of the SSE Church at Antioch.

Regarding the location of religious sites, such as Church buildings and cemeteries, these vary from community to community. In some communities, Church buildings are located at one end of the village compound, while the cemeteries are either located near the houses or some distance away from the residential sites. The graves are either surrounded by wooden planks or stone boulders, which hold the soil in place. Some graves were observed next to the families' dwelling houses or in the center near the Church building (e.g., in Tina Village, Senge, and Pachuki). In some cases, families bury their dead next to their houses (one or two graves), out of concern that someone might disturb or desecrate the graves.

At Tina Village the graves of a notable missionary couple are covered with concrete, whereas at Senge and Pachuki, wooden planks are built around important graves.

Figure 8-18 Antioch South Seas Evangelical Church

8.2.5 Moro Movement

In the Solomon Islands, as elsewhere in Melanesia, there are many stories about various cargo cult movements, which started when people began to experience a new western lifestyle, which was associated with material goods available in large quantities.

The Moro Movement is based on two main objectives: (1) the establishment of a socio-political organization of which the late Moro was the leader; and (2) the launching of a number of co-operative economic enterprises aimed at elevating the standard of living of the followers of the movement. The key premise of the Moro Movement is that the Americans would return and take control of Guadalcanal once more, and that the “Black Americans” were going to send cargo (i.e., large shipments of American materiel), to which only adherents of the Moro Kastom would be entitled. Ships from America would arrive and then transport the faithful followers of Moro to the USA.

In the late 1960s, Moro sent a deputation to Honiara to see the District Officer. “The deputation consisted of four young girls aged roughly 14 to 16 years, dressed in traditional string skirts and adorned with traditional shell money. They carried a bag containing several thousand Australian dollars to “buy their freedom.” The bag of money was sent back with a message from the District Officer to Moro telling him that they had “freedom” and that it could not be bought with cash, only by working in society” (Tedder 2008: 197).

The main headquarters of the Moro Movement is at Makaruaka, on the Weather Coast of Guadalcanal. The Malango branch of the Moro Movement is based at Koropa where Chief Hudson Micah is the main holder of everything related to the movement’s beliefs and powers. He has two boxes with three compartments in each one. In the first compartment in each box are traditional objects including some special shell money beads associated with the preservation of the

Environment (Hairau). The second compartment contains items related to good health or the wellbeing, style of living, wealth and the way of doing things by Man (Tinoni). The third compartment holds the things used to ensure good yields from the gardens, or for protection from diseases affecting crops and the Land (Pari).

The Movement promotes living a very simple lifestyle (Poua), making sure that the ground (Momoru) is protected and not sold, and adopting a lifestyle based on leading by example (Vuluna), at a time that is, otherwise, characterized by the rich getting richer and the poor getting poorer. To abide by the teachings of living a very simple lifestyle, women and young girls wear twisted string skirts with no top coverings, while men and boys wear tapa aprons or *kabilatos* (breech clouts) which cover only the front and back also without any top coverings.

According to a leader of the Movement, families living in Senge, Koropa and Choro, and some of those in the other Christian communities downstream of the Tina River, support the Moro Movement and its ideology - especially the core beliefs and teachings about the land, environment and culture. However, the fundamentalist Churches and some of the chiefs are, reportedly, very opposed to their practices and, as a result, any activities or even symbolic buildings such as the custom style built houses that represent the Movement's ideologies, are not permitted within the Christian communities or villages.

The members of some of the fundamentalist Christian Churches view the Movement and its beliefs and practices as evil and uncivilized, because of how the followers dress and the way they live in hamlets with only two or three members of a family, isolated from other communities. In fact, the late Moro was Roman Catholic, and some current followers and members of the Movement also belong to the Roman Catholic Church.

The implication for the Project of the presence of Moro followers is discussed in the impact section.

8.2.6 Gender Aspects

The Solomon Islands national census report of 2009 identifies the total number of women as 251,415 out of a total population of 515,870 - or just over 48.4% (Census Report: 2009).

Women play the very important roles in Solomon Islands society, as mothers, gardeners, sellers of garden products, caretakers of children, and implementers of household chores. In traditional Guadalcanal society, women used to play an important role with respect to land tenure, land management and access to land, and had an impact on wider decision-making in local communities. Women interviewed as part of the social survey, noted that in today's contemporary society, their interests and roles in dealing with land issues, have become marginalised. These communities, like those of other matrilineal societies *"recognize women as legitimate landowners, but there is need for legal recognition through legislation as stated in the Land and Titles Act 1969"* (Maetala 2008:39).

During field studies, women's views on issues affecting them and their responsibilities in the communities as leaders of families and women's groups, were recorded (Figure 8-19). Since it was not possible to interview women who belong to the Moro Movement, only those women leaders who belong to different Church groups were interviewed. Even though their views and decisions may be heard during community meetings, either on traditional, contemporary or religious issues, they are often not prioritized.

Regardless, it was interesting and worthwhile to hear about their responsibilities as women, and their views on the Project. During discussions, they were able to speak their minds freely concerning the possible impacts they feel the Project will have on their lifestyle, work, and the use of the water from the river. In addition to using the river for transporting timber and other materials from upstream, and obtaining gravel and sand for building houses, local people use the riverbank for drying their laundry.

In other locations, there are special places where children are taken for picnics or camping trips during special events, such as the end of the year when children start their school holidays, or for Sunday School weekend outings.

Even though the communities visited appeared to want the Project to proceed, some women, especially those who are leaders and members of Church groups, expressed some reservations regarding the Project. This is because the river plays an important role in their way of life either every day or occasionally. Some women did not provide an opinion during the meetings because they still did not know what the effects of the Project might be, and because the type and magnitude of the Project is new to the country and, particularly, their region.

Since women are the ones mostly involved in looking after the welfare of the children and, in some cases the whole family, they wanted to ensure that the Project must not interfere with their normal lifestyle. For example, they commented that, presently, they have the freedom to move freely along the river without any fears. However, according to them, free movement will be restricted because no one knows how safe the dam will be when it is completed. Their fear is based on their experience with a huge volume of water, which destroyed some of the communities along the riverbank during Cyclone Namu in 1986.

Figure 8-19 Women at Verakuji and Marava

9. ASSESSMENT OF IMPACTS ON THE PHYSICAL ENVIRONMENT

This section identifies potential direct and indirect construction and operation impacts accruing to the physical environment as a result of the TRHDP. It also identifies mitigation measures, and residual effects and their significance.

9.1 DESCRIPTION OF IMPACT GENERATING ACTIVITIES

This section describes the actions and activities of the TRHDP that could potentially affect the physical environment. Potential physical environmental impacts may include induced seismic activity, local slope stability, soil compaction and erosion, hydrology (surface water and groundwater), sediment transport, regional and local air quality, climate change and greenhouse gas (GHG) emissions. In turn, impacts on the physical environment may influence the project's viability or sustainability (see Section 15 Effects of the Environment on the Project).

9.1.1 Pre-construction and Construction Activities

9.1.1.1 Pre-construction Activities

Pre-construction work involves site investigations, including installing a hydrology monitoring station, mapping topography, undertaking geological and geotechnical surveys, and other related activities. Limited drilling and cutting of new tracks to move equipment onto survey sites was required.

9.1.1.2 Widening and Stabilizing Existing Black Post Road

Black Post Road will be widened and improved along its 13.3 km course. This will necessitate bush clearing, surfacing and stabilization with gravel or cement, creation of roadside ditches for drainage and earthworks to build embankments. The width of the right-of-way will be 50m and include the transmission lines.

Between Rate and Mengakiki the upgraded road will be diverted from the existing course of the Black Post Road to take advantage of favourable topography and to avoid the relocation of residents in the Mengakiki Village.

9.1.1.3 Construction of New Access Roads

Black Post Road will be extended from Mangakiki to the project site to serve as the main access road. This will necessitate clearing forest and other vegetation cover, grubbing stumps, removing top soil, completing earth works (cut and fill), stabilizing the roadbed, road surfacing, installing drainage gutters and ditches, and installing watercourse crossings using culverts. This section of road will be gravel or sealed road. The length of this road is about 8.31km. The primary Contractor may subcontract forest-clearing activities to a local logging company, to avoid importing forest clearing and log transport machinery.

Entura's feasibility study (2014) identified two quarry sites both in the reservoir area, which will be connected to the main construction area by access roads. The access roads to the quarry sites will follow topographic contour lines and have the same width as other access roads for which additional width is not required for the transmission line.

9.1.1.4 Construction of Headrace Tunnel from Dam to Powerhouse

The headrace tunnel will be 3.3m in diameter, will run 3.3 km beneath the ground surface, with an 85m shaft connecting to a 130m long power tunnel. The headrace and power tunnel will be built underground using a combination of primarily mechanical excavation (road headers) to excavate rock as well as drill and blast techniques where the geological conditions require this excavation method.

Drilling and blasting above ground will generate noise and vibration due to the use of hydraulic rock drills and explosives. In addition, removal and disposal of spoil material will utilize heavy haul trucks that generate traffic and dust in the dry season. Topsoil removal will be limited to the entrance of the tunnel, surge shaft and tunnel exit. Approximately 1ha of work area for machinery and trucks to operate will likely be necessary at the entrance of the tunnel, and another 1ha will be required for a work area at the exit of the tunnel. BRLi (2013) has estimated the volume of tunnel spoils to be approximately 24,300m^3, based on the dimension of underground infrastructure. These spoils will be used in road construction and in the concrete mix for the power station and proposed tunnel lining.

9.1.1.5 Construction of Dam and Powerhouse

Construction of the dam will require de-watering the river by diverting it through a diversion structure comprised of an upstream cofferdam, a diversion conduit, and a downstream cofferdam. The riverbed and valley walls will be excavated into the bedrock by drill and blast techniques for the dam foundations and dam abutments. Preparation of the dam abutments will affect approximately 2,800m^2 of terrestrial habitat on the right slope of the gorge and 3,700m^2 on the left side of the gorge.

The powerhouse will be built alongside the Tina River 5.7km by river downstream of the dam and will be founded on competent rock using drill and blast techniques to avoid settlement and vibration of the completed structure. A substation will also be constructed. The construction of the powerhouse and substation will necessitate excavation, fill placement, grouting or pilling and will cover approximately 1080m^2 (Entura, 2014).

9.1.1.6 Construction of Work Area

An area of 130m x 90m (11,700m^2) will be required for construction work areas (e.g., staging, fabrication, materials stockpiling, equipment maintenance, etc.) and will involve forest clearing and topsoil removal.

9.1.1.7 Quarrying

Rock quarries will be developed to provide aggregate for the RCC dam. Entura (2014) estimated that 160,000m^3 of aggregate will be required, from two possible quarry sites located in areas that will be occupied by the future reservoir within the Core Area. Where the identified quarry sites are suitable for construction needs, all quarry sites and access roads will be within the Core Area.

In the event that aggregate available from the identified quarry sites in the Core Area is insufficient to meet all construction needs, additional aggregate will be purchased from a licenced gravel supplier. Specific measures for quarry management, including measures applicable to independent suppliers, will be detailed in the Quarry Management Plan to be prepared by the Developer in accordance with the framework provided in the ESMP – Chapter 13.

Quarry exploitation will require the removal of superficial deposits in or close to the river, which may release suspended material into the water.

9.1.1.8 Reservoir Preparation

Prior to reservoir impoundment, trees with a diameter larger than 10cm will be cleared from within the reservoir area up to an elevation of 186.5masl, which corresponds to Maximum Flood Level (11.5m above FSL 175masl). Loose rocks and rubble along the steep faces of the river gorge will be removed where possible.

Reservoir vegetation clearing will be conducted during the latter phase of the construction program, as the dam and powerhouse are nearing completion, just before reservoir inundation is set to commence. The timing is critical so as not to enable vegetation to regrow or become re-established before water is impounded. Depending on the schedule for reservoir filling, vegetation clearing may proceed in distinct phases, with the lowest elevation areas of the future reservoir inundation zone being cleared first, followed by the higher elevation inundation zone. Steep gorges in the reservoir area are covered with ligneous and herbaceous plant species. Due to the steep terrain, lack of access roads and the risk of flash floods, work using machinery will not be feasible. Vegetation clearance will, therefore, be undertaken using manual labour. Sawn timber will be transported by floating it down the river as is currently done from Choro and Koropa. This activity will release organic matter and suspended solids into the river. Reservoir clearing will not involve grubbing (removal of stumps) and soil stripping, since only manual work will be feasible.

9.1.1.9 Construction Traffic

Heavy haul trucks will be required to transport materials and equipment, including excavated material to the crushing plant, spoils from the headrace tunnel, heavy equipment and construction materials, fuel and other products on a regular basis. Light duty trucks and buses will be used to transport workers to and from the Project site.

9.1.1.10 Soil Stockpiling and Spoils Disposal

During the construction of the dam, topsoil spoil will be generated and will be stored (prior to reusing it for rehabilitation or before transporting it outside the Project Area). Storage will either be short term (in case of outside transportation) or long term (in case of rehabilitation of disturbed areas). An estimated 10 ha storage area will be necessary for the generation of 327,900 m^3 of topsoil, using 10 round shape piles of 50m wide and 5m high. It is suggested to use remnant forests of the Core Area to create the 10 ha storage area.

9.1.2 Operation Activities

9.1.2.1 Operation of the Hydropower Facility

The operation of the dam and reservoir will modify the river flow, especially during the night (during reservoir filling) and will create a reduced flow between the dam and the powerhouse. River flow will also be reduced during reservoir impoundment. Operation will also affect sediment transport.

9.1.3 Impact Assessment

9.1.3.1 Impact Identification Matrix

Both the TRHDP construction and operation phases will generate impacts on the terrestrial ecosystem. Table 9-1 identifies impact-generating activities (X mean that there is a foreseen impact).

Table 9-1 Matrix of construction and operation impacts on the physical environment

Foreseen activities	Impact on components							
	Induced seismicity	**Local slope stability and geology**	**Soil compaction and erosion**	**Surface and groundwater hydrology**	**Sediment transport**	**Climate Change**	**Regional and local air quality**	**GhG**
Construction								
Widening and stabilization of Black Post road including RoW for TL		X	X	X	X		X	X
Creation of a new access road from Black Post road to Project site including quarries and RoW for TL		X	X	X	X	X	X	X
Construction of the head race tunnel from dam to powerhouse		X (minor)		X (groundwater hydrology)			X	X
Construction of dam & powerhouse		X (minor)	X (minor)	X (minor)			X	X
Work area construction		X	X	X	X	X	X	X
Quarry exploitation		X	X	X	X	X	X	X
Vegetation clearance in the reservoir		X (indirect)		X (surface hydrology)			X (burning debris)	X (net positive)

Foreseen activities	**Impact on components**							
	Induced seismicity	**Local slope stability and geology**	**Soil compaction and erosion**	**Surface and groundwater hydrology**	**Sediment transport**	**Climate Change**	**Regional and local air quality**	**GhG**
Soil stockpiling and spoil disposal			X				X	X
Operation (including initial reservoir inundation)	X (unlikely)	X		X (surface hydrology)	X (mostly indirect)	X (unlikely)	X (net positive)	X

9.1.4 Assessment of Construction Impacts

9.1.4.1 Induced Seismicity

Probabilistic seismic hazard assessment (PSHA) was carried out by the Seismology Research Centre in February 2014. Although the region is seismically active, the relatively small volume of the reservoir that will be created by damming the Tina River is unlikely to cause induced seismicity that could contribute to slope failures. Additional analysis on seismicity effects on the Project is included in Section 15 – Effects of the Environment on the Project. Conclusions of the seismic hazard assessment will be taken into consideration for the Project Design Report and the Dam Safety Plan.

9.1.4.2 Local Slope Stability and Geology Impacts

The steep slopes bordering the reservoir may be destabilised as a result of reservoir operation, due to the daily fluctuation in reservoir levels and effects that changing pore water pressures may have on soils around the reservoir margin. Given that the slopes above FSL will remain covered with forest vegetation, the potential for slope failure is likely to be confined to the area within the reservoir itself, unless failure of the slope within the reservoir was to trigger a retrogressive failure, one that works its way upslope.

The creation and operation of a reservoir may affect slope stability as a result of the following:

- Saturation of the banks of the reservoir may re-mobilise existing landslides and potentially induce new landslides;
- Deforestation of the storage area will increase landslide activity;
- Construction activity within the reservoir area will alter slope geometry and drainage patterns, thereby increasing potential landslide activity;
- Fluctuation of the storage level may induce slope instability around the reservoir margins;
- Landslides occurring upstream of the reservoir that contribute material which will reduce the available storage volume.

In addition, along the future access road, small landslides are likely to occur, a situation that may be exacerbated with the construction of the road. Retaining structures, such as gabion walls, or the removal of upslope colluvium may be required to minimize the risk of landslides occurring during both access road construction and operation.

Karst geology, which is created by the dissolution of limestone by acidic water, results in formations with cavities and/or caves. The creation of karst formations may be accelerated by the reservoir, leading to significant water leakage from the storage and dam abutments and foundations. Karst formations within the Project area have not created extensive cave systems according to Entura (2014). Therefore, the presence of karst is not considered to be an important leakage pathway. The feasibility study recommended that the maximum storage level be set at 175masl because karst appears to be less extensive below this elevation. In addition, the less stable Suta Volcanics that occur upstream will be avoided by a reservoir operated to 175masl.

9.1.4.3 Soil Compaction and Erosion Impacts

Large projects usually involve extensive land disturbance, involving removing vegetation and reshaping topography. Such activities make the soil vulnerable to erosion. Soil removed by erosion may become airborne and create a dust problem or be carried by water into natural waterways and pollute them. Measures to address the impact of land disturbance on the environment should be included in the planning and design phase of the project, before any land is cleared.

When considering land disturbance and its consequences, priority should be given to preventative rather than treatment measures. To develop effective erosion controls it is necessary to obtain information on the erosion potential of the site where soil disturbance is planned. Erosion potential is determined by the erodibility of the soil (type and structure), vegetative cover, topography, climate (rainfall and wind), and the nature of land-clearing. Erosion potential will also be affected by the type, nature and intensity of earthwork.

9.1.4.4 Surface Hydrology

The construction of the dam will require the excavation of the riverbed and adjacent embankments, and the clearing of the area to be inundated by the storage reservoir. This will introduce sediment to the river, causing significant adverse impacts on downstream water quality likely for the whole period of project construction.

This impact is described in further detail in Section11 – Assessment of impacts on Aquatic Environment.

9.1.4.5 Regional and Local Air Quality

The Project is set within an area that has relatively good air quality, with only periodic localised impacts from emissions caused by smoke from cooking fires in villages and from fires set to clear small patches of understory vegetation for gardens.

During the initial period of project construction, vegetation will be cleared from access road and transmission line alignments, the reservoir area, and the sites where project structures will be built. Non-merchantable vegetation (i.e., non-timber) will be removed and shredded rather than burned. This measure will prevent local air quality impacts caused by smoke generated by burning.

9.1.4.6 Noise and Vibration

The Project is set within an area of low ambient noise levels and minimal or no human generated noise in the vicinity of the tunnel or dam. The use of hydraulic rock drills and explosives at the tunnel and dam site will generate an increase in noise and vibrations. Noise generated by heavy haul trucks transporting equipment and materials will also increase noise levels along Black Post Road.

9.1.5 Assessment of Operational Impacts

9.1.5.1 Hydrology Impacts

9.1.5.1.1 Surface Hydrology

The Project will result in reduced flow in the Tina River between the proposed dam site and the powerhouse. The proposed development is unlikely to have any long-term negative impacts on the availability of fresh water in the Tina/Ngalimbiu River catchment as a whole. The TRHDP PO has indicated that the dam will be operated for ‘base load’ electricity generation on a daily cycle, with maximum water release from the reservoir during the daytime when electricity demand is highest. However, during the night, the flow will be reduced downstream of the powerhouse, while the reservoir is being refilled.

To mitigate impact of reservoir impoundment, an environmental flow is to be implemented. One option is to include a low level outlet through the diversion plug for this purpose. It is suggested, that an environmental low (EF) of 1m^3/s be maintained during reservoir filling.

9.1.5.1.2 Groundwater Hydrology

The Project will result in an increase of groundwater table within the slopes at the reservoir area. Reservoir impoundment has to be carried out at a slow and steady rate in order to avoid localized slope failures during initial impoundment. The change in water table due to the change in level based on standard operating range during operation of the hydro scheme is unlikely to cause slope instabilities.

The proposed development is unlikely to have any long-term negative impacts on the groundwater hydrology in the Tina/Ngalimbiu River catchment as a whole.

9.1.5.2 Sediment Transport Impacts

Changes to the Tina River hydrology will, in turn, indirectly affect sediment transport mechanisms. The reservoir will intercept most suspended and bedload sediment, which will be stored behind the dam, until either flushed out through a low level port, or excavated when the reservoir level is drawn down to a point that the accumulated sediments can be accessed. Some sediment transfer will occur during overtopping events, particularly during flood events. Likewise, the significant change to the downstream flows resulting from the operation of the dam, will radically change the process of sediment transport and recruitment to the lower reaches of the Tina/Ngalimbiu River, where it is currently excavated for use in road surfacing and building construction.

The impacts of sediment transport are described in more detail in Section 11 – Assessment of Impacts on the Aquatic Environment.

9.1.5.3 Regional and Local Air Quality

Once the Project becomes operational, there are no anticipated adverse impacts to regional or local air quality, as there will be no significant sources of air emissions. Rather, operation of the TRHDP will have a minor positive impact on regional air quality by offsetting the avoided air emissions that would otherwise be produced from an expanded Lungga Diesel Power Station, during those periods of the day when the TRHDP is generating power.

9.1.5.4 Temperature Change

While some reservoirs are known to affect the climate at a micro level in areas immediately surrounding these bodies of water, as outlined in the study set out in section 7.5.1, the small size of the proposed reservoir means that it is unlikely that it will have any effect on the local climate.

As further outlined in section 7.5.1 the temperature of the dewatered stretch of river between the dam and powerstation may rise slightly.

9.1.5.5 GHG Emissions

Reservoir impoundments emit GHG. Newly impounded reservoirs can emit large quantities of GHG, especially methane (CH_4) as vegetation and organic matter in sediments decays. This is particularly true for reservoirs located in tropical regions if the rain forests biomass is not removed prior to inundation. Ebullition (bubbling) of methane in the reservoir and dissolved methane downstream of the powerhouse, are the main contributors to GHG emissions arising from tropical hydropower projects. However, diluted methane diffusing out of solution is less important in terms of GHG emissions (Deshmukh et al., 2014, International Hydropower Association, 2010). GHG emissions will decrease over time, as the source of decaying vegetation and organic sediments diminishes.

Quantifying impacts is difficult without long term monitoring. However, the International Hydropower Association (2010) has produced a table based on GHG emissions monitoring from several tropical regions. Table 9-2 shows the range of GHG emissions per m^2 of reservoir surface per day[71].

Table 9-2 Range of average carbon dioxide and methane gross emissions from freshwater reservoir in tropical regions

GHG pathway	CO_2 in mmol/m²/d	CH_4 in mmol/m²/d
Diffuse fluxes	-19 to 432	0.3 to 51
Bubbling	0	0 to 88
Degassing	4 to 23	4 to 30
River Downstream	500 to 2500	2 to 350

Source: International Hydropower Association, 2010

The unit, mmol/m²/d means that there are "X" millimoles of the molecule per m^2 of the reservoir released per day. Table 9-3 converts mmol of CO_2 and CH_4 to grams, where 1 mol = 44g of CO_2 and 1 mol of CH_4 = 16g. A negative value means that the reservoir acts a carbon sink.

Table 9-3 Converting mmol of CO2 and CH4 into grams

GHG pathway	CO_2 in g/m²/d	CH_4 in g/m²/d
Diffuse fluxes	-0.836 to 19.012	0.005 to 0.818
Bubbling	0	0 to 1.412
Degassing	0.176 to 1.012	0.064 to 0.481
River Downstream	22.005 to 110.024	0.032 to 5.615

If the same ranges are applied to the Tina River and converted to kg, the results shown in Table 9-4 are obtained, considering that the Tina Reservoir will cover an area of 305,200m² (30.52ha at FSL).

Table 9-4 Estimated daily CO2 and CH4 releases (kg) from Tina Reservoir

GHG pathway	CO_2 in kg/d in Tina reservoir	CH_4 in kg/d in Tina reservoir
Diffuse fluxes	- 255.1 to 5,802.4	1.5 to 249.6
Bubbling	0	0 to 430.9
Degassing	53.7 to 308.8	19.5 to 146.8
River Downstream	6,715.9 to 33,579.3	9.7 to 1,713.7

71 Note: the data does not mention time of monitoring, or whether it was done at the time of reservoir impoundment.

Total	**6,514.5 to 39,690.6**	**30.8 to 2,541**

Using the model "GHG Risk Assessment Tool (Beta Version) 8 (2012)", the predicted CO_2 and CH_4 gross flux, following the first years of impoundment for the Tina Reservoir, are much lower, as shown in Table 9-5. However, some of the data used to run the model, such as the amount of rain falling within the Tina River catchment (around 3500mm/yr), are out outside of the calibration range of the model, which makes it less accurate. Table 9-5 shows the gross flux of both CO_2 and CH_4 when the model is applied to the Tina Reservoir. From this model, it is obvious that GHG emissions decrease over time, and stabilise after 20 years of operation.

Table 9-5 GHG gross emissions from the model

Years after impoundment	CO_2 in kg/d applied to Tina reservoir	CH_4 in kg/d applied to Tina reservoir
0	523.1	3.6
1	509. 4	3.4
2	496.3	3.4
3	483.4	3.1
20+	334 (+/-)	1.8 (+/-)

These data provide an approximate indication of the gross fluxes of GHG emissions. Pre-impoundment direct measurements are the only way to precisely assess net emissions.

Modelling of reservoir GHG emissions can be used to inform the assessment of the Project's net GHG emissions. With an installed capacity of 15 MW, TRHDP is expected to annually generate, on average, 78.35 GWh, to displace an equivalent amount of energy generated by current and future diesel generators. Assuming a grid emission factor of 650 tCO_2eq/GWh for a 100% diesel-based system, the net GHG emission reduction potential of the 78.35 GWh Project is 49,500 tCO_2eq on average per year after deducting the anticipated reservoir emissions and emissions of construction and land clearing.

The net GHG emissions abated by the Project represent 8% of the Solomon Islands' most recent estimate of total emissions of 618,000t per year.[72]

SIG's Intended Nationally Determined Contribution (INDC) commits to reducing GHG by 18,800 tons of carbon dioxide equivalent (tCO_2eq) per year by 2025 and by 31,125 tCO_2eq per year by 2030 with appropriate international assistance.

9.1.6 Mitigation Measures

Mitigation measures are addressed below.

[72] Solomon Islands Draft Report to UNFCCC, 2010, excluding land use change and forestry. A similar figure of 540,000t is adopted by World Resources Institute.

9.1.6.1 Construction Impacts Mitigation Measures

9.1.6.1.1 Induced Seismicity

Given the unlikelihood of induced seismicity from such a small reservoir no mitigation measure is proposed for this potential impact.

9.1.6.1.2 Local Slope Stability and Geology Impacts

Some aspects of this impact cannot be mitigated. Retaining structures, such as gabion walls, or the removal of upslope colluvium are recommended to minimize the risk of landslides occurring during both access road construction and operation.

9.1.6.1.3 Soil Compaction and Erosion Impacts

Ground cover provides the most effective means of preventing erosion. Consequently, sediment run-off and dust controls depend on retaining existing vegetation or revegetating and mulching disturbed areas as soon as possible.

The following mitigation measures are proposed:

- Keep land clearance to a minimum.
- Avoid wherever possible clearing areas of highly erodible soils and steep slopes which are prone to water and wind erosion.
- Use shredded vegetation for production of mulch and revegetate and mulch progressively as each section of works is completed. The interval between clearing and revegetation should be kept to an absolute minimum. Mulch generated from shredded vegetation can be used to stabilize steep slopes along road cuts and fills until revegetation is complete.
- Coordinate work schedules, so that there are no delays in construction activities resulting in disturbed land remaining unstabilised.
- Program construction activities so that the area of exposed soil is minimised during times of the year when the potential for erosion is high, for example during rainy season when intense rainstorms are common.
- Stabilise the site and install and maintain erosion controls so that they remain effective during any pause in construction. This is particularly important if a project stops during the wetter months.
- Keep vehicles to well-defined haul roads.
- Keep haul roads off sloping terrain wherever practical.
- Designed the slope of a cut to minimise the angle of incline.
- Cultivating the cut surface will increase infiltration of rainfall and decrease the velocity of water across the slope during rain and therefore reduce erosion.

9.1.6.1.4 Surface Hydrology

Increased suspended sediment load is an unavoidable impact, since most construction work will take place within or adjacent to the river. However, it can be mitigated by implementing best environmental management practices (BEMPs) during construction especially on terrestrial areas. BEMPs for controlling the introduction of sediment into the river include plans for (see Section 13 – ESMP):

- Reservoir preparation;
- Point source pollution management, including concrete work;
- Spoil soil management during earthwork;
- Forest clearance practices;
- Stream crossing practices; and
- Drainage and erosion control.

Notwithstanding that BEMPs will be applied to control sediment entering into the river, moderate residual impacts will continue following application of mitigation measures, since most suspended solids, as measured by TSS, will originate from sources that cannot be fully mitigated. However, due to the effects of heavy rainfall within the catchment and the flashy nature of the Tina River, including tributary streams that enter the Tina River downstream of the damsite, sedimentation will be somewhat masked by the natural situation, as long as best efforts to employ BEMPs are made to prevent soil eroded from the project site from entering the Tina River.

Specific measures for quarry management, including measures applicable to independent suppliers, will be detailed in the Quarry Management Plan to be prepared by the Developer in accordance with the framework provided in the ESMP – Chapter 13. The Quarry Management Plan shall include Good International Industry Practice measures.

Where identified quarry sites in the reservoir are not sufficient for construction needs, additional aggregate will be sourced from a licenced third party gravel supplier. The third party aggregate supplier shall hold all requisite consents for quarry operations including development consent under the *Environment Act* and consent to extract aggregate under the *Mines and Minerals Act*.

9.1.6.1.5 Regional and Local Air Quality

To minimise impacts on regional and local air quality, non-merchantable vegetation is to be shredded rather than burned. Shredded materials may be used to produce mulch for use in erosion control. Excess amounts can be used in agricultural areas or shredded and composted to produce a soil conditioner for use on gardens.

9.1.6.1.6 Noise and Vibration

To minimise impacts of noise and vibration the following measures will be employed:

Specific drill and blast methods will be used to reduce noise and vibration. Hydraulic rock drill equipment will be used instead of pneumatic equipment because it produces less noise. Moreover, blasting and drilling equipment will be equipped with silenced masts, which can reduce noise levels by up to 10dBA. Blasting charges will be covered with blasting mats and screens to reduce generation of noise, fly rock and dust.

9.1.6.2 Operational Impacts Mitigation Measures

9.1.6.2.1 Surface Hydrology

The following mitigation measures are recommended to address surface hydrology:

- Environmental Flow of 1m3/s impacts of surface hydrology during operation, to provide water for aquatic life and water for use by downstream villagers;
- Maintaining a flow of 1m3/s during reservoir impoundment;
- Maintaining a flow of 2.4m3/s through the power station during overnight reservoir re-fill;

Section 11 – Assessment of Impacts on the Biological (Aquatic) Environment discusses in more detail the impacts of changed surface hydrology, and the requirements for an EF. Section 12 discusses in more detail impacts of changed hydrology on local inhabitants residing in villages along the Tina River and mitigation measures to ensure continued access to clean water.

9.1.6.2.2 Groundwater Hydrology

As risk level is low and unlikely, no mitigation measures are proposed for this impact.

9.1.6.2.3 Sediment Transfer

Section 12 – Assessment of Socio-economic / Socio-community Impacts also discusses measures for mitigating the potential change to sediment transport mechanisms as it relates to the gravel extraction industry in the lower section of the Tina/Ngalimbiu River.

Section 11 – Assessment of the impacts on the Aquatic Environment also discusses measures to mitigate the potential change to sediment transport as it relates to the aquatic environment.

The following recommendations are proposed for the design of the Project in relation to river sediment transport:

- The storage should be designed to incorporate as much ‘dead storage’ as possible to accommodate the accumulation of sediment in the reservoir over time;
- The power intake should incorporate a sediment sluicing/flushing structure to ensure that it does not get blocked with sediments;
- Consideration should be given to the impacts of highly turbid water on the headrace tunnel and turbines. Operationally, it may be necessary to close the intake at times of highly turbid flow to prevent deposition of sediments in the headrace tunnel or to prevent any damages to the turbine runner blades, wicket gates, and other parts of the mechanical plant; and

The storage operation should be designed to enable occasional dewatering for the purposes of excavating or dredging accumulated bed load sediments. The design study should consider access to the reservoir to excavate the accumulated bed load, an activity that might help to mitigate impacts on downstream gravel extraction.

Providing an EF during operation will ensure that there is a continuous dry season flow in the 5.7km stretch of by-passed river and beyond to the Tina/Toni River confluence throughout the day. During the dry season, it is expected that up to an additional 1m3/s (or more) of flow will enter the by-passed section of river from lateral tributaries that enter the Tina River just downstream of the dam. During the rainy season, these lateral tributaries will contribute considerable flow. In addition, during heavy rainfall events in the upper Tina River catchment, water will spill over the dam's spillway.

The dam will cause a permanent change to sediment transport process of the Tina/Ngalimbiu River. This can be partly mitigated if the reservoir is periodically lowered to enable accumulated sediments to be excavated and trucked to downstream aggregate (sand and gravel) users.

Based on the available mitigation measures, these impacts will persist as low to moderate residual effects that are considered to be not significant.

9.1.6.2.4 Temperature Change

As temperature changes are expected to be minimal, no mitigation measures are proposed.

9.1.6.2.5 GHG Emissions

Mitigation measures recommended for GHG emissions relate to reservoir preparation. Reservoir preparation will primarily involve clearing of vegetation from the inundation zone of the proposed reservoir area. Vegetation clearing will be done involving local communities and local landowners. Machinery will not be used due to the remoteness of the area, the steep topography and the lack of access road upstream of the damsite. The demarcation of the reservoir will be done by spray painting trees to denote the upper elevation limit of vegetation removal, above which the natural habitat is to remain untouched.

As much vegetation as is practical should be stripped off the future reservoir to limit organic matter decomposition in the lower layer of the reservoir that would create anaerobic conditions and generate methane.

This mitigation measure is discussed in further detail in Section 11 – Assessment of Impacts on the Aquatic Environment.

9.1.6.2.6 Regional and Local Air Quality

As positive impacts identified, no mitigation measures proposed.

9.2 CONCLUSIONS ON IMPACTS TO THE PHYSICAL ENVIRONMENT

Table 9-6 - Summary of Impacts to the Physical Environment

	Impact before mitigation	**Residual impact**
Impact from Construction		
Induced seismicity	Low	Low
Local Slope Stability and Geology	Moderate	Low
Soil Compaction and Erosion	Major	Low
Surface Hydrology	Moderate	Moderate
Regional and Local Air Quality	Low	Not Significant
Noise and Vibration	Moderate	Low
Impact from Operation		
Surface Hydrology	Major	Moderate
Groundwater Hydrology	Low	Low
Sediment Transport	Moderate	Moderate
Temperature Changes	Low	Low
Regional and Local Air Quality	Not Significant	Not Significant
GHG Emissions	Moderate	Moderate Positive

With application of appropriate mitigation, monitoring and management methods, low to moderate direct and indirect impacts will accrue to the physical environment within the project area.

10. ASSESSMENT OF IMPACTS ON THE BIOLOGICAL (TERRESTRIAL) ENVIRONMENT

10.1 BACKGROUND

This section presents the analysis of impacts on the terrestrial ecosystem, including organisms and their habitats. Terrestrial organisms include all wildlife and plants that are not purely aquatic. It includes wetland dependent wildlife and flora. For each identified impact, measures to avoid, mitigate or compensate impacts are presented.

Four types of impacts can be described: direct impacts, indirect impacts, general impacts and cumulative impacts.

- Direct impacts are those that will likely accrue due to the Project footprint. These impacts are habitat-specific or species-specific, and are quantifiable.
- Indirect impacts are those that will take place as a consequence of the Project but with a degree of separation both temporally and spatially. These impacts are non-quantifiable since their extent and intensity are hard to predict.
- General impacts are those that will take place regardless of the Project specificity (e.g., noise from traffic, habitat fragmentation, oil spills, etc.), are not site-specific, and are not quantifiable. Best management practices help to address such impacts.
- Cumulative impacts are impacts arising from the Project that may aggravate existing impacts from other existing or reasonably anticipated projects in the study area. Cumulative impacts are presented in Section 14.

10.2 ASSESSMENT METHODOLOGY

Impact assessment methodology for environmental components (both aquatic and terrestrial) is presented in Annex 19 of the Annex Report. Impacts significance has been applied using a standardized method based on the integration of the following steps:

- Identification of impact sources - the first step of the impact assessment is to determine which activities will have an impact on environmental components. This identification is done using an impact matrix.
- assessment of impacts using the criteria of impact duration, extent, magnitude / intensity, and probability of occurrence. This assessment includes an assessment of fauna species of highest ecological importance;
- application of mitigation measures; and
- determination of post-mitigation residual effects and significance, the latter being determined to be either Not Significant, or Significant.

Where a residual effect is deemed to be Significant, it falls to decision makers within government to determine whether the need for the project outweighs the concerns for potential, non-mitigable, significant impacts.

10.3 ACTIVITIES AFFECTING THE TERRESTRIAL ENVIRONMENT

The section identifies the main project components, and the actions and activities that will affect terrestrial environment components.

Impacts on physical and biological-terrestrial environment arise from the same activities and are listed below for completeness as to each section to be regarded as a standalone section of the ESIA.

10.4 PRE-CONSTRUCTION AND CONSTRUCTION ACTIVITIES

10.4.1 Pre-construction Activities

Pre-construction work involves site investigations, including installing a hydrology monitoring station, mapping topography, undertaking geological and geotechnical surveys, and other related activities. Limited drilling and cutting of new tracks to move equipment onto survey sites was required, with only minor impacts accruing to aquatic habitats and water quality.

10.4.2 Widening and Stabilizing Existing Black Post Road

Black Post Road will be widened and improved along its 13.3 km course. This will necessitate bush clearing, surfacing and stabilization with gravel or cement, creation of roadside ditches for drainage and earthworks to build embankments. In these areas, habitats are no longer natural. Rather, they have been anthropogenically altered for use as oil palm plantations, grazing sites for cattle, grassland, settlements, and other human use. Therefore, there is no forest to clear and exposed soils will be limited. Since the transmission line will follow Black Post Road, impacts related to the transmission line are treated in the same manner as those related to widening the road. The width of the road alignment will be up to 50m, and includes the right-of-way for the transmission line.

10.4.3 Construction of New Access Roads

Black Post Road will be extended from Mangakiki to the project site to serve as the main access road. This will necessitate clearing forest and other vegetation cover, grubbing stumps, removing top soil, completing earth works (cut and fill), stabilizing the roadbed, road surfacing, installing drainage gutters and ditches, and installing watercourse crossings using culverts. This section of road will be paved. The width of the right-of-way will be up to 50m and include the easement for the transmission line. The length of this road is about 8.31km. The primary Contractor may subcontract forest-clearing activities to a local logging company, to avoid importing forest clearing and log transport machinery.

Entura’s feasibility study (2014) identified two quarry sites both in the reservoir area, which will need to be connected to the main construction area by access roads. As these access roads were not identified by Entura, it has been assumed that they will follow topographic contour lines and have the same width as other access roads for which additional width is not required for the transmission line.

10.4.4 Construction of Headrace Tunnel from Dam to Powerhouse

The headrace tunnel will be 3.3m in diameter, will run 3.3 km beneath the ground surface, with an 85m shaft connecting to a 130m long power tunnel. The headrace and power tunnel will be built underground using drill and blast techniques to excavate rock. Drilling and blasting above ground will generate noise and vibration due to the use of hydraulic rock drills and explosives. In addition, removal and disposal of spoil material will utilize heavy haul trucks that generate traffic and dust in the dry season. Topsoil removal will be limited to the entrance of the tunnel, surge shaft and tunnel exit. Explosives will be stored on site in a secure, purpose built explosives magazine, surrounded by an earth berm, located away from the main areas of activity. Approximately 1ha of work area for machinery and trucks to operate will likely be necessary at the entrance of the tunnel, and another 1ha will be required for a work area at the exit of the tunnel BRLi (2013)_has estimated the volume of tunnel spoils to be approximately 24,300m^3, based on the dimension of underground infrastructure. Tunnel construction will be by drill and blast.

10.4.5 Construction of Dam and Powerhouse

Most impacts of dam construction are related to fish and the aquatic environment. Construction of the dam will require de-watering the river by diverting it through a diversion structure comprised of an upstream cofferdam, a diversion conduit, and a downstream cofferdam. The riverbed and valley walls will be excavated into the bedrock by drill and blast techniques for the dam foundations and dam abutments. Drilling and blasting above ground will generate noise and vibration due to the use of hydraulic rock drills and explosives.

Preparation of the dam abutments will affect approximately 2,800m^2 of terrestrial habitat on the right slope of the gorge and 3,700m^2 on the left side of the gorge.

The powerhouse will be built alongside the Tina River 5.7km by river downstream of the dam and will be founded on competent rock using drill and blast techniques to avoid settlement and vibration of the completed structure. A substation will also be constructed. The construction of the powerhouse and substation will necessitate excavation, fill placement, grouting or pilling and will cover approximately 1080m^2 (Entura, 2014). The total area of terrestrial habitat disturbance is estimated to cover approximately 1.5ha.

10.4.6 Construction of Work Area

An area of 130m x 90m (11,700m^2) will be required for construction work areas (e.g., staging, fabrication, materials stockpiling, equipment maintenance, etc.) and will involve forest clearing and topsoil removal.

10.4.7 Quarrying

Rock quarries will be developed to provide aggregate for the RCC dam. Entura (2014) estimated that 160,000m^3 of aggregate will be required, from two possible quarry sites located in area that will be occupied by the future reservoir. Aggregate will also be sourced directly from the river bed downstream of the dam (Entura, 2014). Where the two identified quarry sites are suitable for construction needs, all quarry sites and access roads will be within the Core Area.

In the event that aggregate available from the two identified quarry sites does not meet all construction needs, additional aggregate will be purchased from a licenced third party aggregate supplier. The Developer will prepare a Quarry Management Plan in accordance with the framework plan provided in the ESMP, incorporating measures to meet GIIP.

Quarry exploitation will require the removal of superficial deposits in or close to the river, which may release suspended material into the water.

10.4.8 Reservoir Preparation

Prior to reservoir impoundment, trees will be cleared from within the reservoir area to an elevation of 175 masl. Loose rocks and rubble along the steep faces of the river gorge will be removed where possible.

Reservoir vegetation clearing will be conducted during the latter phase of the construction program, as the dam and powerhouse are nearing completion, just before reservoir inundation is stet to commence. The timing is critical so as to not enable vegetation to regrow or become re-established before water is impounded. Depending on the schedule for reservoir filling, vegetation clearing may proceed in distinct phases, with the lowest elevation areas of the future reservoir inundation zone being cleared first, followed by the higher elevation inundation zone. Steep gorges in the reservoir area are covered with ligneous and herbaceous plant species. Due to the steep terrain, lack of access roads and the risk of flash floods, work using machinery will not be feasible. Vegetation clearance will, therefore, be undertaken using manual labour. Sawn timber will be transported by floating it down the river as is currently done from Choro and Koropa. This activity will release organic matter and suspended solids into the river. Reservoir clearing will not involve grubbing (removal of stumps) and soil stripping, since only manual work will be feasible.

Vegetation clearing represents important planning in terms of land access and timing, and may also require a government logging permit. The reservoir was acquired as part of the Core Land and will be part of the registered land owned by Tina River Core Land Company (TRCLC) and will be leased to the developer.

10.4.9 Construction Traffic

Heavy haul trucks will be required to transport materials and equipment, including excavated material to the crushing plant, spoils from the headrace tunnel, heavy equipment and construction materials, fuel and other products on a regular basis. Light duty trucks and buses will be used to transport workers to and from the Project site. In addition to issues related to safety and comfort of local communities, the movement of vehicles, especially heavy haul trucks, generates noise and vibration, and presents a risk of wildlife-vehicle collisions.

10.4.10 Worker Accommodation

Entura (2014) and TRHDP Office (personal communication, 2014) indicate that non-local construction workers will reside in Honiara, Lungga or Henderson, likely in existing accommodations, and be transported to and from the project site each day. The estimated number of workers will peak at approximately 175 during the construction of the dam; this number includes experienced expatriate labour and unskilled labour that will be sourced locally. There will not be a worker's camp that would be a source of direct impact on terrestrial habitat.

10.4.11 Soil Stockpiling and Spoils Disposal

During the construction of the dam, topsoil spoil will be generated and will be stored (prior to reusing it for rehabilitation or before transporting it outside the Project Area). Storage will either be short term (in case of outside transportation) or long term (in case of rehabilitation of disturbed areas). An estimated 10 ha storage area will be necessary for the generation of 327,900 m^3 of topsoil, using 10 conical-shaped piles of 50m diameter and 5m high. It is suggested to use remnant forests of the Core Area to create the 10 ha storage area.

10.5 OPERATION ACTIVITIES

10.5.1 Operation of the Hydropower Facility

The operation of the dam will modify the river flow especially during the night (during reservoir filling) and will create a reduced flow between the dam and the power station.

10.5.2 Access Road Use

Continued use of the access road to the dam site and powerhouse during operation will have an indirect impact on certain species of fauna, as a result of wildlife-vehicle interactions. However, given the relatively low expected volume of traffic, the impacts upon fauna are likely not significant.

10.6 IMPACT ASSESSMENT

10.6.1 Impact Identification Matrix

Both the TRHDP construction and operation phases will generate impacts on the terrestrial ecosystem. Table 10-1 identifies impact-generating activities (X mean that there is a foreseen impact).

Table 10-1 Matrix of construction and operation impacts on the terrestrial environment

Foreseen activities	Impact on components						
	Flora and habitat	**Native Rainforest Rodents**	**Bats and marsupials**	**Birds**	**Amphibian**	**Reptiles**	**Wetland dependent insects**
Construction							
Widening and stabilization of Black Post road including RoW for TL	X	X	X	X	X	X	X
Creation of a new access road from Black Post road to Project site including quarries and RoW for TL	X	X	X	X	X	X	X
Construction of the head race tunnel from dam to powerstation	X (minor)	X (minor)	X (minor)	X (minor)	X (minor)	X (minor)	X (minor)
Construction of dam & powerstation	X (minor)	X (minor)	X (minor)	X (minor)	X (minor)	X (minor)	X (minor)
Work area construction	X	X	X	X	X	X	
Quarry exploitation	X	X	X	X	X	X	X
Vegetation clearance in the reservoir	X	X	X	X	X	X	X
Soil stockpiling and spoil disposal	X		X	X	X	X	

Foreseen activities	Impact on components						
	Flora and habitat	**Native Rainforest Rodents**	**Bats and marsupials**	**Birds**	**Amphibian**	**Reptiles**	**Wetland dependent insects**
Operation (including initial reservoir inundation)	X (mostly indirect)	X (mostly indirect)	X (mostly indirect)	X (mostly indirect)	X (mostly indirect)	X (mostly indirect)	X (mostly indirect)

10.6.2 Impact Assessment Limitations

The terrestrial ecology impact assessment is lacking supporting scientific literature regarding specific life cycle, breeding and feeding habits of most fauna in the Solomon Islands. Therefore, due to limited scientific data and limited previous surveys, there is little knowledge on the specific impacts that the TRHDP activities may have on many species.

In addition, the terrestrial ecology impact assessment has some limitations due to uncertainties regarding the Project layout:

- Uncertainties regarding the location of the quarry site: the terrestrial ecology impact assessment was based on Entura feasibility report (March 2014), which identified multiple potential quarry sites. The final quarry site locations will be confirmed in the design report.
- Uncertainties regarding right-of-ways of some project components such as access roads to quarries. These are not described in Entura 2014 report.

10.7 ASSESSMENT OF CONSTRUCTION IMPACTS

10.7.1 Construction Impacts on Flora

10.7.1.1 Direct Impacts on Flora

This section presents the potential direct impacts on flora during the construction phase of the TRHDP, and proposed mitigation measures, and residual effects and their significance after mitigation is applied. Table 10-2 identifies the potential direct construction related impacts to the terrestrial ecosystem. Man-made habitats (e.g., gardens, settlements, oil palm plantations) have been omitted in the table since the TRHDP will not affect them.

10.7.1.1.1 Identification of Potential Direct Impacts

Construction activities, including clearing vegetation prior to reservoir impoundment, will reduce the biomass of forest and grassland areas. Riparian habitats will be removed or inundated to provide for the access roads, tunnel entrance and exit, transmission lines, quarries, powerhouse and the reservoir.

The assessment of impacts is based on the baseline habitat description of the study area and the proposed project layout at the time the ESIA was prepared. In total, 115.49ha of natural terrestrial habitat will be permanently lost due to construction activities. An additional 10ha will be necessary for the temporary storage of topsoil. However, this area will not be permanently lost and will be regenerated by TRHDP using native vegetation species toward the end of the construction phase.

Although the change in the area of terrestrial flora represents a permanent loss, for undisturbed forest this represents a site-specific (local area) loss of less than 0.2% within the Tina River catchment. For all forest types combined, the Project will result in the loss of only 0.4% of forest habitat. Therefore, the impact on critical forest vegetation before application of mitigation measures is considered to be low-moderate.

Table 10-2 Direct impacts on terrestrial ecosystem habitats

Project component, action or activity	Area of habitat directly lost to construction activities									
	Grasslands (ha)*	**Undisturbed forests (ha)**	**Disturbed forests (ha)**	**Remnant forests (ha)**	**Montane forests (ha)**	**Riparian (ha)**	**Cliffs (ha)**	**Garden (ha)**	**Fallow brush land (ha)**	**Total Area (ha) affected by Project**
Widening and stabilising Black Post Road including RoW for TL	6.09	0	3.90	4.80	0	0	0	0	6.23	21.02
Creation of a new access road from Black Post Road to Project site including quarries and RoW for TL	0	5.27	23.57	7.07	0	3.07	0	0	0.17	39.13
Construction of the headrace tunnel from dam to powerhouse	0	0	0	0	0	2	0	0	0	2 (above ground)
Construction of dam & powerhouse	0	0	0	0	0	1.55	0.60	0	0	2.15
Work area construction	0	0	1.18	0	0	0	0	0	0	1.18
Quarrying	0	4.27	0	0	0	Already calculated in reservoir clearance	0	0	0	4.27

Project component, action or activity	Area of habitat directly lost to construction activities									
	Grasslands (ha)*	**Undisturbed forests (ha)**	**Disturbed forests (ha)**	**Remnant forests (ha)**	**Montane forests (ha)**	**Riparian (ha)**	**Cliffs (ha)**	**Garden (ha)**	**Fallow brush land (ha)**	**Total Area (ha) affected by Project**
Reservoir Preparation	0	0	0	0	0	15	15.52	0	0	30.52
Temporary Soil storage area in the Core Area***	0	0	0	10	0	0	0	0	0	10
Total	6.09	9.54	29.65	21.87	0	21.62	16.12	0	6.40	
Area by habitat Type in Tina Catchment	**59.84**	**5146.97**	**295.16**	**92.40**	**9013.21**	**Not assessed****	**Not assessed****	**4.62**	**25.38**	
Percentage of affected Habitats by type in Tina Catchment	**10.18%**	**0.19%**	**10.04%**	**23.66%**	**0%**			**0%**	**25.22%**	

* Grassland will only be affected along the access road (15m wide) and not under the transmission line.

**Riparian and cliff habitats where only assessed along the future reservoir, and not in the entire catchment due to inaccessibility of the area.

***An estimated 327,900m^3 of topsoil will be temporarily stored on the project site in 10 conically shaped piles of 50m wide and 5m high, requiring an area of approximately 10ha.

10.7.1.1.2 Mitigation Measures

Reservoir Preparation

Reservoir preparation will primarily involve clearing of vegetation from the inundation zone of the proposed reservoir area. Vegetation clearing will be done involving local communities and local landowners. Machinery will not be used due to the remoteness of the area, the steep topography and the lack of access road upstream of the dam site. The demarcation of the reservoir will be done by spray painting trees to denote the upper elevation limit of vegetation removal, above which the natural habitat is to remain untouched.

Ideally, all plants and topsoil should be stripped fromthe future reservoir to limit organic matter decomposition in the lower layer of the reservoir creating anaerobic conditions.

Due to the high cost of importing logging equipment to the Solomon Islands, the construction contractor may choose to subcontract forest-clearing activities to a local logging company. The contractor in charge of forest clearing will be governed by the commitments and assurances made by the TRHDP and included as conditions in any environmental approvals.

Prior to commencing construction, TRHDP PO should consult with local communities through the Tina Core Land Company to identify possible existing trails along which sawn timber can be transported to the river. Sawn timber could be transported downstream using the river as it is currently done from Choro and Koropa. It would then have to be hauled out at a site immediately upstream of the dam and transported from there downstream again by river, or by truck on the access road.

Prior to commencing construction, a reservoir preparation plan will be prepared by the construction contractor. Preparation of this plan should be based on an assessment of the feasibility of reservoir vegetation clearance, and involve consultation with communities. Key issues that will need to be resolved include:

- Moving logs and sawn timber safely from where they are cut, down to the river in an area that is defined by a steep-sided gorge subject to frequent flash floods; and
- The location of the access road that will be constructed from the dam site to one or both of two possible quarry sites in the reservoir, which could be used to facilitate vegetation clearance.

Trees with a diameter larger than 10cm will be cleared from within the reservoir area up to an elevation of 186.5masl. Loose rocks and rubble along the steep faces of the river gorge will be removed where possible.

Access Road

Once the final access road alignment has been determined, and all areas that require forest clearing have been identified, a botanist will walk the full length of the road (starting from Mangakiki) and other areas where construction will take place to geo-reference and fence environmentally and culturally sensitive areas such as:

- Wetlands;

- Streams;
- Rare, endangered plants and culturally or economically important plants colonies; and
- Large trees that need to be kept to maintain canopy closure to decrease the amount of edge-effected forest.

Fencing will be done using orange plastic construction fencing material supported on wooden or steel pickets. Once fenced, each environmentally or culturally sensitive area will be mapped. The map of these protected sensitive areas will then be presented to a committee comprised of the resident engineer for the dam construction, construction contractors and forest clearing subcontractors, and the independent environmental expert. This committee will discuss potential solutions for protecting each sensitive area identified, including:

- Wetlands located in the right-of-way – these areas will be fenced to denote their sensitivity. If the road alignment potentially bi-sects a wetland then culverts will need to be installed to ensure water exchange continues to occur between both parts of the bisected wetland. If the work areas are located in a wetland, they should be relocated nearby.
- Streams located in the right-of-way – sites where the road will cross streams will be fenced to denote the site of the crossings, the areas outside of which would be "no go" zones. Work should not occur within the wetted perimeter of any streams. Stream crossings requiring bridging should be clear-spanned. Smaller stream crossings should be equipped crossed using open-bottomed box culverts to enable fish and wildlife to pass under the roads.
- Rare or endangered plants in the right-of-way – fencing will be installed to encircle these areas and denote that they are to be avoided moving the road alignment or relocating work areas. If measures to avoid endangered plants are not possible, then transplanting plant colonies should be considered an option. Plants that are capable of being transplanted would be relocated as far as possible away from the area of disturbance under the supervision of a botanist, with the help of local villagers.

Large canopy trees – in the interest of maintaining important ground level shade and humidity, that is so important to the ecosystem, large trees that provide canopy cover will be protected from unnecessary clearing, wherever possible. Fencing will be placed around these trees.

Achieving No Net Loss of Biodiversity

Of the 115 ha of land that will be cleared, 50 ha has forest cover, but only 9.5 ha can be considered primary forest. Half of the other 40 ha is disturbed secondary forest, and the other half is remnant forest, i.e., secondary forest formed by natural revegetation of cleared areas.

Cliff habitat and riparian habitat (partially disturbed), approximately 15 ha of each, will be affected by reservoir preparation. The 50 ha represents 0.9% of the total area of non-montane forest and 0.3% of all forest in the catchment. In the context of the assemblage of terrestrial vegetation communities and the wildlife habitats they provide, this permanent loss within the Tina River catchment is not considered to be significant.

The proposed mitigation measures will help to ensure the direct impacts of vegetation clearing are confined to the 115 ha. However, Performance Standard 6 requires that when natural habitat is degraded or converted, measures will be designed to achieve no net loss of biodiversity where feasible. With respect to the potential impacts on critical habitat, PS 6 requires that net gains shall be achieved for the biodiversity values for which the habitat was designated.

To achieve these outcomes, the Project will take steps to protect the upper catchment biodiversity from threats of extractive industries (see Appendix K). The protection of the upper catchment is conceived as a staged approach reflecting the ownership of the land by indigenous customary landowners. Immediate protection measures will include actions of the TCLC and Project Company to restrict access to vehicles (including commercial logging machinery) to the upper catchment through the Core Area, to monitor changes in forest coverage in the upper catchment, to monitor logging truck activity on existing logging roads, and to support SIG to enforce seldom used statutory restrictions on logging at elevations above 400 masl (which if enforced would represent the vast majority of the upper catchment). This protection work will be furthered by Project Office funding for an NGO to facilitate consultations with landowners to seek support for the creation of a protected area in the upper catchment and to conduct mapping and forestry studies, towards preparation of a management plan.

In addition to upper catchment offset activities, the Project Company will implement measures including a post construction rehabilitation plan for disturbed areas, and an offset within the Core Area which will include measures to protect the remaining natural habitat in the Core Area, and to rehabilitate an area of modified habitat within the Core Area of at least 9.5 ha. These measures will be set out in the Biodiversity Management Plan.

Independent Environmental and Social Monitor

To limit habitat clearing to the strict minimum, an independent consultant specialized in environmental and social monitoring will be present on site during key activities to audit all ESMP measures. The consultant will ensure that all mitigation measures are implemented. Special attention will be paid to access road alignment clearing. The consultant will prepare a monitoring report for use by the construction contractor and its subcontractors to inform them of non-compliances. The monitoring consultant will also ensure that corrective measures are implemented (refer to ESMP).

The construction contractor and all subcontractors will also appoint a team of environmental and social specialists with proven qualifications in environmental and social monitoring. They will be responsible for following up on issues raised by the independent monitoring consultant, including ensuring corrective and preventive actions are taken to rectify and avoid environmental and social concerns. Their experience will enable them to make decisions throughout the TRHDP construction program to minimize losses of valuable biomass.

10.7.1.1.3 Residual Effects and Their Significance

Just over 115ha of vegetation cover will be permanently removed from the project area. In the context of the assemblage of terrestrial vegetation communities and the wildlife habitats they provide, this permanent loss within the Tina River catchment is not considered to be significant. The proposed mitigation measures will help to ensure the direct impacts of vegetation clearing are confined to the 115ha.

10.7.1.2 Indirect Impacts on Flora

This section presents the potential indirect impacts on flora during the construction phase of the TRHDP, and proposed mitigation measures, and residual effects and their significance after mitigation is applied. Habitat-specific impacts and residual impacts are also analysed and quantified in this section.

10.7.1.2.1 Identification of Potential Indirect Impacts

Colonisation by Invasive Plant Species

Construction activities, including construction of the access road, will create open spaces and gaps in the canopy. These areas are more prone to colonization of terrestrial invasive plant species, especially if the equipment used carries mud or soils from previous construction sites.

In the Study areas, risk of invasive plant colonization could occur along the access road, quarries and along the transmission line.

Depending on the species, three situations can occur with invasive plants:

- Native plant species may be out-competed by invasive plants with adverse environmental consequences.
- Invasive plant species may adversely affect agricultural and garden plants and pasture, thereby affecting livelihoods.
- Invasive plant species may affect infrastructure, thereby leading to economic consequences for the Project.

Evidence of invasive plant species in the study area was observed, especially within anthropogenically affected areas, including along roads. A good example of an invasive plant is the vine *Mikania micrantha* (Mile-a-Minute) that can grow up to 1m in a month, and is considered one of the most important weeds of this region of the Pacific. This vine invades subsistence gardens and tree plantations (oil palm) forming thick ground cover that competes with crop plants. It grows from lowland areas up to an elevation of 1200masl, and the seeds are easily dispersed by wind, and by people when seeds attach to clothing (Day et al., 2011). In the study area, the vine is already widely distributed in open areas along Black Post Road and in villages along the Tina River (e.g., Sengue). It not only competes with crop species, but also smothers native vegetation (CABI, 2013).

Mimosa invisa and *Mimosa pudica* are two invasive plant species from Brazil that have also been observed in the study area and are weeds affecting agricultural and garden plants. They form thickets along road margins and at the edge of cleared forest. They do not colonize undisturbed forests. Their behaviour as weed that competes with native plants is, therefore, limited to grassland areas (CABI, 2013).

Water Hyacinth (*Eichhornia crassipes*) is by far the biggest threat to any hydropower projects in tropical countries. It is the world's worse invasive aquatic plant in dam reservoirs, as it can quickly colonize entire reservoirs, reducing electricity production by clogging water intakes and interfering with reservoir uses (such as fisheries). Water Hyacinth is present everywhere in the South Pacific including in the Solomon Islands (SPC, 2005) and is present in Vella Lavella Island, according to Polhemus et al. (2008). Water Hyacinth have not been observed in the study area likely because of the fast flowing nature of the Tina River. Moreover, if it was to be accidentally or intentionally introduced, it would likely not thrive in the reservoir due to the extreme daily fluctuations in water levels and the expected low concentration of nutrients (see Section 7 – Biological Environment Baseline - Aquatic).

Habitat Fragmentation

Construction activities, especially road construction, may cause habitat fragmentation. Habitat fragmentation effects are more obvious on wildlife than on vegetation. Nonetheless, habitat fragmentation can lead to the "edge effect" along forested areas. The edge is the area where natural habitats come into contact with manmade habitats or infrastructure (e.g., road, transmission line). The edge effect causes abrupt changes in vegetation cover and reduces the true surface of the forest, leading to the colonization of heliophitic shrub and vine species. The edge effect also leads to local changes in soil characteristics from a cool, dark and moist to a warm, exposed and dryer environment due to solar radiation. This change can lead to a higher rate of tree mortality along the edge.

In tropical rainforests, the edge effect can affect forests and plant composition up to 100m into the forest (Laurance et al., 2009). Fragmentation increases local erosion as slopes and small landslides are created at the edge of the forests. Therefore, habitat fragmentation can lead to changes beyond the line of contact with the construction activities. The edge effect is diminished when the canopy stretches across the clearing (Goosem, 2007). In terms of edge effect on habitat, forested areas are more vulnerable than grasslands.

Local Hydrological Changes

Some plant habitats can be indirectly fragmented when local hydrologic conditions are changed by construction activities. For example, many small tributary streams within the Tina River catchment area are free flowing perpendicular to the future access road (see Section 5 – Physical Environment Baseline). These small streams are conveying water to micro wetlands and cliffs habitat (waterfalls) where hydrophilic and epiphytic plants thrive. The construction of the access road could change local small stream hydrology leading to disappearance or displacement of micro wetlands. Such changes could come from soil deposited in cut-and-fill approaches, earth works, and access road construction, blockage of water flow due to poor dimensioning of culverts or absence of culverts.

Point Source Pollution

The presence of machinery during construction activities can lead to oil spills and to the spread of other pollutants that could result in either the mortality of plants in adjacent areas along roads, or in bioaccumulation of the food chain (Goosem, 2007). Concrete wash waters, with their high pH, and high concentration of suspended solids could leak into the Tina River during the construction thereby affecting riparian habitats and forests. Suspended solids released from earthworks could also affect the vegetation. Workers may also be tempted to use the river as an open defecation area.

Impacts on Topsoil and Vegetation Regeneration

Earthworks will locally modify topsoil leading to three type of impacts: increased erosion and sedimentation of surface runoff, disturbance of soil nutrient cycles, and delayed natural regeneration due to invasive species colonization.

In the Solomon Islands vegetation regeneration is vigorous. According to a study of vegetation regeneration in Papua New Guinea (Hartley, 1991 quoted by PNG LNG Project, Coffey Natural Systems, 2009), regeneration is quick in disturbed soil in the region. Regeneration is poor to non-existent in areas made out of hard limestone pavement or compacted limestone, especially for ligneous species. This study of vegetation regeneration involved regeneration follow-up from 1991 to 2005. For the Project, most of the access road will be built on conglomerate formation. It is, therefore, difficult to qualitatively assess the rate of vegetation recovery based on this study. However, based on field observations made for previously disturbed areas, such as logging roads and on observations of the Project area, it appears that vegetation regeneration is vigorous, especially mainly in areas where the topsoil has been retained.

According to Coffey Natural Systems (2009), factors influencing vegetation regeneration include:

- Whether the topsoil remains in place or not - when the topsoil is left in place it enhances vegetation regrowth as the seed bank remains on site.
- Whether the soil is compacted or not - a compacted soil may prevent rooting of woody (e.g., tree) species.
- Length of time soils are disturbed - the longer the soil is disturbed, the higher the chances of seed bank losses due to erosion and colonization by invasive species.
- Vegetation type prior to disturbances - the richer the plant composition, the richer the seed bank in the soil.
- Rainfall pattern - the higher the rainfall, the faster the topsoil erosion will take place.
- Topography - steep slopes are prone to gullying, causing unstable surfaces for rehabilitation, erosion and loss of topsoil.
- Altitude - disturbed lowland forests are quicker to regenerate that montane forests because of their cooler climate.

10.7.1.2.2 Mitigation Measures

During the TRHDP construction phase, good international industry practice (GIIP) will be implemented by the construction contractor, to mitigate indirect impacts on flora.

Colonisation by Invasive Plant Species

The following actions will be implemented to protect against encroachment and colonization by invasive species:

- Machinery will be checked by designated project staff before the equipment is allowed to enter the project area, to ensure that wheels, tracks, buckets and other parts of machinery that may have come into contact with mud or soil, are clean of these materials. A washing station will be installed just outside the project area at Veroande (see Section 6.4.2.1 – Invasive and Feral Species) to ensure that all machinery that enters the work area is clean. Drainage water from washing stations will be diverted away from water bodies.
- Importation of soil from outside work areas will be prohibited.

- Soil stockpiles in the construction area will never be permanent in order to avoid colonization by invasive species. Soil stockpiles will be covered with geofabric tarps or revegetated with native plants. The soil management plan (see ESMP) will be amended by the construction contractor: to assess the amount of spoils from road cuts; to assess the need for road embankment and future use of excess soil; and to locate stockpiles.
- Topsoil will be left on site and will be reused as much as possible.
- Chemical and biological control of invasive plant species is not recommended as the extent of the impacts will be limited spatially.
- Local population will be sensitized regarding the threat posed by Water Hyacinth and the consequences should it find its way into the area**.**

To mitigate indirect impacts of the terrestrial habitat fragmentation and the edge effect, the following actions will be implemented:

- Construction activities will be favoured in already affected areas (such as along the existing access road) and in disturbed and remnant forests rather than undisturbed primary forests.
- Where possible, impact-causing activities will be spatially concentrated to limit any encroachments.

Local Hydrological Changes

To mitigate indirect impacts of local hydrological changes, the following actions will be implemented:

- Small tributary streams in the vicinity of the access road will be identified and geo-referenced prior to the construction of the access road.
- All identified tributary streams in the vicinity of construction activities will be protected by fences to avoid any encroachments.
- Culverts will be installed along the access road to enable water to flow freely. More measures are detailed in Section 13 – ESMP.
- A watercourse crossing management plan will be produced by the construction contractor prior to commencing the TRHDP construction.
- Depositing soil outside the limits of access road earthworks will be prohibited within 100m of nearby streams.

Point Source Pollution

To mitigate the indirect impacts of point source pollution, the following actions will be implemented:

- The presence of on-site toilet facilities for workers will be mandatory.
- All sanitary wastewater will be regularly transported outside of the study area for treatment.

- Oil management will be clearly defined prior to commencing construction and secondary containment will be required for all hydrocarbon products (fuel, oil, lubricants) used on the Project. Hydrocarbons will be stored at least 100 meters from any water body or wetland. Any hydrocarbon storage tanks or oil/fuel drums will be free of rust and cracks. The Project will provide and maintain bund walls around the fuel storage areas within the Site. These bund walls will be of a sufficient height to contain a volume equal to one and one half (1.5) times the entire contents of its fuel storage facilities. Fuel dispensing areas and machinery maintenance areas will be built with concrete hard standing surface, which will drain to oil separators. The oil will be pumped by a tanker and sent to Honiara for treatment. A hydrocarbon (fuel, oil, lubricant) management plan will be prepared and implemented by the construction contractor(s) prior to commencement of construction.
- All necessary means will be taken to reduce sediment loads in the river, especially when earthwork activities are being undertaken for dam construction. (see Section 13 – ESMP).
- Wash water from concrete works will never be directly or indirectly released in waterbodies or wetlands. Instead, it will be reused, stored and treated on site or collected and transported by road tankers for treatment in Honiara. A designated impermeable containment area must be used for concrete activities. To treat concrete washout onsite, a combination of settling ponds can be useful:
    - Coagulants or flocculants will need to be added before discharging the water into the first or primary pond. This will help to reduce the size of ponds. Water must flow over small weirs from one basin to the next until the quality is good enough to be reused as plant water (closed loop system). The first pond will require periodic cleaning. The hardened concrete that is removed can be crushed and sent to a landfill in Honiara or reused on site as non-structural aggregate for road ballasting or surfacing works yards. The capacity of each pond must be greater than a full day supply of wash water and will take into account that the area often receives considerable rain. Due to the sensitive nature of the area, wash water will never be released in the Tina River.
    - Each settling pond could allow for seepage and evaporation. For seepage, the water table needs to be low enough so that the water can be filtered without escaping. Settling ponds will need to be well sealed to limit any risks of infiltration of groundwater.
    - Water levels of settling ponds will be inspected daily. Before intense rain, the water levels will be lowered. Suitable cover will be installed to cover the pond in the event of intense rain (e.g., folding tarps). Tarps will cover the pond at night to keep birds and bats from drinking unsafe water. When excess water becomes a disposal issue, its pH will be adjusted with automatic pH neutralizer using $C0_2$ gas (the use of acids for that purpose is prescribed) prior to a potential discharge off-site in Honiara.

Impacts on Topsoil and Vegetation Regeneration

It is assumed that all excavated soil will be reused for restoration of construction work areas no longer required as the project moves into operation. Therefore, soils will be stockpiled in an area roughly 10ha in size, which will be developed with limited encroachment on natural habitats.

To ensure good soil management and revegetation, the following mitigation measures will be implemented during any earthworks conducted in forested areas where rich organic topsoil is present.

- Salvaging topsoils with high organic content, and mineral soils (i.e., subsoil not capable of supporting plant growth) - prior to commencing construction of the access road, the contractor will be required to do soil coring to assess the depth of organic soil in the right-of-way in cleared forested areas, from Mangakiki to the dam and quarry sites. This will determine the depth of soil stripping that is required. Collection of soil cores, and the management of soil stripping, will be done under the supervision of a soil expert. The aim is to conserve the topsoil for future use in rehabilitation of disturbed areas and to reuse subsoil for road embankments.

  Usually, machinery will be used to strip topsoil layers to a depth of 1m. With an access road length of about 21.86 km and a width of roughly 15m, it is estimated that approximately 327,900m^3 of topsoil will be removed from the access road right-of-way. Measures taken during earthworks to protect waterbodies are presented in Section 13 – ESMP).

- Storage of topsoil – topsoils having a high organic matter content, that have good potential for plant regrowth, will be stored within a soil stockpile area. Topsoil storage will be done away from all water bodies on a flat terrain, and close to work areas. Stockpiles will be compacted and covered with geo-fabric tarps to avoid unwanted prolific plant growth. Another option is to seed soil stockpiles with indigenous herbaceous plant species to maintain the organic content of piles. If the supply of native plants to vegetate piles is limited then stockpiles will be covered. In both cases, stockpiles slopes will not exceed a horizontal to vertical ratio of 5H:1V, and will be surrounded by sediment control structures, such as deeply anchored sediment fences, ditches, or berms around the stockpiles.

  In addition, stockpiles and all disturbed areas, including those adjacent to road alignments, will be drained to enable sediment control structures, such as settling ponds, to prevent sediment laden runoff flowing into water bodies. Stockpiles of topsoil will be maintained at a pH of greater than pH5.5, since a lower pH may lead to reduced organic matter content. With pH below 5.5, many essential nutrients may leach from the topsoils, and toxic elements may become available to plants, which in turn, will affect future plant regeneration. If necessary, agricultural lime could be spread onto the stockpiles to maintain a stable pH level.

  Monitoring of stockpiles will be done throughout the construction phase. An estimate of 10 conical stockpiles each 5m high, and 50m wide, will be necessary to store 327,900m^3 of topsoil. Stockpiles will be located within the Core Area, with the exact location being determined by the construction contractor, a botanist, and the independent consultant. It is recommended that spoils be stored in the remnant forest habitat to minimize forest clearing and because this habitat is located close to the access road (see Figure 6-12 – Study area habitat types and land use).

- In addition to soil spoils, non-organic (mineral subsoil spoils) and rock will also need to be removed and disposed, or reused, as follows:

  - Subsoil spoils - the Project access road will be located in steep terrain, and will require excavation of high cuts, placement of high fill embankments, and construction of retaining walls. Some soil spoils produced by cuts will be reused for fill embankments and unsuitable soil spoils will be transported outside the Project area to a designated disposal site.

  - Rock spoils - Construction of the tunnel (headrace tunnel, surge shaft, power shaft) will produce approximately 24,300m^3 of spoils. Spoils may be used either for road construction as aggregate base, or for river diversion works downstream of the dam and adjacent to the powerhouse tailrace. Excess rock spoils will be disposed of in the reservoir.

10.7.1.2.3 Residual Effects and Their Significance

By applying the mitigation measures recommended above and GIIP, the indirect impacts on flora during construction can be reduced to an acceptable level of low residual impacts and are, therefore, considered to be not significant.

10.7.1.3 Conclusions Regarding Impacts on Flora

10.7.1.3.1 Conclusions Regarding Direct Impacts

Construction activities will necessitate clearing approximately 115.49ha of natural vegetation, mainly forests, to create an access road and to prepare the reservoir area. Measures to mitigate impacts include conducting a pre-construction road alignment survey to delineate environmentally sensitive areas where valued or protected species are to be avoided or, where avoidance is not possible, transplanted where feasible. Changes in road alignment may be necessary based on this survey. Good international industry practice (GIIP) will be implemented by the construction contractor that is responsible for forest clearing, to minimize impacts. Some natural habitat will be disturbed beyond the road alignment and footprint of other project components, as a result of colonization by invasive species and fragmentation of habitats.

10.7.1.3.2 Conclusions Regarding Indirect Impacts

With application of appropriate mitigation, monitoring and management methods, minimal indirect impacts will accrue to flora within the project area.

10.7.2 Construction Impacts on Fauna

Impacts on fauna arising from construction activities will generally be of short-term duration. Long-term changes and impacts resulting from operation of the dam are discussed in Section 10.5.3 – Operation Impacts on Fauna).

10.7.2.1 Direct Impacts on Fauna

This section identifies potential sources of direct impacts on valued species or group of animals. These groups have been classified according to their habitat requirements. In the Solomon Islands, the lack of scientific research on many species does not enable precise assessment of how each species will react to the construction and operation of the Project. Therefore, professional judgment of biologists and ecologists based on experience from other projects on similar species has been used to predict impacts.

The following table (Table 10-3) provides an assessment of the species specific and direct impacts that could potentially accrue to fauna as a result of project construction, and includes the following analysis:

- Fauna that could potentially be affected;
- Value within the ecosystem and as a resource utilised by local communities;
- Potential impacts;

- Impact significance, based on magnitude, extent, duration and probability of impacts;
- Mitigation measures, and
- Residual impact and significance after mitigation has been applied.

Table 10-3 Assessment of potential direct impacts on fauna resulting from construction

Fauna type	**Native forest rodents**				
Ecosystem or resource value	The Emperor Rat is probably extinct (IUCN, 2013), while the King Rat is endangered. Both species are, therefore, highly valued.				
Potential Impact(s)	The extension of Black Post Road into the forest will follow the 160masl to 200masl topographic line, thus avoiding montane forest areas. Since both species seem to prefer forests in higher altitudes (600masl), they are unlikely to be directly affected by the Project or indirectly affected by noise or vibration. Studies in tropical Queensland Australia have shown that movement of native rodents fell by 67% to 90% across narrow forest clearing (6m to12 m), and by 90% to 100 % across larger forest clearings (20m to 60 m) Laurance (2009). However, the access road will not be located within the native home range altitude of the native rodent species. Some King Rat could be impacted at lower altitude. With most habitat in the area likely to be unsuitable this impact is considered to be of low significance and low probability.				
Impact significance rating	Magnitude	Extent	Duration	Probability	Overall Rating
	Low	Not in range	Short term	Unlikely	Low
Mitigation measures	None required.				
Post-mitigation residual impacts and significance	No residual impacts. Not significant.				

Fauna type	Bats & marsupials
Ecosystem or resource value	Endemic bat species are threatened and, therefore, have a high ecosystem value. The only marsupial in the Solomon Islands (Cuscus) is widely distributed and is of moderate resource value.
Potential Impact(s)	The marsupial known as the “Northern Common Cuscus”, as well as fruit eating bats, may be adversely affected by project construction, as they inhabit all kinds of forests, including

<table>
<tr><td></td><td colspan="5">remnant forests and gardens. Extension of Black Post Road into forested areas is the area that will be primarily affected.

The Cuscus tolerates degraded forested areas (IUCN, 2013). The species feeds on fruits, leaves and seeds and dwells in Ficus trees. It forages at high canopy but also in gardens. Cuscus requires shade, moderate temperatures and humidity (Pikacha, 2008). Areas that will be totally cleared, such as the access road, will no longer provide suitable habitat for this species. Impacts include disturbance from forest clearing, leading to species displacement, exposition and vulnerability to opportunistic hunters, noise and vibration disturbance from drilling and blasting, and vehicle-wildlife interactions.

Fruit-eating bats are adaptable to disturbances and degraded areas as long as artificial light is kept to a minimum. The main threat from project construction will come from blasting, carried out close to caves, and destruction of roosting trees by forest clearing. Many fruit eating bats roost in the daytime in the inland hills and forage in coconut groves along the coast (Campbell & Beecher, 1947). Project construction activities will probably temporarily disturb this daily migration pattern, and bats will probably become disoriented if their roosting areas are destroyed. In addition, forest clearing may destroy fruit trees used as sources of food.</td></tr>
<tr><td rowspan="2">Impact significance rating</td><td>Magnitude</td><td>Extent</td><td>Duration</td><td>Probability</td><td>Overall Rating</td></tr>
<tr><td>Moderate</td><td>Localised</td><td>Short term</td><td>Likely</td><td>Moderate</td></tr>
<tr><td>Mitigation measures</td><td colspan="5">Fauna-friendly underpasses at stream crossings will be installed to provide safe crossing opportunities during dam construction. Speed limits will be imposed on all construction traffic along access road.

The use of artificial light during construction will be kept to a minimum, Lights to be of low intensity and orientated towards the ground to avoid disrupting bats in flight.

Specific drill and blast methods identified in the ESMP to be used to minimise blasting noise and vibration.

Measures to mitigate for habitat loss, such as the creation of shelters or nest boxes, would lead to opportunistic hunting from local villages.</td></tr>
<tr><td>Post-mitigation residual impacts and significance</td><td colspan="5">Low impacts will persist in project affected area and are considered of low significance due to wide spread availability of suitable habitats throughout Guadalcanal.</td></tr>
</table>

<table>
<tr><td>Fauna type</td><td colspan="5">Forest-dependent birds (e.g., pigeons, doves and ground birds)</td></tr>
<tr><td>Ecosystem or resource value</td><td colspan="5">Many of the forest-dependent birds are endemic to Guadalcanal and are not found anywhere else in the world. Some are threatened. Therefore, they have a high ecosystem value.</td></tr>
<tr><td>Potential Impact(s)</td><td colspan="5">Extension of Black Post Road into the forested area is the main location of impacts. According to a study on the edge effect in Malaysia (Hossein, et al, 2009), abundance of many bird species decreases at forest edges. Forest clearing for the access road and truck traffic during construction activities will adversely affect forest-dependent birds in forested areas because the forest canopy will be completely or partially uncovered. Forest-dependent birds find shelter in the dense cover of the forest and in tree cavities. The access road will only fragment a small patch of forest, the extent of fragmentation is, therefore, somewhat localised. The intensity of the impact is moderate since there will only be a limited number of truck trips per day (e.g., roughly 40). Trucks will generate noise and vibration, which further startles birds. Impact duration, although temporary, may lead to permanent changes in bird composition in the vicinity of the new access road, where it passes through forested areas.

Forest dependent birds will also be impacted by noise and vibration from machinery works and blasting. Other impacts will include loss of habitat through clearance of construction work area. Impact duration will be temporary.</td></tr>
<tr><td rowspan="2">Impact significance rating</td><td>Magnitude</td><td>Extent</td><td>Duration</td><td>Probability</td><td>Overall Rating</td></tr>
<tr><td>Moderate</td><td>Localised</td><td>Short term</td><td>Highly likely</td><td>Moderate</td></tr>
<tr><td>Mitigation measures</td><td colspan="5">Forest canopy shall be “sealed” where possible by minimising large tree clearing and maintaining canopy connectivity to reduce edge effect. Botanist to identify large canopy trees for retention.

Construction work area to be rehabilited as part of no net loss of biodiversity measures.

Specific drill and blast methods identified in the ESMP to be used to minimise blasting noise and vibration.

Additional measures, such as the creation of shelters or nest boxes would lead to opportunistic hunting from local villages.</td></tr>
<tr><td>Post-mitigation residual impacts and significance</td><td colspan="5">Low impacts will persist and are considered to be of low significance due to temporary and localised nature of impacts and wide spread availability of alternative habitat</td></tr>
</table>

Fauna type	River dependent birds				
Ecosystem or resource value	Most of the river-dependent birds are widespread and none are endemic to Solomon Islands.				
Potential Impact(s)	All construction activities along the river that are associated with the project, including dam and powerhouse construction will have an adverse effect on river dependent birds, as noise and vibration from machinery and shock waves from blasting will startle them. During construction of the dam and mining of quarries, the water of the Tina River will become turbid. This will reduce visibility which, in turn, will make it difficult for fish-eating birds, such as kingfishers, to locate their prey. During construction, the affected areas will likely not be utilized by birds. Impact duration, although moderately long, will be temporary. Impact magnitude will be low, since construction is not likely to cause any bird casualties.				
Impact significance rating	Magnitude	Extent	Duration	Probability	Overall Rating
	Low	Localized	Short term	Likely	Low
Mitigation measures	Mitigation will not appreciably reduce impacts on river dependent birds. However, to mitigate encroachment on riparian habitats, work areas will be clearly delineated prior to commencement of work. Specific drill and blast methods identified in the ESMP to be used to minimise blasting noise and vibration.				
Post-mitigation residual impacts and significance	Low impacts will persist but are considered to be not significant.				

Fauna type	Grassland & widely distributed birds
Ecosystem or resource value	As most of these species of birds are widely distributed, they have moderate ecosystem value.
Potential Impact(s)	Grassland and widely distributed birds, such as forest edge birds, roost along the forest edge and forage in grassland and forest clearings. Birds that inhabit areas of grassland along the portion of Black Post Road that will be enlarged and improved and where the transmission line will be installed, will be adversely affected. Over the long-term, forest located openings along the access road will most likely favour some bird species that are accustomed to open spaces. However, it is expected that during construction the areas adjacent to the access road will not likely be utilized by most bird species, due to noise and

	vibration impacts. The traffic along the existing access road will affect grassland birds that use this area, as the access road will be see traffic from heavy haul trucks, light duty trucks and other vehicles, that will generate noise and vibration. The intensity of the impact is low since grassland species can easily find other suitable habitat in the vicinity of the access road during construction. Impacts will be moderate but the duration is temporary.				
Impact significance rating	Magnitude	Extent	Duration	Probability	Overall Rating
	Low	Localised	Short term	Likely	Low
Mitigation measures	To mitigate impacts on grassland dependent birds, it is recommended that as many trees and shrubs be left standing as possible along the existing Black Post Road, as they offer good roosting sites for birds.				
Post-mitigation residual impacts and significance	Low impacts will persist but are considered to be not significant.				

Fauna type	Amphibians
Ecosystem or resource value	A number of amphibian species are deemed ecologically important due to their endemicity, or threatened status and, therefore, have high ecosystem value. They are further threatened by the introduced cane toad.
Potential Impact(s)	Access road construction will be the most affected site. Amphibians will be adversely affected by project construction in a variety of ways, including: being confined to small territories or home ranges; their restricted mobility and speed limits their ability to escape from construction activities, making them vulnerable to physical damage and pollution; they are highly sensitive to changes in humidity and vulnerable to the edge effect, and some, like tree frogs, are highly dependent of dense forest cover; increased predation by feral cats and dogs might reduce their numbers; and improved access may facilitate further encroachment into the area by cane toads. Habitat in the vicinity of the access road is largely modified habitat and is marginal habitat for high value amphibian species. The density of high value amphibian species is relatively low due to the presence of invasive cane toad populations. Blasting and construction noise and vibration would result in temporary adverse impacts to amphibians. High value amphibians identified in the baseline surveys inhabited upper forest habitats

	and riparian habitats unaffected by the majority of construction activities.

Impact significance rating	Magnitude	Extent	Duration	Probability	Overall Rating
	Low	Localised	Short term	Likely	Low

Mitigation measures	It is not possible to limit the incursion of new amphibian species along the extension of Black Post Road, including the cane toad, which is already present in the area. To mitigate habitat fragmentation consideration was given to installing frog-friendly crossing culverts beneath the access road to facilitate crossing the road without being hit by moving vehicles. However, since the volume of traffic is expected to be light during operation, and local species of frogs are not known to migrate end mass between hibernation and breeding wetlands in the Solomon Islands, access road traffic will not represent a serious threat to frogs. Rather it is recommended fauna-friendly underpasses be installed at stream crossings (see Figure 10-1), as these would also be beneficial to amphibians. Specific drill and blast methods identified in the ESMP to be used to minimise blasting noise and vibration.
Post-mitigation residual impacts and significance	Low impacts will persist

Fauna type	Reptiles
Ecosystem or resource value	A number of reptile species are deemed ecologically important due to their endemicity, or threatened status and, therefore, have high ecosystem value. They are further threatened by the introduced cane toad.
Potential Impact(s)	The access road will be the most affected site during construction. Some reptiles will probably be favoured by the Project in the long-term, since partial opening of the canopy will create more favourable conditions (i.e., sunny and drier environment) for them. This positive impact is further discussed under operation impacts. In the short term, during forest clearing for access road construction, reptiles will be adversely affected in the same manner as amphibians. Reptile mortality will occur because of their limited mobility and small home ranges. Many reptiles found in the study area rely on trees. Therefore, forest clearing will probably lead to diminished productivity. In addition, snakes may suffer from persecution by construction workers. Reptiles will also be impacted by noise and vibration from machinery works and shock waves from blasting. Other impacts

	will include loss of habitat through clearance of construction work area. Impact duration will be temporary.				
Impact significance rating	Magnitude	Extent	Duration	Probability	Overall Rating
	Low	Localised	Short term	Moderate	Low
Mitigation measures	It is recommend fauna underpasses be installed at stream crossings (see Figure 10-1). Some species of reptile will probably be favoured once the access road is finished since they thrive in sunnier and dryer environments. In addition, during construction, workers will be prohibited from harming any wildlife. They will receive wildlife awareness training informs them of the requirement to request the project's environmental specialist capture and remove animals that are either in danger or are dangerous to construction workers. Construction work area to be rehabilited as part of no net loss of biodiversity measures. Specific drill and blast methods identified in the ESMP to be used to minimise blasting noise and vibration.				
Post-mitigation residual impacts and significance	Low impacts will persist, but are considered to be not significant.				

Fauna type	Wetland dependent insects				
Ecosystem or resource value	A number of wetland dependent insect species are deemed ecologically important due to their endemicity, or threatened habitat status and, therefore, have high ecosystem value. They are further threatened by activities such as timber harvesting that threaten wetland habitats, and by the introduced little fire ant.				
Potential Impact(s)	The site of powerhouse construction is the most affected site. Many micro-wetlands are created by flash floods along the Tina River, especially where low relief topography occurs adjacent to the Tina River. Around the dam site, the topography is very steep and, therefore, does not support micro-wetlands. At the powerhouse site, some micro-wetlands will be destroyed leading to localized loss of wetland dependent insects, such as dragonflies and damselflies.				
Impact significance rating	Magnitude	Extent	Duration	Probability	Overall Rating
	Low	Localised	Short term	Moderate	Low

Mitigation measures	Specific measures for mitigating the production of wetland dependent insects are limited. Best Environmental Management Practices will be implemented.
Post-mitigation residual impacts and significance	Low impacts will persist but are considered to be not significant.

10.7.2.2 Indirect Impacts on Fauna

10.7.2.2.1 Identification of Indirect Impacts

This section identifies potential sources of indirect impacts on fauna.

Habitat Fragmentation and Barrier Effects

As previously stated, access roads will have adverse impacts on flora. The following discusses how fragmentation may affect wildlife. According to Laurance (2009), wildlife habitat fragmentation is particularly acute in tropical rainforests, including rainforests of the South Pacific, due to road development because:

- Many tropical species are adapted to moist, dark and stable microclimates provided by forest understories;
- tropical forests sustain species with microhabitats which are sensitive to slight changes of light and humidity;
- Sediments eroded from access roads and small stream blockages at road crossing points can alter habitats;
- Waterborne pollutants, such as oil spills on roads, can easily be flushed into water courses and, in turn, may affect amphibians living in adjacent wetlands,
- In developing countries, access roads have been known to induce increase hunting pressure, settlements and population growth.

Two types of habitat fragmentation can take place:

- Fragmentation caused by roads that bi-sect wildlife habitats and cause populations to become isolated or separated. This can result from vehicle-wildlife interactions (i.e., road kills), and from species that are easily startled and, therefore, hesitate to cross roads; and
- Fragmentation that results from improved access to predators, such as birds of prey and snakes, which are provided with improved foraging along newly exposed forest edges for species such as amphibians, native rats and Cuscus.

The potential impacts of habitat fragmentation on wildlife may be:

- Decreased species adaptation to change due to genetic isolation causing population decline;
- Reduction in home range surfaces and an abandonment of the habitat by species when habitat surface thresholds are crossed;
- Change in microclimate and increase predation, leading to an abandonment of the habitat by species;
- Increased encroachment of opportunistic wildlife species.

Ultimately, habitat fragmentation leads to reduction in wildlife diversity.

In addition to contributing directly to habitat fragmentation, linear clearings such as access roads, and transmission line rights-of-way can create a barrier to wildlife movement. Many species adopt an avoidance behaviour when confronted with linear clearings (Laurance, 2009). As noted above, this behaviour can ultimately contribute to wildlife habitat fragmentation.

Most species that adopt an avoidance behaviour are those that are usually not affected by road kills. The barrier effect has been reported even in cases of narrow clearings. Species at risk are those that:

- Are strictly arboreal;
- Are adapted to fly short distances in dense forested environments;
- Are easily startled and dazzled by light, traffic noise, pollution and dust and human presence. For example, bats are disturbed by artificial lighting, especially when installed along river corridors, and forest edges;
- Align their territories with forest clearing boundaries (Laurance, 2009).
- Whose means of communication will be interfered by traffic noise (Goosem, 2007)
- Are physically unable to cross when roads include deep drainage channels, gabion baskets or when roads are built with a cut-and-fill approaches. In this case, road construction represents an impassable obstacle that leads to permanent habitat fragmentation and permanent genetic isolation of small patches of population. This issue is particularly significant in the case of the access road extension to the dam, because many cuts and embankment fills are foreseen.

Species that are of greatest concern are insects, rainforest amphibians, reptiles (such as skinks), forest-interior birds, bats and other small mammals.

Vehicle-Wildlife Interactions

Any access road represents a risk of vehicle-wildlife interactions leading to wildlife mortality (i.e., road kills). Laurance (2009) identifies species at risk as being those that:

- Require wide habitat ranges;
- Are less mobile, slow or freeze when faced with danger, such as ground dwelling species (mainly amphibians but also some reptiles, ground and understory birds and small mammals) (Goosem, 2007). The highest casualties occur when these species find good hunting or breeding ground near roads and when the activities of the crepuscular species coincide with traffic peaks;
- Are predominantly arboreal and are less agile when required to move on the ground;
- Birds and bats with low flight paths; and
- Species with poor eyesight.

Feral and Invasive Species

The access roads will have an indirect effect on native wildlife by providing improved access for feral and invasive species into new areas, and the associated predation on native species. Islands around the world are particularly vulnerable to invasive species. In the case of the Solomon Islands, dogs and feral cats are known to represent a threat to native rats and the Cuscus.

Fire Ants

In Guadalcanal, logging roads have opened the way for invasive insects such as the little fire ant (*Wasmannia auropunctata*), which is native to South and Central America. This species was introduced in the Solomon Islands as a biological control for a nut fall bug (IUCN, 2012). This species, because of its plundering behaviour, reduces insect diversity. The access road will lead to the colonization of fire ants of new undisturbed areas. Proliferation of the little fire ant in rainforests occurs approximately 60 times faster with the presence of roads, than in undisturbed forests (Polhemus et al., 2008).

Feral Animals

Cats, non-native rats (Polynesian Rat and House Rat) and dogs are known to move along roads (Goosem, 2007). In the Solomon Islands, they threaten the survival of many native small mammals and ground birds such as pigeons. Feral cats are the most dangerous introduced predator of native species in the Solomons Islands and are a threat to native rats and the Cuscus (Pikacha, 2008). Goldridge fauna surveys revealed the presence of introduced rats in disturbed and degraded areas. The TRHDP construction phase may create new ecological niches for, or facilitate the spread of, non-native rat species, which might compete with - or spread disease to - native rats (if these are still extant).

Cane Toad

The cane toad (*Bufo marinus*), which is native to Central and South America, is an introduced species that is found throughout the Solomon Islands. In the Project area, the cane toad was found as far as the upper catchment area along the Vohara River. According to Pikacha (2008) and IUCN (2013), cane toads are a threat to snakes and native frogs that eat the tadpoles and die from the toxic poisons present in the Cane toad glands. Cane toads are more successful in open areas such as roadsides (Urban et al., 2007). In tropical Australia, a recent study has shown that cane toads colonize new habitat moving along roads and cleared fence lines, avoiding heavily vegetated habitat (Brown et al., 2006). Forest clearing for the access road will, therefore, facilitate the continuing encroachment of cane toads into the project area. Evidence of cane toad presence was observed (juvenile toad and tadpoles) on 12 May 2016 in the reach of the Tina River just upstream of the powerhouse site (see Figure 10-1).

Figure 10-1 Photo of juvenile Cane Toad caught just upstream of proposed powerhouse site

Source: Scott Hanna photo (2016)

Giant African Snail

The Giant African Snail was introduced into the Solomon Islands, probably as eggs and juvenile snails within soil that was adhered to imported logging equipment. The snail competes with native species and damages food crops. During the mitigation workshops, it was mentioned that this species has already reached Veraande village (along Black Post Road).

Noise, Vibration and Light

In addition to the fragmentation of habitat, noise, light and vibration can have adverse impacts on wildlife. However, dust will not be a significant problem thanks to the rainy climate in Guadalcanal. During the TRHDP construction phase, noise and vibration from blasting and drilling (during the tunnel construction or the quarry exploitation) and from vehicle traffic will startle many wildlife species. In addition, artificial light may disorient bats. In tropical regions, artificial light alters the foraging behaviour of fruit-eating bats (Lewanzik and Voigt, 2014).

10.7.2.2.2 Mitigation Measures

Habitat Fragmentation and Barrier Effects, and Vehicle Wildlife Interactions

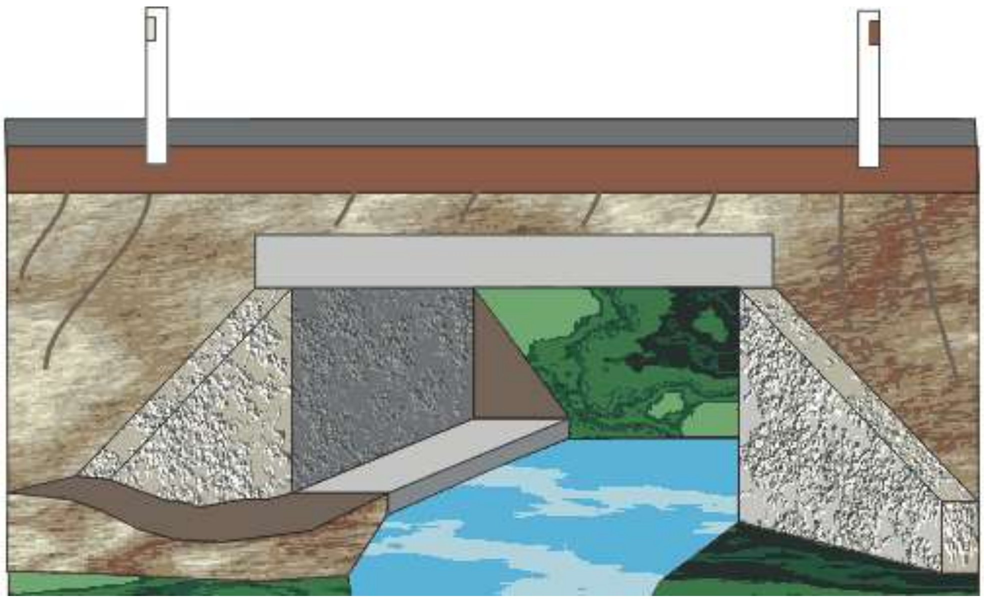
To mitigate habitat fragmentation and barrier effects, and vehicle-wildlife interactions, the following measures will be implemented:

- Best Environmental Management Practices will be implemented by the Construction Contractor during the TRHDP construction phase;

- Faunal underpass - culverts (or bridges) across small stream will allow terrestrial species to underpass the access road. These culverts will be large enough to allow the water flow and to ensure permanent dry passage using ledges (see Figure 10-2). The dry passage will provide suitable cover such as rock piles, logs, and brush. For example, ledges will be large enough to allow Cuscus to cross (with a width of 1m).

However, these corridors can also pose a risk to prey species if predators learn that these underpasses are a source of prey. Notwithstanding, compared to the numbers of fauna that could be killed crossing the access road, the use of wildlife underpasses will likely more than make up for the number of road kills.

Figure 10-2 Faunal underpass in open bottom culvert



Source: Main roads, Western Australia, 2014

- The forest canopy will be kept intact wherever possible to maintain ground level shade and humidity levels, and to minimise creating an edge effect; and
- Vehicle speed limits will be controlled along the access roads, to ensure that drivers are able to prevent running over wildlife that may be lying on, or crossing, the access road.

Feral and Invasive Species

Only intensive long-term trapping or control could attempt to stop further encroachment of feral and invasive species such as fire ants, cats, dogs, and cane toads that are already known to have entered the project area. However, to mitigate the spread of the Giant African Snail, the following actions will be implemented:

- An equipment cleaning station, employing pressurized steam, will be installed at Veraande. This location was chosen because the Giant African Snail is already located there. All wheels, tracks, excavation blades and buckets, as well as other pieces of machinery that could have come into contact with soil, will be cleaned prior to entering the project site. This measure will provide an opportunity to create small jobs for local communities; and
- Soil will never be imported into the project area.

Noise, Vibration and Light

To minimise impacts of noise, vibration and light, the following measures will be employed:

- Specific drill and blast methods will be used to reduce noise and vibration. Hydraulic rock drill equipment will be used instead of pneumatic equipment because it produces less noise. Moreover, blasting and drilling equipment will be equipped with silenced masts, which can reduce noise levels by up to 10dBA. Blasting charges will be covered with blasting mats and screens to reduce generation of noise, fly rock and dust; and

- The number of artificial lights will be kept to a minimum, while still maintaining a safe working environment. Light intensity will also be limited, where possible, and the lights will be oriented toward the ground to avoid disorienting bats in flight.

10.7.2.2.3 Residual Effects and Their Significance

By applying the mitigation measures recommended above and GIIP, the indirect impacts on fauna can be reduced to an acceptable level of low to moderate residual impacts and are, therefore, considered to be not significant.

10.7.2.3 Conclusions Regarding Construction Impacts on Fauna

Table 10-4 summarises impact significance on fauna during construction. Forest clearing is the main impacting activities. It will disturb fauna and fragment their habitats. Forest clearing will potentially lead to diminished numbers of less mobile species, such as amphibians and reptiles, but given the short duration, localised nature of the impacts, they are considered overall to be not significant.

Table 10-4 Summary of construction impact ratings on fauna

Group of animals	Pre-mitigation Impact Rating	Opportunity for Mitigation	Residual Effect
Native Rainforest Rodents	Low	No	Not significant
Bats and marsupial	Low – Moderate	Yes	Low Significance
Forest-dependent birds	Moderate	Yes	Low Significance
River-dependent birds	Low	No	Not significant
Grassland and widely distributed birds	Low (positive)	Not required	Not significant
Amphibians	Low	Yes	Low Significance
Reptiles	Neutral	Yes	Not significant
Wetland dependent insects	Low	No	Not significant

10.8 ASSESSMENT OF OPERATION IMPACTS

10.8.1 Operation Impacts on Flora

10.8.1.1 Direct Impacts on Flora

10.8.1.1.1 Identification of Direct Impacts

Project operation will necessitate vegetation control under the transmission line. Herbicides such as glyphosate will not be used for vegetation clearance, due to the potential toxic effects on amphibians and reptiles, as well as on fish and water quality. Instead, manual vegetation control methods will be employed for the Project to maintain the right-of-way.

10.8.1.1.2 Mitigation Measures

Other than vegetation control, there will not be any additional work involving forest clearing during operation. The transmission line will mainly pass through grasslands, and will most likely only require minor vegetation control. This will be accomplished using manual or equipment vegetation control techniques. No herbicides will be used to manage vegetation growth along the transmission right-of-way.

10.8.1.1.3 Residual Effects and Their Significance

During project operation, direct impacts to flora are considered to be not significant, as most of the impacts will have already occurred as a result of project construction.

10.8.1.2 Indirect Impacts on Flora

This section identifies and rates portential indirect impacts on flora that will result from project operation. Most indirect impacts are related to the presence of the access road through the forest, which will could act as an agent of change in the area, leading to a gradual degrading of surrounding ecosystems.

10.8.1.2.1 Identification of Indirect Impacts

Ongoing Encroachment by Invasive Species

Once the dam and the hydropower plant is in operation, improved access will facilitate increased presence of people in the area around the dam, which could in turn, lead to colonization of invasive, vine and pioneer species leading to local displacement or disturbance of native plant species. The primary concern is the accidental or purposeful introduction of invasive plant species. As noted previously, Water Hyacinth colonization does not represent a significant risk for the Project, if accidentally or intentionally introduced, given the daily fluctuations in reservoir water levels and the expected low concentration of nutrients.

Opening of forested areas along access roads will create on-going opportunities for invasive species to settle.

Changes in Vegetation Induced by Changes in River Hydrology

Impacts can arise from changes in the Tina River hydrology downstream of the dam. Changes could have an effect on riparian habitats and small wetlands located along the river between the dam and powerhouse. The dam will provide flood attenuation but does not provide flood control. A major effect of flood attenuation will be a reduction in flow variation. This reduced variation will lead to a reduction in littoral wetland habitats that will be most pronounced in the low flow region (there will be diurnal variation/generation related variation below the powerhouse). There will also be additional littoral wetland habitats created by variable exposure water levels in the reservoir.

Changes in the Accessibility to Forest Products

Wood and non-wood products will be under increased human pressure if the new access road facilitates access into areas presently covered by undisturbed forest (primary forest) or regenerating forest (disturbed forests) this is particularly true for the Core Area.

Improved access to the dam and reservoir area provided by the access road could lead to development of settlements in upstream areas by landowners who wish to take advantage of better access available forest resources such as fruits, nuts, medicinal plants, wild game, timber for construction, fuel wood, aggregates at the upstream end of the reservoir, and other resources. Therefore, the extent of road related impacts on habitats is not limited to the width of the access road but to newly accessible forested areas.

Improved access afforded by the new access road could also lead to increase logging activities in upstream areas. This impact has been well documented in the Gold Ridge area (Ross Mining, 1994).

Land Use Dynamics on Natural Habitats

Over the long term, the access road will allow people to modify land use since it will promote rapid deforestation and transformation to gardens. Vegetation composition will gradually change in proximity to the access road. In addition, the 4.288km^2 Core Area will probably be under increasing development pressure. The extent of modification is impossible to predict. However, development of gardens and increased use of timber for house construction will inevitably modify the forest and create openings in the canopy leading to modification of ecosystems.

10.8.1.2.2 Mitigation Measures

Ongoing Encroachment by Invasive Species

To mitigate impacts of ongoing encroachment by invasive plant species, the following actions will be implemented:

- Monitoring of Water Hyacinth will be undertaken to assess its presence in the reservoir and to ensure quick response in case it becomes established. This monitoring will be done twice each year and will include surveys of the entire reservoir. In the event that Water Hyacinth does become established in the reservoir, immediate removal of the plant and its roots will be carried out to limit the ability for it to propagate further.
- Site restoration using native plant species will be undertaken in affected areas, including the Core Area (see Section 13 – ESMP). As discussed in Section 13, native vegetation species are expected to become quickly established if planted in good quality soils.

Changes in River Vegetation Induced by Changes in River Hydrology

To mitigate impacts, an environmental flow (EF) must be implemented downstream of the dam. Details on the determination of the EF are presented in Section 11 – Assessment of Impacts on the Biological (Aquatic). This environmental flow is, however, not sufficient to mitigate impacts and long-term changes in vegetation along the river banks.

Changes in the Accessibility to Forest Products, and Land Use Dynamics on Natural Habitats

To mitigate the impacts of changes in the accessibility to forest products and increased development pressure on natural habitats, the following action will be implemented:

Management of access - during mitigation workshops, local communities requested that access to the Core Area by non-local settlers be prohibited, and that the extension of Black Post Road be declared a private access only. Control of access would be done by the Tina TCLC, which will own the Core Land, including the access road from Marava Village to the dam site. The access road to the dam will be gated to prevent access to logging companies. Access would only be granted to the local population and hydropower facility operator. The TCLC will not permit anyone to live or construct housing within the land leased for the project, except where strictly necessary for project activities, including housing fort rangers or security staff. A settlement policy will be developed and implemented with the assistance of the TCLC and incorporated into the Biodiversity Management Plan. The settlement policy will include enforcement measures to prevent the use of the land for a workers camp. It will also address restrictions on the use of the private project road through the Core Area by people seeking to build new settlements beyond the Core Area.

10.8.1.2.3 Residual Effects and Their Significance

By applying the mitigation measures recommended above and GIIP, the indirect impacts on flora during operation can be reduced to an acceptable level of low residual impacts and are, therefore, considered to be not significant.

10.8.1.3 Conclusions Regarding Impacts of Operation on Flora

Impacts on flora during project operation are mostly indirect and will accrue due the presence of the access road that will allow communities to access better forest resources in upstream areas, and move deeper into the forest in areas bordering the road. The access road will be an agent of change in the area. Land use along the access road could also change with the arrival of new settlers.

10.8.2 Operation Impacts on Fauna

10.8.2.1 Direct Impacts on Fauna

The following section discusses direct species-specific impacts on wildlife, proposed mitigation measures, and examines residual impacts and significance following the application of mitigation measures. This section studies the same group of species as presented in the construction section to analyse whether the situation for these species will worsen, improve or stabilize with the Project operation. Impacts accruing from operation are permanent, as the Project will permanently modify some ecological function and habitats.

The following table (Table 10-5) provides an assessment of the species specific and direct impacts that could potentially accrue to fauna as a result of project construction, and includes the following analysis:

- Fauna that could potentially be affected;
- Value within the ecosystem and as a resource utilised by local communities;
- Potential impacts;
- Impact significance, based on magnitude, extent, duration and probability of impacts;
- Mitigation measures, and
- Residual impact and significance after mitigation has been applied.

Table 10-5 Assessment of potential impacts to fauna resulting from operation

Fauna type	**Native forest rodents**				
Ecosystem or resource value	The Emperor Rat is probably extinct (IUCN, 2013), while the King Rat is endangered. Both species are, therefore, highly valued.				
Potential Impact(s)	No direct impact due to operation. Indirect impact due to presence of an access road, relatively close to montane forest could increase human and invasive species (e.g. cats, rats) presence in previously pristine montane forest, leading to potential impacts on native rodents.				
Impact significance rating	Magnitude	Extent	Duration	Probability	Overall Rating
	Moderate	Localised	Long term	Likely	Low
Mitigation measures	Access to private road through Core Land to be limited. No human habitation of Core Land to be permitted.				
Post-mitigation residual impacts and significance	Low				

Fauna type	Bats & marsupials (i.e., Cuscus)

<table>
<tr><td>Ecosystem or resource value</td><td colspan="5">Endemic bat species are threatened and, therefore, have a high ecosystem value. The only marsupial in the Solomon Islands (Cuscus) is widely distributed and is of moderate resource value.</td></tr>
<tr><td>Potential Impact(s)</td><td colspan="5">Forest areas adjacent to the access road will be the main areas affected. Progressively, this impact will extend into the forest interior away from the road. Project operation and ongoing use of the access road will create on-going impacts on mammals as hunting activities and the presence of new settlers create additional pressures on wildlife.

In addition, if the transmission line is constructed using wooden power poles, there is a risk that cuscus may climb the poles and be electrocuted, causing power outages as circuits are tripped.</td></tr>
<tr><td rowspan="2">Impact significance rating</td><td>Magnitude</td><td>Extent</td><td>Duration</td><td>Probability</td><td>Overall Rating</td></tr>
<tr><td>Low</td><td>Localised</td><td>Long Term</td><td>Highly likely</td><td>Low - Moderate</td></tr>
<tr><td>Mitigation measures</td><td colspan="5">Metal shields will be installed on wooden power poles in forested areas to prevent Cuscus from climbing poles and becoming electrocuted.</td></tr>
<tr><td>Post-mitigation residual impacts and significance</td><td colspan="5">Not Significant</td></tr>
</table>

<table>
<tr><td>Fauna type</td><td colspan="5">Forest dependent birds (e.g., pigeons and ground birds)</td></tr>
<tr><td>Ecosystem or resource value</td><td colspan="5">Many of the forest-dependent birds are endemic to Guadalcanal and are not found anywhere else in the world. Some are threatened. Therefore, they have a high ecosystem value.</td></tr>
<tr><td>Potential Impact(s)</td><td colspan="5">Majority of operational impacts will affect modified forest habitats with limited suitability for forest dependent birds especially ground birds. There is current evidence of wide spread presence of feral animals particularly cats throughout the area. According to Laurance (2004), edge effect can lead to reduction in forest-dependent bird species extending up to 70m away from road margins in Amazonia. Predation by feral animals could continue. As for construction, forest near the access road will be the main impacted site. Progressively, this impact will reach forest interior away from the road. Dependent on design, the transmission line may present collision or electrocution risks to larger-bodied species, such as birds of prey, parrots and hornbills.</td></tr>
<tr><td rowspan="2">Impact significance rating</td><td>Magnitude</td><td>Extent</td><td>Duration</td><td>Probability</td><td>Overall Rating</td></tr>
<tr><td>Moderate</td><td>Localised</td><td>Long term</td><td>Highly likely</td><td>Moderate</td></tr>
<tr><td>Mitigation measures</td><td colspan="5">Natural habitats within the Project Area to be protected and 9.5 Ha of modified habitat will be rehabilitated to forest habitat. These</td></tr>
</table>

	measures are to be set out in the developer's Biodiversity Action Plan. Forest canopy shall be "sealed" where possible by minimising large tree clearing and maintaining canopy connectivity to reduce edge effect. Botanist to identify large canopy trees for retention. Transmision line design and mitigation will follow well-established global best practice (e.g., from the Avian Power Line Interaction Committe and BirdLife International) to minimise the risk of both collisions and electrocutions. Other mitigation measures not feasible as the access road will create a clearing in the canopy and associated edge effect.
Post-mitigation residual impacts and significance	Low impact, not significant

Fauna type	River dependent birds				
Ecosystem or resource value	Most of the river-dependent birds are widespread and none are endemic to Solomon Islands.				
Potential Impact(s)	River dependent birds will be affected by the low flow conditions created by operation in the reach between the dam and the powerhouse, where water levels will be reduced. Floods, which are known to create and feed small riparian wetlands, will be attenuated by the dam. There will be some reduction in wetland habitats in the reduced flow section; less or no reduction in wetland habitrats downstream of the powerhouse, and some increase in habitats on the margins of the lake. Environmental flow conditions are expected to increase fish density from baseline medium flow conditions.Impacts may be felt in the upper catchment, should fish numbers decline if fish passage provisions are not effective. Lower flows in the affected reach could also expose fish making them easier prey for some fish-eating species of birds.				
Impact significance rating	Magnitude	Extent	Duration	Probability	Overall Rating
	Low	Localised	Long term	Likely	Low
Mitigation measures	Key mitigation measures will be maintenance of environmental flow and trap and haul fish passage.				
Post-mitigation residual impacts and significance	Not significant				

Fauna type	Grassland and widely distributed birds
Ecosystem or resource value	As most of these species of birds are widely distributed they have moderate ecosystem value.

Potential Impact(s)	Bird species that utilize forest edge and grassland habitats, and bird species that are otherwise widely distributed across many different types of habitats, might benefit by the extension of Black Post Road, which will create additional habitats for these species.				
Impact significance rating	Magnitude	Extent	Duration	Probability	Overall Rating
	Low (positive)	Localised	Long term	Likely	Low (positive)
Mitigation measures	No mitigation measures required.				
Post-mitigation residual impacts and significance	Not significant				

Fauna type	Amphibians				
Ecosystem or resource value	A number of amphibian species are deemed ecologically important due to their endemicity, or threatened status and, therefore, have high ecosystem value. They are further threatened by the introduced cane toad.				
Potential Impact(s)	The river reach between the dam and the powerhouse is the main affected riparian habitat. A reduction in wetlands in this area may reduce habitat for the San Cristobal Treefrog (the only Solomon Islands' frog with a tadpole stage) while the creation of a dam may improve habitat in the reservoir area. Habitat of other high value amphibians is above the project affected area in the upper catchment. Cane toads and feral animals will continue to exert pressure on native species of amphibians where disturbed areas (e.g., access road, and along the low flow river reach).				
Impact significance rating	Magnitude	Extent	Duration	Probability	Overall Rating
	Low	Localised	Periodic	Highly likely	Low
Mitigation measures	The steady 1 m^3/s environmental flow will not be sufficient to recharge riparian wetlands. Floods, which are known to create and feed small riparian wetlands, will be attenuated by the dam. There will be some reduction in wetland habitats in the reduced flow section; less or no reduction in wetland habitats downstream of the powerhouse, and some increase in habitats on the margins of the lake.				
Post-mitigation residual impacts and significance	Low significance				

Fauna type	Reptiles
Ecosystem or resource value	A number of reptile species are deemed ecologically important due to their endemicity, or threatened status and, therefore, have high

	ecosystem value. They are further threatened by the introduced Cane Toad.				
Potential Impact(s)	The extended access road will modify habitat quality for reptiles. Some reptiles will be positively affected by the new access road, as this road will create additional open habitat along the forest edge and will bring more solar radiation to the ground. Which species will benefit is difficult to assess. However, snakes will likely benefit the most by forest openings. However, all reptiles could also be affected by the ongoing arrival of feral animals and by potential vehicle-wildlife interactions where reptiles try to cross the road or lay on the road to absorb residual heat given off by the surface of the road during the cooler parts of the day.				
Impact significance rating	Magnitude	Extent	Duration	Probability	Overall Rating
	Neutral	Localised	Long term	Highly likely	Neutral
Mitigation measures	No specific mitigation measures can be implemented for reptiles.				
Post-mitigation residual impacts and significance	Not significant				

Fauna type	Wetland dependent insects				
Ecosystem or resource value	A number of wetland dependent insect species are deemed ecologically important due to their endemicity, or threatened habitat status and, therefore, have high ecosystem value. They are further threatened by activities such as timber harvesting that threaten wetland habitats, and by the introduced little fire ant.				
Potential Impact(s)	Micro-wetlands along the by-passed reach are the most affected sites. “Wetting” of these sites by floodwaters will be reduced due to the flood attenuation effects of the dam, however the reservoir will not have flood control storage and impacts will be short lived. Simulation of the hydro operation indicated that floods or freshets would occur on average every 6 weeks, and their average duration would be between 4 to 6 days. Additional aquatic terrestrial contact zones (ATCZ) along the shores of the reservoir are expected to provide additional habitat for wetland dependent insect species. There is therefore expected to be a minimal reduction in the number of wetland dependent insects.				
Impact significance rating	Magnitude	Extent	Duration	Probability	Overall Rating
	Low	Localised	Periodic	Likely	Low
Mitigation measures	No specific mitigation measures can be implemented.				
Post-mitigation residual impacts and significance	Low significance				

10.8.2.2 Indirect Impacts on Fauna

10.8.2.2.1 Identification of Indirect Impacts

Some of the indirect impacts on wildlife that will occur during construction activities will continue during operation of the Project, as the access road could facilitate increased access through the Core Area. Measures to restrict vehicle access to the new section of Black Post Road above Mengakiki will be instrumental in minimising this impact. No residences, settlements or workers' camps are to be permitted in the Core Area other than limited accommodation necessary for the Project (eg. security guards or on-call engineers). Terrestrial ecology will adapt over the long term, and ecological functions of the affected area will be redefined. Some species types will probably be favoured by road presence, but most will be disadvantaged. During operation, the access road will be a low-volume road used only for Project activities, including implementation of environmental mitigation measures, with impacts being related less to vehicle-wildlife interactions, and more to ecological modifications brought about by opening of the canopy. .

Changes in Accessibility to Bush Meat

Several studies have shown that newly created access roads in forests bring negative indirect impacts on forest products (wood and non-wood products) and wildlife, when access roads are not controlled. These impacts are generated because access roads greatly facilitate human encroachment into areas that would normally be difficult to access, thereby leading to development of new economic activities along roads (Young, 1994). Even when access is controlled by the local population, indirect impacts are still significant. Suarez et al. (2012) has demonstrated that, in Brazil, despite access along new roads being controlled by Indigenous communities, wildlife depletion accelerates due to increased hunting pressure and the establishment of new settlements along the road. Similar studies have not been carried out in the South Pacific region. However, settlements along the access road, and associated impacts on bush meat, are likely to occur over the long term.

Access provided to the local population along the road is a key issue that was discussed with local populations during mitigation workshops. Local communities indicated that the new extension of Black Post Road past Mangakiki should be controlled by local communities. However, it will not be accepted by local communities that this road be strictly prohibited to new settlements. It is also possible that some local chiefs will take advantage of the access road to sell access to logging companies to newly accessible areas. Therefore, impacts as described above are expected.

It has been decided that the TCLC will own the Core Area, including the access road from approximately Marava to the dam site. TCLC, which is a joint venture between customary landowners and government, will be subject to the terms of the lease agreement between the TCLC and the TRHDP, and will control who can access the land. Management of access as a means of mitigating impacts is presented in Section 13.2.1.4.

On-Going Habitat Fragmentation

Once the dam is in operation, the access road will be used less by heavy haul trucks. However, its presence will continue to contribute to permanent habitat fragmentation, increased human presence along the road, local population uses of forest products, land transformation into gardens, and other activities. This is particularly true in the Core Area and around the reservoir. Wildlife that is affected by the access road and the Core Area will not fully recolonize their initial habitat once the Project is in operation. Moreover, human encroachment will spread to a certain extent out into forest areas.

On-Going Feral and Invasive Species Encroachment

The permanent access road will allow for feral and invasive species to continue encroaching into new areas. Most feral animals follow human settlements. With new settlers, impacts occurring during construction will continue during operation of the Project. However, regardless of whether the Project was to proceed, or not, the feral and invasive species that currently threaten the region will continue to encroach into new areas, given enough time.

10.8.2.2.2 Mitigation Measures

The new access road will locally modify the environment and change ecological dynamics. To minimize human presence in previously undisturbed areas, it is suggested that workshops be held with local communities to raise awareness about the need for protecting the ecosystem and for applying practices aimed at the sustainable use of forest products. The TRHDP will also meet with local Chiefs to raise awareness regarding the need to sustainably use forest products, and to avoid selling access to logging companies. Raising awareness will also include discussions aimed at reducing opportunistic hunting of bats and Cuscus.

10.8.2.2.3 Residual Effects and Their Significance

During project operation, direct impacts to fauna can be mitigated by implementing measures to raise awareness of local communities and their chiefs. If these measures are put into effect, the impacts will be considered to be not significant, as most of the impacts will have already occurred as a result of project construction.

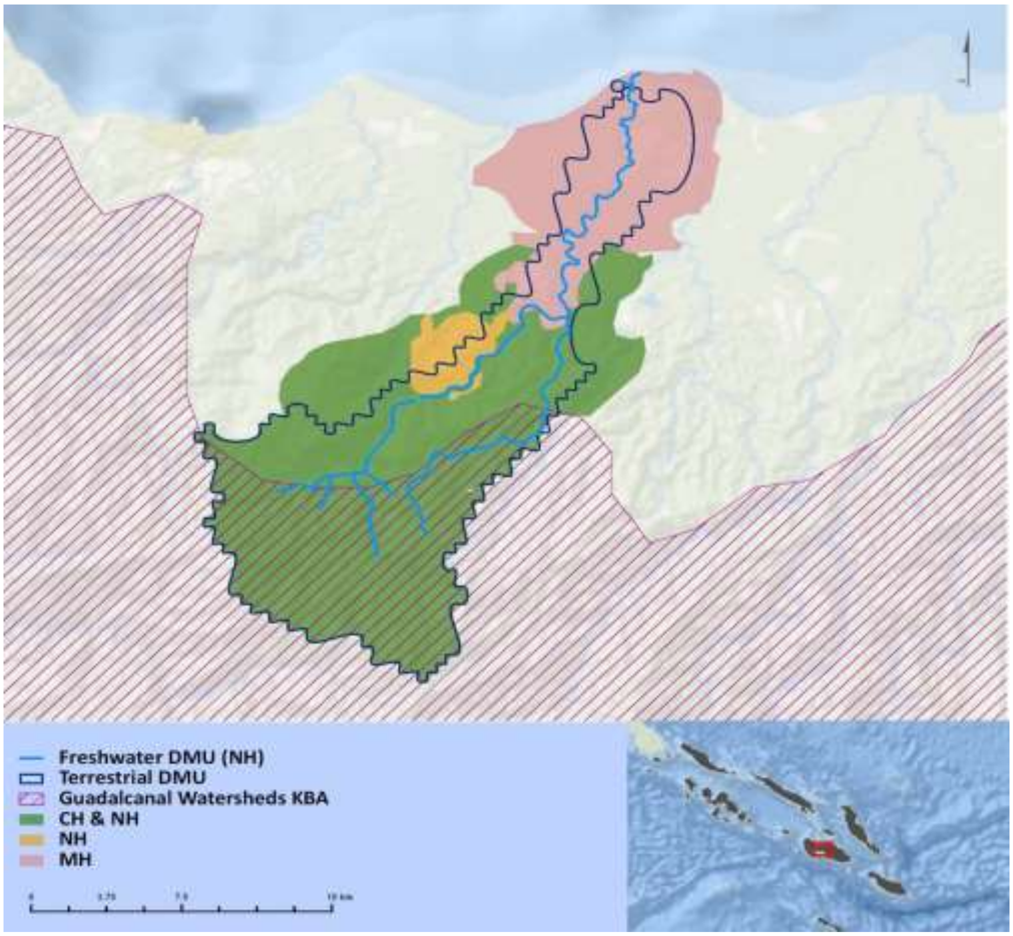
10.9 IMPACTS ON NATURAL AND CRITICAL HABITATS

10.9.1.1 Identifying Natural and Critical Habitat

Both PS 6 and SPS require assessment of whether the project is planned in an area that may qualify as critical or natural habitat. A broad terrestrial area and a relatively long freshwater area were considered, to incorporate all potential project impacts (Figure 10-3). The natural and critical habitat assessment (refer to full report at Appendix Q), based on information in the ESIA, concludes that the project is situated within a watershed containing substantial natural habitat, comprising both undisturbed and disturbed/remnant forests as well as the Tina River and its tributaries. Critical and natural habitat assessment ideally takes place across sensible ecological or political units that are sufficiently large to encompass all direct and indirect impacts from the project. These areas of assessment, referred to as 'discrete management units'

(DMUs) are thus often much broader than the direct project footprint. DMUs may be separate or combined, depending on the ecology of the biodiversity concerned.

Figure 10-3 – Map of discrete management units and areas of critical, natural and modified habitat



The species of concern in this area are freshwater fish, birds and mammals. Birds and mammals are likely to be impacted by a hydropower project in similar ways (e.g., direct terrestrial footprint, induced clearance) and so are considered together. The Tina River watershed (including the Toni) forms a relatively discrete ecological unit, and is likely to be the focus of any project-related direct and indirect impacts. This watershed was thus taken as an appropriate terrestrial DMU, covering approximately 243 km2. Given the potential for project impacts both upstream (e.g., blocked fish migrations) and downstream (e.g., owing to altered flows) of the dam, and the interconnected nature of freshwater ecosystems, the whole Tina River and its tributaries were considered together as one freshwater DMU. These two discrete management units, with mapped areas of critical, natural and modified habitat, are outlined on Figure 10-3.

Identification of these 'discrete management units' does not mean that the project has management obligations across them. The aim of this critical and natural habitat assessment is to identify whether the broad units qualify as critical habitat and, if so, for what biodiversity features. This information helps to prioritize impact assessment and to focus mitigation efforts.

Downstream from the project, large areas of modified habitat exist, owing to intensive logging and small-scale agriculture – as well as widespread incursion of invasive species. Despite some logging, the project area and surrounds have retained forest cover and basic ecological integrity, and can be considered to largely comprise natural habitat. The upper and outer watershed, upstream from the proposed dam location and further down away from the river itself, remain largely undisturbed and represent critical habitat. The freshwater area appears to have retained most of its original ecological functionality, despite extensive fishing and household use by communities, and the Tina River and its tributaries can thus be considered natural habitat.

Two restricted-range bird species (Guadalcanal Boobook and Black-headed Myzomela) and one reptile (Guadalcanal Bow-fingered Gecko) appear to qualify the Tina watershed as Critical Habitat. In addition, some threatened species might remain undetected in the area and – if present – would qualify it as critical habitat. The project should thus continue low-level monitoring for these species (King Rat and White-eyed Starling). On a precautionary basis, the project can best manage these unknown risks by acting as though the area might be critical habitat for these two species, and so ensuring that appropriate mitigation and offset measures are in place.

More broadly, as well as providing a number of important ecosystem services to local communities, natural forests in the Tina Watershed can be considered critical habitat owing to the limited global extent of this forest ecosystem type and the particularly unique nature of the species' assemblage it supports.

10.9.1.2 Assessment of Natural Habitat

Guadalcanal as a whole would originally have been largely forested. Across the lower reaches of the project discrete management unit, forest has been degraded and/or removed by logging and small-scale agriculture, and a number of invasive species are now prevalent in the area. These degraded and deforested areas in the lower Tina watershed can thus be considered modified habitat (covering 51 km2 of the DMU). These comprise the potentially-impacted ecosystems identified in the ESIA as 'garden', 'fallow brush land', 'grasslands', as well as areas of farmland and oil palm nearer the coast. Although this is a coarse classification, grasslands in lowland Melanesia are, for the most part, not natural ecosystems and are comprised largely of non-native or widespread generalist species.

Despite some degradation of forest and some incursion of invasive species – particularly in the mid-reaches and closer to the river – the majority of the discrete management unit away from the coast remains largely forested and ecologically functional. Therefore, the forests of the majority of the Tina watershed can be considered natural habitat (covering 192 km2 of the DMU). It is more challenging to assess the current level of functionality in the freshwater ecosystems. There has clearly been some level of degradation from gravel mining and fishing, as well as general household use, but it appears that these ecosystems retain the majority of their original ecological functionality and thus that the Tina River and tributaries can be considered natural habitat.

Many of the terrestrial areas of natural habitat within the DMU (covering 184 km2) are also considered critical habitat (see below), owing to the intact nature of their restricted ecosystems and the unique assemblages of species they contain, including two very restricted birds and one reptile.

10.9.1.3 Biodiversity Which May Qualify the Area as Critical Habitat

Table 10-6 summarizes the candidate critical habitat-qualifying biodiversity identified within this ESIA as actually or potentially present. In each case, reasons are identified for each biodiversity feature likely meeting or not meeting critical habitat. Two categories of biodiversity that might qualify the area as critical habitat, considered briefly here, are areas that provide key ecosystem services and areas with biodiversity that has significant social, cultural or economic importance to local communities.

Table 10-6 Triggers and qualifiers for critical habitat in Project Area

Trigger	Biodiversity/Species	Discussion	Qualification
(i) critically endangered and endangered species - only species assessed globally by IUCN are included since there is no national Red List. Species are included if they were found during surveys, or there is indication of their presence from literature.	Emperor Rat (*Uromys imperator)*	This globally Critically Endangered species is only known from northern Guadalcanal. There have been no confirmed sightings since the last specimen was collected in 1888, although local sightings reported by Flannery (1995) suggest that the species' range receded to higher mossy forest and that it persisted there until at least the early 1960s. It appears that this species was largely terrestrial, and so invasive species (e.g., predation from feral cats or disease from introduced rats) may thus have had significant impacts on the species' range and distribution. Even if the species is not yet globally Extinct, it seems unlikely that the project area continues to hold this species, given that it is partially degraded and already significantly impacted by invasive species.	Area does not qualify as critical habitat for Emperor Rat.
	White-eyed Starling (*Aplornis bruneicapillus)*	This Endangered bird occurs rarely and patchily on at least Guadalcanal, Choiseul, Rendova and Bougainville, but is very poorly-known and may occur more widely. While the species does appear to have some reliance on primary forest for nesting (in colonies in trees with high epiphyte cover), it also regularly feeds in semi- and heavily-degraded areas, where small fruit trees provide abundant food (Guy Dutson, *in litt.* 2017; Chris Filardi, pers. comm. 2017). While project surveys did not detect the species, it is not always easy to find during field surveys even when present (Chris Filardi, pers. comm. 2017), is most regularly observed nearby (at Mount Austen, around five miles from the project site), and appears to have seasonal or interannual movements which are not yet understood. There is thus potential for the species to use the project area, for example on a seasonal or periodic basis in response to fruit availability.	In the absence of any evidence of its presence, it is recommended that the area should not be considered as critical habitat for the species. It would, however, be advisable to put in place some adaptive management by implementing low-level monitoring for the species over the project lifetime, and help to protect nesting colonies should they be located in the project area.
	King Rat (*Uromys rex)*	This species is globally Endangered, and only known from a small number of records. In contrast to the Emperor Rat, this species is arboreal and thus more	Recommended that the area should not be considered as critical

Trigger	Biodiversity/Species	Discussion	Qualification
		likely to be able to resist impacts from (more terrestrial) invasive species. Although likely to prefer primary forest, it has been recorded relatively recently (in 1988) even from a patch of remnant forest close to Honiara (Flannery 1995). In 1989, two individuals were captured at 600m elevation at Gold Ridge, very close to the project. A local hunter (per Kevin Jeanes, December 2016) reported the species was last seen in the Tina catchment in the 1980s. Relatively recent records in and near the project area, and some apparent tolerance of the species to forest fragmentation and invasive species, suggest that the King Rat may still persist in the project area. The absence of records on project surveys should not be taken as evidence of the species' absence, since it is extremely difficult to survey for rare, nocturnal, arboreal rodents. The species' area of occupancy is considered to be less than 500 km^2 (Helgen *et al.* 2016). The discrete management unit includes about 192 km^2 of forest which might be considered natural habitat and thus potentially suitable for this species. On a precautionary basis, and given that the population distribution of this species is not well understood, this watershed could thus potentially be considered of significant importance to the King Rat, and the loss of the area could potentially impact the long-term survivability of the species. On such a precautionary basis, the area would qualify as critical habitat for King Rat (IFC 2012, Criterion 1d). In the absence of any evidence of its presence, however, it seems over-precautionary to treat the area as critical habitat for the species.	habitat for the species, but ***the project should act as though the area might be critical habitat for King Rat and so ensure that appropriate mitigation and offset measures are in place***.
(ii) endemic or restricted-range species - species were considered restricted-range if their global extent of occurrence was 50,000	Solomons Flying Fox (*Pteropus rayneri)*	This Near Threatened bat species has an extent of occurrence of 29,500 km^2. It is known from the project area, and occurs more widely across the Solomon Islands – as well as on Bougainville and Buka in Papua New Guinea (Hamilton & Leary 2008).	This species thus does not qualify the project area as critical habitat.

Trigger	Biodiversity/Species	Discussion	Qualification
km^2 or less (for terrestrial vertebrates) and 20,000 km2 or less (for freshwater fish). Species are included if they were found during surveys, or there is indication of their presence from literature. 'Endemism' *per se* was not considered – this can be a useful approach for species such as plants for which distributions are poorly known, but is less useful for better-known vertebrate species (many of which, in the Solomon Islands, are endemic to just several islands). Based on current knowledge, none of the plant species observed during ESIA surveys appear to have a restricted-range (the most restricted being *Palaquium firmum*, potentially endemic to the Solomon Islands, and *Syzygium onesima*, which appears to be restricted to the eastern Papua New Guinea islands and the Solomon Islands).		While this is a restricted-range species, it is still relatively widespread and the project DMU is too small in its entirety to hold 1% of the species' global population.	
	Malukuna Webbed Frog (*Cornufer malukuna)*	This species, sometimes known as *Discodeles malukuna*, is stated by Richards & Parker (2004a) as known only from the vicinity of the type locality, which lies in the upper Tina River catchment. It has since, however, been found on several islands throughout the New Georgia group and may potentially be patchily more widespread in the Solomon Islands (Scott Travers, *in litt.* 2017)	It is unlikely to qualify as a restricted-range species, or to qualify the area as critical habitat.
	Schmidt's Crocodile Skink (*Tribolonotus schmidti)*	This restricted-range species is listed as potentially present in the project area by the ESIA, based on occurrence nearby (ESIA Appendix C). It is considered very common in forest on Guadalcanal between sea level and 1,500 m (Harlow 2013), so it is surprising that it was not recorded during ESIA surveys. If it does occur in the Tina River watershed, the area may well hold more than 1% of its population or distribution (given that the watershed holds c. 180 km^2 of Natural Habitat within its elevation range, representing about 3% of the known range of the species). In the absence of any evidence of its presence, however, it is recommended that the area should not be considered as Critical Habitat for the species. In any case, the species does not face any particular threats other than habitat loss, so impacts and necessary mitigation measures would very much reflect those for the forest as a whole.	It is unclear whether this species qualifies the area as critical habitat but, even if it does so, no additional mitigation or offset measures are foreseen to be necessary
	Guadalcanal Bow-fingered Gecko (*Cyrtodactylus biordinis)*	This fairly common restricted-range species occurs only on Guadalcanal. It is known from elevations of 300-500 m, rarely lower, and mainly lives on smaller trees and vines in the understorey of forest (Allison 2013). It appears to have been recorded from the project area, on the basis of local knowledge (ESIA Appendix C). Within the project DMU, there is only about 33 km^2 of suitable habitat. Nonetheless, given the limited range of this species, this is likely to	Pending confirmation that the species does occur in the project area, ***it is quite possible that Guadalcanal Bow-fingered Gecko qualifies the Tina River watershed as critical habitat***. Pending further

Trigger	Biodiversity/Species	Discussion	Qualification
		represent more than 1% of the species' global distribution and population.	information on the distribution and ecology of this species in the project area, higher quality forest between 300-500 m elevation within the project DMU is preliminarily assessed as critical habitat for this species.
	Solomons Bent-toed Gecko (*Cyrtodactylus salamonensis)*	This Near Threatened species is stated to have an extent of occurrence of less than 10,000 km^2 (McCoy 2013), and so qualifies as a restricted-range species. It has not yet recorded from the project area, but does appear to occur nearby (ESIA Appendix C) and so may yet be found in the project area. It is a lowland species, being found in undisturbed and moderately disturbed forests up to 400 m elevation. As such, the Tina Watershed offers relatively little remaining habitat of suitable quality for this species and is unlikely to hold more than 1% of its population or distribution.	This species thus does not qualify the project area as critical habitat.
	Faro Island Treefrog (*Litoria lutea)*	This is considered a restricted-range species by Richards & Parker (2004b) and is listed as potentially present in the project area by the ESIA. It is not clear, however, that this species' extent of occurrence is <50,000 km^2, and thus whether it actually qualifies as restricted-range.	It is not considered to qualify the area as critical habitat
(ii) endemic or restricted-range species…continued	San Cristobal Treefrog (*Papurana kreffti)*	This species, sometimes known as *Hylarana kreffti*, is stated by Richards & Parker (2004c) as likely to have an extent of occurrence of <20,000 km^2. It would thus qualify as a restricted-range species. However, as well as being widespread in the Solomon Islands it is known from New Ireland and Buka in Papua New Guinea.	While it has a small overall area of occupancy, it has an extent of occurrence exceeding 50,000 km^2 and does not qualify the project area as critical habitat
	Guadalcanal Rail (*Hypotaenidia woodfordi)*	Guadalcanal Rail is a Near Threatened bird known only from Guadalcanal, with an estimated range of 6,500 km^2 (BirdLife International 2017a). It occupies grassland and thickets up to c. 600 m elevation (Dutson 2011). The project DMU contains c. 51 km^2	Seems unlikely that the DMU holds more than 1% of the species' global range or population, and thus this species does not

Trigger	Biodiversity/Species	Discussion	Qualification
		of Modified Habitat, of which a subset (and some degraded Natural Habitat) is likely to be suitable for this species.	qualify the project area as critical habitat.
	Buff-headed Coucal (*Centropus milo)*	Buff-headed Coucal has a range of almost 47,000 km^2 and also occurs on several other islands, including New Georgia, Vella Lavella and Rendova (BirdLife International 2017a). It has been observed in the project area, but the Tina Watershed as a whole is too small in comparison to the species' distribution to be likely to hold more than 1% of the population of this species.	Does not qualify the project area as critical habitat.
	Guadalcanal Boobook (*Ninox granti)*	Guadalcanal Boobook has been recently recognized as a bird species separate from *Ninox jacquinoti* (BirdLife International 2017a). It is considered Vulnerable and is known only from forests up to 1,500 m elevation on Guadalcanal (BirdLife International 2017a). It occupies grassland and thickets up to c. 600 m elevation (Dutson 2011). The project DMU contains c. 180 km^2 of forest within this elevational range, representing about 3% of the known range of this species. It thus seems quite possible that the DMU holds more than 1% of the species' global range or population.	***It is quite possible that Guadalcanal Boobook qualifies the Tina River watershed as critical habitat***. Without further information on the distribution and ecology of this species in the project area, higher quality forest within the project DMU is preliminarily assessed as critical habitat for this species.
	Black-headed Myzomela (*Myzomela melanocephala)*	This fairly common restricted-range species occurs only on Guadalcanal, including in the project area, and nearby Nggela Sule. It has a range estimated at 10,200 km^2 (BirdLife International 2017a) and occurs up to 1,550 m elevation (Dutson 2011). The project DMU contains c. 180 km^2 of forest within this elevational range, representing about 1.7% of the known range of this species.	***It is quite possible that this species qualifies the Tina River watershed as critical habitat***. Without further information on the distribution and ecology of this species in the project area, higher quality forest within the project DMU is preliminarily assessed as critical habitat for this species.

Trigger	Biodiversity/Species	Discussion	Qualification
(ii) endemic or restricted-range species…continued	Other potentially restricted-range birds	White-eyed Starling is considered a restricted-range species and has the potential to occur in the project area – dealt with under trigger (i). Another set of observed species were considered restricted-range by Stattersfield *et al.* (1998) but current information (BirdLife International 2017a) clarifies that their extents of occurrence exceed 50,000 km², and they can thus no longer be considered restricted-range.[73]	
	Restricted-range fishes	Three *Schismatogobius* (*S.* cf. *ampluvinculus*, *S.* cf. *marmoratus* and *S.* cf. *roxasi*) and three *Stiphodon* (*S.* cf. *atropurpureus*, *S.* cf. *multisquamus* and *S.* cf. *ornatus*) were found, but not conclusively identified, by ESIA surveys (R. Hevalao, *in litt.* 2017). This is understandable, given the paucity of information available to draw from in identifying freshwater fish in the Solomon Islands. The known range of the six species which these specimens resembled (e.g., *S. ampluvinculus*) suggests that these actually represent other species.. Knowledge of *Schismatogobius* taxonomy and distribution is advancing rapidly, with many new species described to science recently from the Pacific – including three that occur in the Solomon Islands (Keith *et al.* 2017). It is quite possible that some of these unidentified fishes represent species described by Keith *et al.* (2017), or described by those authors as now known from the Solomon Islands. An alternate possibility is that these represent undescribed species. Fish from	If any are identified as *Schismatogobius* or *Stiphodon* species known from the Solomon Islands, many of these are known to be restricted-range species and would be likely to qualify the Tina River and its tributaries as Critical Habitat. Any un-described fish species would inherently likely be restricted-range and thus qualify the Tina River and its tributaries as critical habitat, and represent a significant risk to the project. As such, the project should pursue accurate identification of

[73] These species comprise Sanford's Sea-eagle (*Haliaeetus sanfordi*); Red-knobbed Imperial-pigeon (*Ducula rubricera*); Crested Cuckoo-dove (*Reinwardtoena crassirostris*); Solomons Corella (*Cacatua ducorpsii*); Yellow-bibbed Lory (*Lorius chlorocercus*); Green Pygmy-parrot (*Micropsitta finschii*); Chestnut-bellied Monarch (*Monarcha castaneiventris*); Solomons Pied Monarch (*Symposiachrus barbatus*); Midget Flowerpecker (*Dicaeum aeneum*); Brown-winged Starling (*Aplonis grandis*); White-billed Crow (*Corvus woodfordi*). A further set of such species were considered potentially present in Appendix D of the ESIA: Melanesian Scrubfowl (*Megapodius eremita*); Yellow-banded Fruit-dove (*Ptilinopus solomonensis*); Pale Mountain-pigeon (*Gymnophaps solomonensis*); Cardinal Lory (*Chalcopsitta cardinalis*); Duchess Lorikeet (*Charmosyna margarethae*); West Solomons Boobook (*Ninox jacquinoti*); Solomon Cicadabird (*Edolisoma holopolium*); White-winged Fantail (*Rhipidura cockerelli).*

Trigger	Biodiversity/Species	Discussion	Qualification
		some other genera (*Apogon*, *Caranx*, *Scomberoides*, *Gerres*, *Polydactylus*, *Redigobius*, *Stenogobius*, *Lentipes* and *Sicyopus*) were not identified to species, leading to similar concerns. All of these fish species urgently need identification.	collected specimens of these fishes as soon as possible.
(iii) migratory or congregatory species	Common Sandpiper (*Actitis hypoleucos)*	This is the only species identified in the ESIA which is migratory. It is globally common and widespread, and winters regularly in the Solomon Islands. The population of the species in the project area is likely to be considerably less than 1% of the species' global population.	This species thus does not qualify the project area as critical habitat.
(iii) migratory or congregatory species…continued	Solomons Flying Fox (*Pteropus rayneri*)	This restricted-range bat species often roosts in large colonies. As assessed for trigger (ii), the project DMU is too small in its entirety to hold 1% of the species' global population.	This species thus does not qualify the project area as critical habitat.
	Admiralty Flying Fox (*Pteropus admiralitatum)*	The ESIA considers this poorly-known colonial bat species as possibly present in the project area. It may actually comprise several different species, of which one would be restricted to the islands of Western Province, Guadalcanal and Malaita. In the absence of any evidence of its presence, it is recommended that the area should not be considered as Critical Habitat for the species. Even if the species was found to be present, the species' extent of occurrence is more than 67,000 km^2.	The project area would not contain a significant enough proportion of its population to be considered critical habitat
	Geoffroy's Rousette (*Rousettus amplicaudatus)*	This colonial bat species may ultimately be found to contain more than one species (Csorba *et al.* 2008). However, as currently understood, it has a very wide range across South-East Asia and Melanesia. Given this wide distribution, the project area is very unlikely to hold more than 1% of the species' global population.	This species thus does not qualify the project area as critical habitat.
(iv) unique assemblages of species that are associated with key evolutionary processes - the Solomon Islands are notable for their high levels of bird and mammal endemism,	Solomon Islands Rainforest	Most of the project area was originally covered by forest, classified by WWF as one ecoregion, 'Solomon Islands Rainforest' (Wikramanayake *et al.* 2001). This has a small global extent (c. 36,000 km^2) and holds a particularly unique assemblage of species (e.g., 90 endemic or near-endemic bird species). The value of this ecosystem on	Solomon Islands Rainforest qualifies the project area as critical habitat

Trigger	Biodiversity/Species	Discussion	Qualification
because their fauna has a continental origin, but many of the islands – including Guadalcanal – have experienced long-term isolation owing to deep marine trenches between islands. Unique assemblages of species can often be identified by their association with 'highly threatened and/or unique ecosystems' (GN90-93). Martin *et al.* (2015) make a first, global-level assessment of which marine ecosystems might qualify as critical habitat under this criterion, and a similar effort is ongoing for terrestrial ecosystems. In the current absence of an assessment of which terrestrial ecosystems might qualify as critical habitat, it is necessary to assess whether any ecosystems in the project area might be considered 'highly threatened' or 'unique'. The most useful ecosystem classification, while imperfect, is that of the WWF eco-regions, since it has achieved global coverage and thus allows global comparison.		Guadalcanal is acknowledged by other authorities. For example, CEPF (2012) and BirdLife International (2017b) recognize the 'Guadalcanal Watersheds' area as a Key Biodiversity Area and Important Bird Area, respectively. Further, the interior forests of Guadalcanal around Mount Popomanaseu – including the upper reaches of the Tina River watershed – were proposed in 2008 by the Government of the Solomon Islands as the 'Tropical Rainforest Heritage of Solomon Islands' World Heritage Site. This ecosystem can be considered to comprise those forest types identified in the ESIA as relatively intact, namely 'undisturbed forests', 'montane forests' and 'riparian', totaling about 184 km^2 in the DMU. The riparian ecosystem is naturally more disturbed and less forested than the other two, but is included here on a precautionary basis. It is clear that actual project impacts on high quality areas of Solomon Islands Rainforest will be small (c. 32 ha of direct footprint and increased access with potential to induce additional clearance), direct project impacts on this ecosystem are not considered significant, given the small scale of project residual impacts compared to the extent of the ecosystem.	

Trigger	Biodiversity/Species	Discussion	Qualification
(v) areas having biodiversity of significant social, economic, or cultural importance to local communities (including ecosystem services)	Section 8.1.6.2 - ESIA discusses local livelihood strategies, including – relying on biodiversity – small-scale timber-milling and a fishery at mouth of the Tina River. Sections 8.1.11.5-7 – ESIA expand on local use of natural resources. Section 8.1.11 - ESIA discusses natural capital. Section 8.2.3 - ESIA discusses cultural heritage sites.	The forests of the project area and Tina Watershed are important to local communities for: · timber and non-timber materials for housing (i.e., timber, loya cane, thatch, bamboo, and bark): · game wildlife for hunting, such as wild pigs, possums, flying foxes, lizards, skinks, frogs, hornbill, pigeons, and ducks: · plants used for medicinal purposes and magic; · wild foods such as fruits, wild palm, wild yam, various nuts, and ferns, megapode eggs, and emergency foods when required; · materials for handcrafts, such as baskets; · regulation of run-off from the heavy rains that occur on Guadalcanal especially around the high mountains, and climate regulation; and · aesthetic appeal, and places for recreation and relaxation. Cultural heritage sites, appear to be site- or history-based, rather than biodiversity-based	It is clear that the forests of the Tina Watershed are important not only in their own right, but also in providing ecosystem services for local communities living in the area. However, there is little precedent for this use to qualify the area as critical natural habitat.

10.9.1.4 Impacts on Critical and Natural Habitat

Direct project impacts on the various ecosystems in the project area are summarized in Table 10-7.

Table 10-7 Estimation of direct project impacts on terrestrial critical, natural and modified habitat

Habitat type	Ecosystem	Direct impact area
Critical Habitat	Undisturbed forests	9.54
	Montane forests	0
	Riparian	21.62
Sub-total - critical habitat		***31.16***
Natural Habitat	Disturbed forests	29.65
	Remnant forests	21.87 (of which 10 ha is temporary)
	Cliffs	16.12
Sub-total - natural habitat, including critical habitat		***98.80***
Modified Habitat	Grasslands	6.09
	Garden	0
	Fallow brush land	6.40
Sub-total - modified habitat		***12.49***
Total		**111.29**

Project direct impacts on critical habitat total just over 31 ha (Table 10-7), or about 0.3% of critical habitat within the catchment. Moreover, the majority of Guadalcanal remains forested, with much of that area still in a good condition and thus representing critical habitat for similar reasons. Direct project impacts on critical habitat are thus not considered significant, and will not impair the critical habitat's high biodiversity value or ability to function. Induced project impacts present more of a risk.

The scale of indirect impacts on critical habitat are difficult to predict. As a first estimate, it is estimated that induced residual impacts on terrestrial critical habitat will be of a similar scale to direct impacts (e.g., complete loss of another 32 ha of forest; or a halving in condition of a wider area of 64 ha of forest). This estimate is likely precautionary.

Direct project impacts on undisturbed forests represent <0.2% of the extent of this forest type in the Tina catchment, with further impacts on riparian forest. Project direct impacts on Natural Habitat total almost 100 ha, or about 0.5% of natural habitat within the catchment. The majority of Guadalcanal remains forested natural habitat, with much of that area still in a good condition. Direct project impacts on natural habitat might thus not be considered significant at the scale of Guadalcanal, or even at the scale of the Tina River watershed. Nonetheless, the project is committed to achieving no net loss of natural habitat.

Two bird species were identified as qualifying forests in the Tina River watershed as critical habitat. These have the potential to be impacted by the project in similar ways, mostly related to loss and degradation of forest habitat. Induced access from the Black Post Road extension could lead to small-scale logging, degradation or fragmentation of forests. The project ESMP contains a set of good practice mitigation measures which have the potential to benefit both species, including: minimizing footprint; preventing disturbance from construction workers; preventing access along this road by non-local people; and restrictions on settlement along the road by local people. Project impacts on these species are not considered likely to differ significantly from those on forest more generally.

The Tina River and its tributaries represent natural habitat. The project is expected to result in unavoidable short-term impacts on water quality during construction and long-term impacts on flow regimes. Mitigation has been planned to avoid and minimize these impacts as much as possible, based on current information.

10.9.1.5 Offsets for Residual Impacts

The developer has committed to development of a Biodiversity Management Plan (BMP), with the objective of achieving no net loss of biodiversity as a result of natural habitat conversion. This BMP will be in place at least one month prior to the Engineering Procurement and Construction mobilizing to the field. The BMP will include an offset comprising measures to protect the remaining natural habitat in the Core Area (ESIA Appendix K) and a program to rehabilitate at least 9.5 ha of modified habitat (ESIA Section 10.7.1.1.2; ESIA Appendix P). It is proposed to rehabilitate forest in an area adjacent to an unused logging road, impacted by previous logging operations.

Direct impacts on natural habitat are likely to affect c. 100 ha, of which c. 32 ha comprise critical habitat. Given the absence of quantitative spatial estimates of the scale of indirect impacts on forest ecosystems, first estimates here are that these will be at a similar scale to direct impacts, i.e. another 100 ha of natural habitat, of which c. 32 ha comprise critical habitat. Given these preliminary assumptions, the project is assumed to result in residual impacts of c. 200 ha of natural habitat (including c. 64 ha of critical habitat). Refined estimates are presented in Table 10-8.

Assessment of project offset needs requires quantification of the scale and severity of project impacts. No significant residual impacts are currently expected for species, beyond those for which their habitat already represents a useful proxy. Offset estimates regularly use ‘extent × condition’ metrics74 (e.g., quality hectares or QH) to account for variable quality of impacted ecosystems and varying severity of impacts. A pristine or ‘benchmark’ ecosystem would be judged to be 100% quality. In general, the critical habitat areas are essentially in natural/undisturbed/pristine condition (e.g., Appendix F) and may thus – for the purposes of this exercise – be taken as a 100% benchmark condition. Appendix F and Section 6.3.5 note that many non-critical natural habitat areas of ‘disturbed’ forest in the project area have been affected by logging and only have a moderate ecological value, although they still show rich plant diversity, and rapid vegetation regeneration. For the purposes of this assessment, these are classed as of 60% condition. Some (‘remnant forest’) areas are stated to have undergone extensive disturbance, with few large remaining trees. For the purposes of this assessment, these are classed as of 30% condition.

Table 10-8 Preliminary estimation of residual impats on terrestrial criticial and natural habitat

Habitat type	**Ecosystem**	**Impact area (ha)**			**Ecosystem condition (‘quality’)**	**Impact (Quality Hectares)**
		Direct	Indirect (estimated)	Total		
Critical habitat	Undisturbed forests	9.54	9.54	19.08	100%	19.08
	Riparian	21.62	21.62	43.24	100%	43.24
Sub-total - critical habitat		***31.16***	***31.16***	***62.32***	**-**	***62.32***
	Disturbed forests	29.65	29.65	59.30	60%	35.58

[74] e.g., see Parkes *et al.* (2003) Assessing the quality of native vegetation: The ‘habitat hectares’ approach. *Ecological Management and Restoration* 4, supplement.

Natural habitat	Remnant forests	11.87[75]	11.87	23.74	30%	7.12
	Cliffs	16.12	16.12	32.24	100%	32.24
Sub-total - natural habitat, including critical habitat		***88.80***	***88.80***	***177.60***	***-***	***137.26***

ESIA Appendix K outlines the opportunity for protection of an extensive area of critical habitat in the upper watershed of the Tina River of up to 12,5000 ha. This opportunity is at a very early stage of consideration, and considerable engagement with stakeholders, in particular the customary landowners of the upper catchment, will be necessary before it is clear whether there is sufficient support to protect the area.

An offset as proposed would represent an 'averted loss' offset in which offset gains comprise the area of forest which would have been expected to have been lost in the absence of the offset action. In Solomon Islands, particularly at higher altitudes, the most likely reason for forest loss is logging. At a national level, annual deforestation rates have been estimated at about 0.2%/year (FAO 2015). Real rates are likely to be higher, but to disproportionately impact more accessible area at lower elevations nearer coasts. In the absence of any data specific to the project area, a precautionary baseline to estimate offset gains might be 0.1%/year, and that this would relate to heavy deforestation (resulting in an ecosystem of lower quality than that considered 'remnant forest' in the ESIA, assumed here to be of only 10% quality). The life of the project, and its accompanying offset, is expected to be very long-term. However, for the purposes of no net loss assessments, a reasonable timescale such as 25 years is usually taken.

An offset as proposed might thus be expected to produce 11.25 QH of gains in its first year (0.001 [deforestation rate averted] × 0.9 [quality loss averted] × 12,500 [offset area]). Over 25 years, this would equate to approximately 300 ha, more than double the necessary level to compensate for project residual impacts of c. 138 ha (Table 2, Section 4.1). Despite considerable uncertainties and major (albeit largely precautionary) assumptions, it thus appears very likely that the proposed offset model would – if successfully implemented – be sufficient to allow the project to achieve No Net Loss with regard to terrestrial impacts.

10.9.1.6 Achieving No Net Loss of Biodiversity

The Project's proposed mitigation measures will help to ensure the direct impacts of vegetation clearing are confined to the 115 ha. However, Performance Standard 6 (PS 6) and SPS policy principle 8 require that when natural habitat is degraded or converted, as 31.16 ha will be directly, and 62.31 ha will be indirectly, measures will be designed to achieve no net loss of biodiversity where feasible. With respect to the potential impacts on critical habitat, PS 6 and SPS require that net gains shall be achieved for the biodiversity values for which the habitat was designated. To achieve these outcomes, the Project will take steps to protect the upper catchment biodiversity from threats of extractive industries (see Appendix K).

The protection of the upper catchment is conceived as a staged approach reflecting the ownership of the land by indigenous customary landowners. Immediate protection measures will include actions of the TCLC and Project Company to restrict access to vehicles (including commercial logging

[75] An additional 10 ha represents temporary footprint for topsoil storage. The project plans to restore this area afterwards. It is likely that restoration will be able to restore this area to the previous low condition ('30%'), so this 10 ha is omitted from calculations here.

machinery) to the upper catchment through the Core Area, to monitor changes in forest coverage in the upper catchment, to monitor logging truck activity on existing logging roads, and to support SIG to enforce seldom used statutory restrictions on logging at elevations above 400 masl. If enforced, these restrictions would protect the vast majority of the upper catchment from the most significant biodiversity threat. This protection work will be furthered by Project Office funding for an NGO to facilitate consultations with landowners to seek support for the creation of a protected area in the upper catchment and to conduct mapping and forestry studies, towards preparation of a management plan.

In addition to upper catchment offset activities, the Project Company will implement measures including a post construction rehabilitation plan for disturbed areas, and an offset within the Core Area which will include measures to protect the remaining natural habitat in the Core Area, and to rehabilitate an area of modified habitat within the Core Area of at least 9.5 ha. These measures will be set out in the Biodiversity Management Plan (the TOR for which is provided in Appendix P).

With appropriate restrictions on access, impacts on critical habitat of deforestation and degradation from project-induced access are likely to remain low in the short-medium term. These are very unlikely to impair the critical habitat's high biodiversity value or ability to function at any meaningful scale (compared to the current extent of Solomon Islands Rainforest across the island).

Mitigation and offset measures already designed for forests are thus appropriate and sufficient to achieve no net loss for the two bird species qualifying the area as critical habitat. On a precautionary basis, the project should act as though the area might be critical habitat for King Rat and White-eyed Starling. If present, these have the potential to be impacted by the project in similar ways to the birds listed above, but also by induced increases in access leading to increased hunting or spread of invasive species which may compete with, predate or spread disease to these species. The project ESMP contains good practice mitigation measures which have the potential to benefit both species, including: preventing hunting from construction workers; preventing access along this road by non-local people; restrictions on settlement along the road by local people; and setting up an invasive species management program (see also Appendix P). It would be advisable for the BMP to include a low-level surveillance program for these species, in order that mitigation can be adapted/enhanced should the species be found in the area during the project life. Such surveillance could be achieved at low cost by, for example, developing simple posters with small rewards for anyone who finds these speciesin the area and can take project staff to see them alive.

10.9.1.7 Conclusions

The undisturbed (both lowland and montane) forests in the watershed are globally restricted as an ecosystem type and hold a particularly unique assemblage of species. This, their recognition as part of a Key Biodiversity Area, Important Bird Area and proposed World Heritage Site, and their importance in providing ecosystem services for local communities, mean that the upper and outer forests of the Tina watershed qualify as critical habitat. Two restricted-range bird species (Guadalcanal Boobook and Black-headed Myzomela) and one reptile (Guadalcanal Bow-fingered Gecko) also appear to qualify the Tina watershed as Critical Habitat.

Direct impacts on this critical habitat appear to be non-significant, given the remaining extent of high quality forest on Guadalcanal. Nonetheless, significant risks remain of induced increases in clearing of upper watershed forest. These will need to be carefully managed.

It is possible that the endangered King Rat and White-eyed Starling might also remain undetected in the area and – if present – would also qualify it as critical habitat.

Direct and indirect impacts on natural habitat are small, but not insignificant. Mitigation has been systematically identified in order to minimize impacts, but residual impacts will necessarily require offsets. A staged offset program has been proposed, in order to compensate for project residual direct and indirect impacts on terrestrial critical and natural habitat. Together with mitigation measures, the proposed offset would allow the project to achieve No Net Loss for terrestrial biodiversity.

10.10 OVERALL CONCLUSIONS REGARDING IMPACTS ON TERRESTRIAL ECOSYSTEM

The operation of the hydropower facility will not directly affect terrestrial biodiversity, which will already have been adversely affected as a result of project construction. However, there may be some indirect effects, especially on wildlife species due to the improvements of access and possible river ford crossing opportunities to new habitats on either side of the river between the dam site and powerhouse, under the low flow conditions that will prevail.

Operation of the reservoir will not impact terrestrial wildlife, since there is no known diurnal or seasonal migration of terrestrial wildlife species across the area defined for the reservoir. The reservoir will occupy a steep-sided gorge that presently acts as a natural barrier to the movement of ground dwelling wildlife, but is not pose a physical impediment to avifauna, such as birds or bats, that are able to fly from one site to the other.

Some of the potential construction impacts will continue to affect terrestrial ecosystems during operation. These impacts are related to the access road and the advantages that it will bring for local communities. The access road will allow villagers and feral animals to move into the project area placing additional pressure on natural resources and wildlife. New impacts will also arise due to the presence and operation of the dam, such as shortage of water in riparian micro-wetlands along the Tina River, which will affect both amphibians and water dependent insects. Whether the access road will be beneficial to reptiles is difficult to assess. Some species such as snakes could benefit from forest openings while smaller species might be more vulnerable to feral cats and mortality from vehicle-wildlife interactions. Grassland birds will be able to colonize areas along the access road.

Mitigation measures are limited to raising awareness of with local communities, which could help to reduce pressure on natural resources along the access road.

Table 10-9 summarizes pre-mitigation impact ratings and post-mitigation residual impact significance determinations on fauna resulting from construction and operation.

Table 10-9 Summary of impacts on fauna from construction and operation of the Project

Group of animals	Construction		Operation		Species situation with Project operation
	Impact before mitigation	Residual impact	Impact before mitigation	Residual impact	
Native Rainforest Rodents	Low and improbable	Not significant	Low	Not significant	Species could be affected by human encroachment in newly accessible montane forest areas
Bats and marsupial	Low - Moderate	Low significance	Low – Moderate	Not significant	Opportunistic hunters and new settlers will create additional pressures on mammals. Residual impact low with mitigation measures.
Forest-dependent birds	Moderate	Low significance	Moderate	Low significance	Ongoing impact of low impact with mitigation measures
River dependent birds	Low	Not significant	Low	Not significant	Operation of the dam will bring forward new impacts on river dependent birds
Grassland and ubiquitous birds	Low	Not significant	Low (positive)	Not significant	New open areas created by the access road will be colonized by grassland and ubiquist birds.

Group of animals	Construction		Operation		Species situation with Project operation
	Impact before mitigation	Residual impact	Impact before mitigation	Residual impact	
Amphibians	Low	Low significance	Low	Low significance	Cane toads will continue to colonize areas along the access road. Micro-wetlands along Tina River reach may suffer from water shortage
Reptiles	Moderate	Not significant	Neutral	Not significant	Some species will take advantage of forest openings other will suffer from ongoing feral cats predation
Wetland dependent insects	Low	Low significance	Low	Low significance	Micro-wetlands along Tina River reach may suffer from water shortage. New ATCZ habitats may arise.

11. ASSESSMENT OF IMPACTS ON THE BIOLOGICAL (AQUATIC) ENVIRONMENT

11.1 BACKGROUND

This section includes an analysis of hydrology, water quality, water use, sediment dynamics, fish and aquatic biota.

Four types of impacts can be described: direct impacts, indirect impacts, general impacts and cumulative impacts.

- Direct impacts are those that will likely accrue due to the Project footprint. These impacts are habitat-specific or species-specific and are quantifiable.
- Indirect impacts are those that will take place as a consequence of the Project but with a degree of separation both temporally and spatially. These impacts are generally non-quantifiable since their extent and intensity are hard to predict.
- General impacts are those that will take place regardless of the Project specificity (e.g., noise from traffic, habitat fragmentation, oil spills, etc.), are not site-specific, and are not quantifiable. Best management practices help to address such impacts.
- Cumulative impacts are impacts arising from the Project that may add to or aggravate existing impacts from other existing or reasonably anticipated projects in the study area. Cumulative impacts are presented in Section 14.

11.2 ASSESSMENT METHODOLOGY

Impact assessment methodology for environmental components (both aquatic and terrestrial) is presented in Annex 19 of the Annex Report. Impacts significance has been applied using a standardized method based on the integration of the following steps:

- Identification of impact sources - the first step of the impact assessment is to determine which activities will have an impact on environmental components. This identification is done using an impact matrix.
- assessment of impacts using the criteria of impact duration, extent, magnitude / intensity, and probability of occurrence;
- application of mitigation measures; and
- determination of post-mitigation residual effects and significance, the latter being determined to be either Not Significant, or Significant.

Where a residual effect is deemed to be Significant, it falls to decision makers within government to determine whether the need for the project outweighs the concerns for potential, non-mitigable, significant impacts.

11.3 ACTIVITIES AFFECTING THE AQUATIC ENVIRONMENT

Activities that may affect the aquatic environment are, in most cases, the same as those described for terrestrial ecosystems in Section 10. However, the following additional activities related to operation of the dam and powerhouse will generate specific impacts on the aquatic environment:

11.3.1 Operation of the Headrace Tunnel

11.3.1.1 Reduced flows in the bypassed river section

The potential effects of hydroelectric dam developments are mostly related to the change in flows. Where there are large flow reductions, an environmental flow will usually be provided to prevent or mitigate potential detrimental effects of low or zero flow.

For the Tina River Hydropower Development Project, environmental flows will be required for the river reach between the dam and tailrace and downstream of the tailrace. The magnitude of the environmental flow will be the flow that provides an adequate amount of suitable habitat for the fish species in the river, as determined from an instream habitat survey and information of habitat use by the various fish species. No vulnerable or endangered species are anticipated to be present in the reduced flow section of river.

The necessary information on habitat use is gathered from a field survey to determine the relative densities of fish in the various habitats, depths and velocities present in the Tina River, in the vicinity of the tailrace. The instream habitat analysis uses a hydraulic model based on cross-sections surveyed in each of the habitat types, and habitat suitability models for the various species, as well as fish density and species richness. The model predicts how habitat suitability for the various species varies with flow.

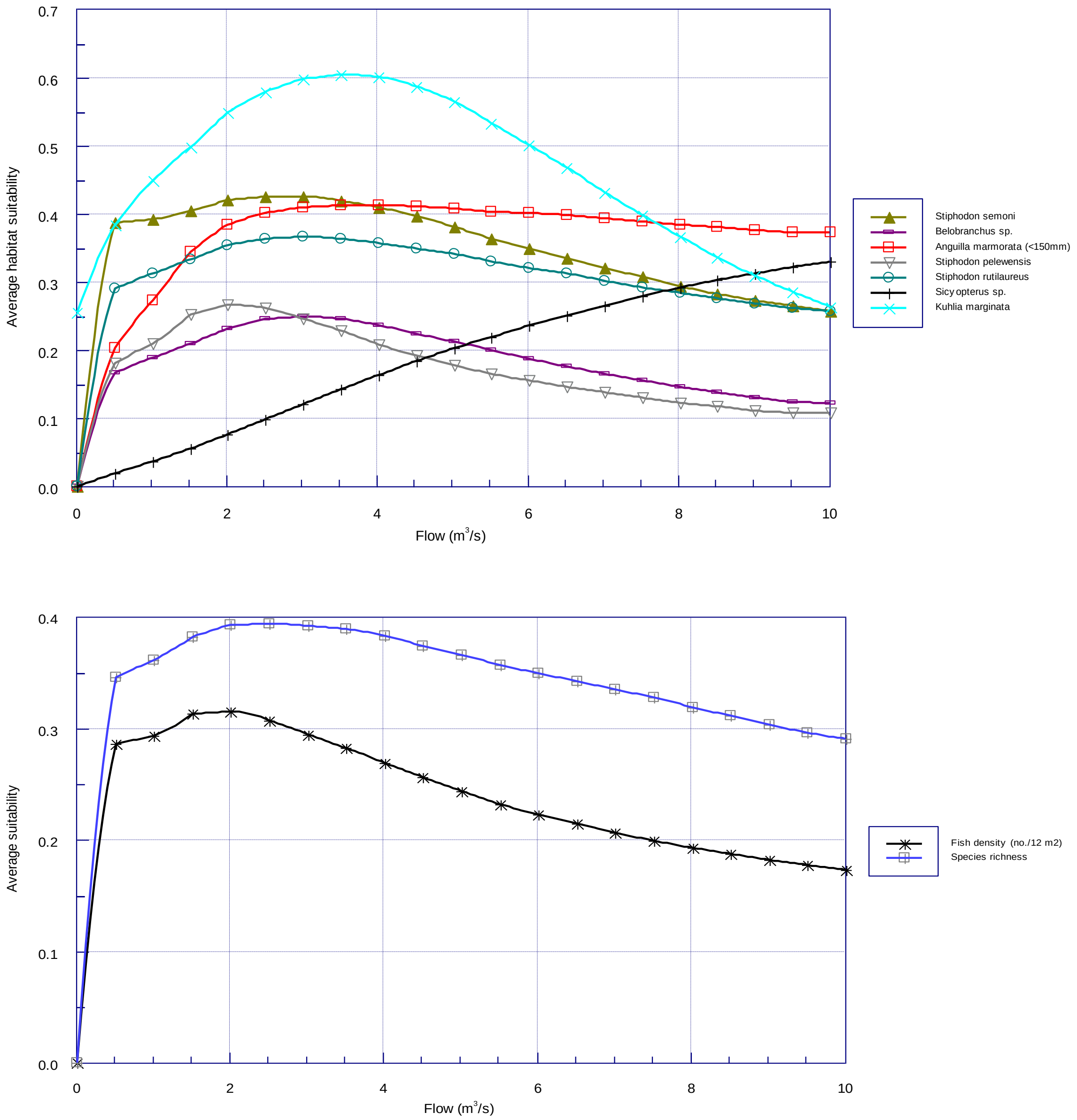
A reduction in flow from the median flow of 11.1 m^3/s to an environmental flow of 1 m^3/s between the dam and the powerhouse reduces the water surface width by 27%, the average depth by 41%, and the average velocity by 68% (Table 11-1).

Table 11-1 Predicted variation of water surface width, average depth and width weighted average velocity with flow in the Tina River between the dam and powerhouse

Flow (m^3/s)	**Width (m)**	**Depth (m)**	**Velocity (m/s)**
1	18.0	0.36	0.23
2	20.1	0.40	0.29
3	21.0	0.44	0.35
4	21.4	0.47	0.42
5	21.8	0.50	0.47
6	22.3	0.53	0.52
7	22.7	0.55	0.57
8	23.1	0.57	0.61
9	23.5	0.58	0.65
10	23.9	0.60	0.69
11	24.6	0.60	0.72

The analysis of habitat variation with flow suggested that a flow of 2-4 m^3/s would provide maximum habitat for most of the common species, fish density and species richness. Figure 11-1 shows the variation in average habitat suitability with flow for the 8 common fish species (upper) and for fish density and diversity (lower) in the reach between the dam and powerhouse. However, for the species that live in very swift water (*Sicyopterus cyanocephalus* and *S. lagocephalus*), habitat suitability is greatest at flows greater than 10 m^3/s.

Figure 11-1 Variation in average habitat suitabiliy



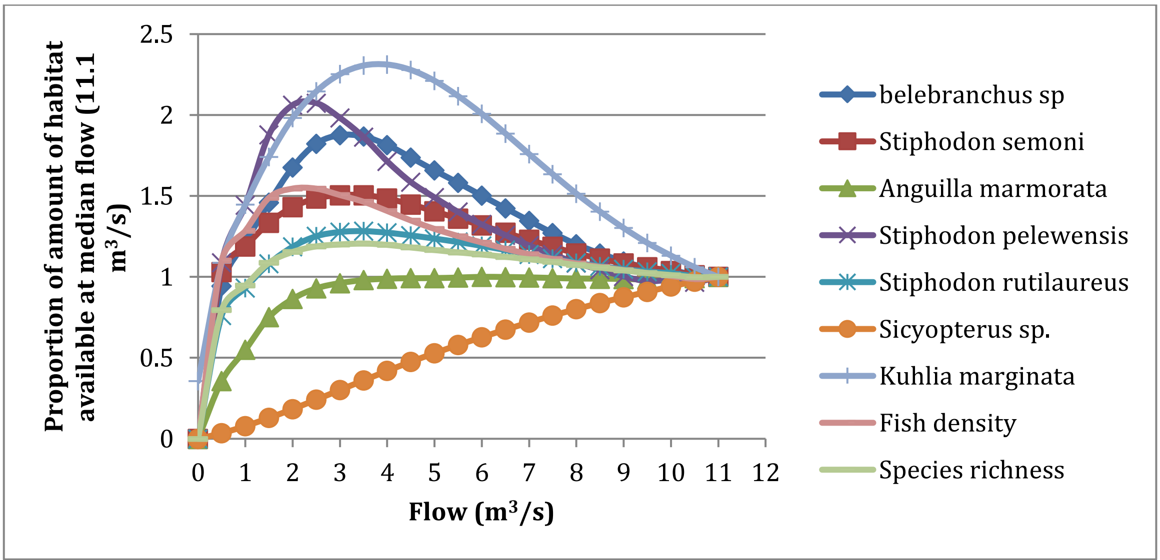
The standard of environmental protection provided by an environmental flow can be assessed by comparing the amount of habitat (m^2/m of river length) at the environmental flow with the amount of habitat at median flow.

A flow of 1 m^3/s would provide more habitat than is available at median flow for *Stiphodon semoni*, *Belobranchus* sp., *Stiphodon pelewensis* and *Kuhlia marginata* and a similar amount for *Stiphodon rutilaureus* (Figure 11-2). The only species showing significant decrease in modelled habitat availability are those in the Stiphodon genus which prefers higher flow conditions. While reduced habitat availability is probable at the environmental flow rate, population maintenance at reduced density is expected. The Stipohodon species identified in Tina River are widespread through the Western Pacific region from the Phillipines through New Guinea and the Bismarck Archipelgo, and do not have an endemic or endangered status.

Overall, fish density and species richness are likely to be greater with a flow of 1m^3/s than with the median flow of 11.1 m^3/s. The estimated fish density at an environmental flow of 1 m^3/s is approximately 50 fish per 12 m^2. This is slightly less than the average of 60.4 fish/12m^2 observed in the Toni River and considerably higher than the 6.7 fish/12m^2 observed in the Tina River. Similarly, the estimated number of species per quadrat with an environmental flow of 1m^3/s was 2.1 compared to the observation of 2.61 and 1.17 in the Toni and Tina rivers, respectively.

As illustrated in the second part of Figure 11-1, composite measures of species richness and density at the environmental flow level are modeled to be higher than at median flow levels. Species richness is expected to be 1.2 times higher than median flow, and species density to be 1.7 times higher.

Figure 11-2 Variation in habitat availability at median flow of 11.1 m3/s



At present, a large amount of sediment is transported through the steep, relatively narrow section of river between the dam and powerhouse sites. The movement of sediment during floods and in the deeper swifter areas of the river at normal flows reduces algal growth, benthic invertebrate production and fish habitat. The creation of a dam will prevent much of this sediment movement and will gradually coarsen the substrate. This will improve the fish habitat considerably, as the habitat observations showed a clear preference for coarse substrate and avoidance of deep swift water where sand was being transported along the riverbed.

The selection of an environmental flow depends on the balance between environmental effects and loss of generation, and the relative values placed on the environment and generation. Based on the available data, the amount of habitat provided by a 1 m^3/s environmental flow is similar to the amount of habitat at a median flow of 11.1 m^3/s for most of the common fish species. Predicted overall fish density should be higher than at present and should be similar to that in the Toni River. A 1 m^3/s flow would provide for fish passage and would maintain pool habitat for the pool dwelling species and good riffle habitat for the riffle dwelling species that comprise the majority of fish in the river. In addition, there would be an improvement in habitat quality resulting from a reduction in the amount of fine gravel and sand in the river channel.

The gradient of the Tina River between the tailrace and its confluence with the Toni River is less than the gradient between the dam and tailrace. Environmental flow requirements tend to increase as the gradient decreases, so that the flow requirement downstream of the tailrace would be higher than the flow requirement upstream of the tailrace. The critical period will be the off-peak hours in the evening, when the reservoir will be refilling. The recommendation is to maintain a discharge through the power house or dam during that period at least equal to what is needed to operate one turbine at minimum capacity, i.e., 2.43 m^3/s (which is desirable for other reasons discussed below). When added to the environmental flow of 1 m^3/s and the varying amounts of inflow from the tributaries between dam and powerhouse, this would result in a minimum flow downstream of between 3.43 and 4.43 m^3/s.

Entura (2015b) estimated that with a 1 m^3/s environmental flow, potential long-term generation (powerhouse plus generator on environmental flow, less transmission losses) would be about 80.6 Gwh/a with 3 turbine/generator units compared to this report's estimate of 81.8 GWh/a (i.e., 83 Gwh/a less 1.2 Gwh/a transmission loss). The current design proposal does not include a generator on the environmental flow.

11.3.1.2 Disturbance of amenity values in the reduced flow section of the river

The reduction in mean flows in the Tina River between the dam and powerhouse tailrace will alter the channel size and form throughout this section. This together with changes in flow patterns will lead to a modification in the littoral zone and river bed associated wetted vegetation areas. These modifications will disturb existing amenity values of the river, which derive from its availability to provide access to water collection, recreational and clothes washing opportunities.

11.3.2 Operation of the Dam and Powerhouse

11.3.2.1 Changes in hydrology – Variability of flows

The river between the dam and powerhouse requires some flow variability, particularly for floods and freshets. The maximum capacity of the powerhouse and the amount of storage in the reservoir are not large compared to the flow in the river, and the sizes of floods and freshets. Thus, it is likely that there will be frequent periods of spill between the dam and tailrace. Simulation of the hydro operation indicated that floods or freshets would occur on average every 6 weeks, and their average duration would be between 4 to 6 days. This frequency is probably sufficient to prevent prolific periphyton (algae attached to substrate) accumulation in this low nutrient river.

11.3.2.2 Changes in hydrology – Hydro-peaking

Large scale hydro-peaking can severely affect fish and benthic invertebrates. During the dry season, the intention is to generate electricity at full discharge during the day and reduce to zero power station discharge during the night, leaving only the environmental flow in the river. This means that the flows could fluctuate between 18 m^3/s and the environmental flow on an almost daily basis. The maximum flow from the generators is relatively low compared to the magnitude of floods and freshes during the wet season, so that it is unlikely that fish habitat will be affected by hydro-peaking. Nonetheless, impacts remain a possibility given the very limited current understanding of fish habitat use at different times of year. Depending on the mobility of the species, there is the possibility of fish stranding and a reduction in benthic invertebrate and periphyton abundance. A reduction in periphyton or benthic invertebrates (as long as within natural variation) is unlikely to affect fish, because there is no evidence of a reduction in species richness during the wet season when there are frequent floods and freshets that reduce periphyton and benthic invertebrate abundance.

Local people make considerable use of the river, and sudden increases in water level can endanger people if they are caught in the river bed. Usually, a rate of rise of 0.3 m per hour is considered safe. Safe rates of change in flow were calculated from data collected at a wide riffle at the powerhouse tailrace site during the instream habitat survey. Water levels at this cross-section were measured at flows of 8.7 m^3/s and 19.7 m^3/s and a rating curve (relationship between water level and discharge) was developed. This indicated that a flow change from minimum generation (2.4 m^3/s) to maximum generation (18 m^3/s) will increase the water level by about 0.38 m. This is likely to be conservative since much of the river downstream of the tailrace is less confined than at the powerhouse tailrace location. Thus, it might be advisable to ramp up generation from minimum to maximum load over a period of 1 to 1.5 hours.

Sudden reductions in water level can strand fish. Therefore, it is recommended that an adaptive management approach be taken to determining whether ramping flows are needed to mitigate potential fish stranding. This would involve carrying out studies during initial operation to determine whether fish are stranded on sudden reductions in flow. If necessary, the rate at which flow is reduced (i.e., flow ramping) could then be decreased to see if that prevents stranding.

Maintaining the minimum flow downstream of the powerhouse of 3.43 m3/s, as recommended to preserve aquatic habitat, would also reduce the magnitude of fluctuations in flow and thus the risk to river users and the likelihood of fish stranding and interference with downstream water uses.

11.3.2.3 Reservoir establishment - Change from riverine to lacustrine (lake) habitat

The creation of the reservoir will replace about 2.6 km of riverine habitat with a reservoir (Entura 2014). The average width of the reservoir would be about 118 m at a FSL of 175 m amsl. There are very few lakes on Guadalcanal, so it is not known what riverine fish species will take up residence in the newly formed lake with its lacustrine environment. Non-native fish species could be introduced into the lake, but this should be avoided if possible because of potential effects on native species..

11.3.2.3.1 Sediment in the reservoir

The reservoir volume up to the invert of the sediment scour outlet (155m) is 2344x10^3 m^3, and 6900x10^3 m^3 up to Full Supply Level (175 m). Entura (2014) estimated that the annual suspended sediment load would be about 500 t/km^2/year, which would deposit about 45000 m^3/year of sediment in the reservoir. They estimate that it would take approximately 65 years before it became necessary to flush deposited sediment from around the power station intake.

11.3.2.3.2 Changes in downstream sediment dynamics

The dam will trap all bed load sediment (sand and coarser material) and a proportion of suspended sediment, and reduce the amount of bed load in the river downstream of the dam. This will result in a coarsening of the substrate within the river downstream of the dam, as reduced sediment input, combined with high flows that wash the sand and fine gravel component from the substrate, will leave coarser gravels and cobbles. An increase in the amount of coarse substrate will improve habitat for eels, gobies and benthic invertebrates that live around and under coarse substrates. In addition, the reduction in sand supply would tend to deepen pools and improve habitat for the pool dwelling species like kuhlia and grunters. Any effect of sediment removed by the reservoir will gradually reduce with distance downstream, as sediment is entrained from the sands and gravels on existing river banks and introduced from tributaries.

Observations downstream of New Zealand hydro dams on gravel bed rivers (Waitaki, Clutha) indicate that the riverbed will not degrade (erode) to any noticeable degree because the surface will be armoured by cobbles and larger gravels once the surface fines are removed.

11.3.2.3.3 Water quality

Because there is little diurnal and seasonal temperature variation and little wind mixing, tropical reservoirs often become stratified (Barrow 1988) and there is a risk that dissolved oxygen concentration is reduced in the lower layers (hypolimnion). Shallow lakes with high inflow are least at risk of stratification.

The residence time of the proposed reservoir when full is approximately 7 days at median flow of 11.1 m^3/s and the average flow depth is approximately 10 m (Entura 2014). Entura's analysis (see Table 11-11 in Section 11.4.4) indicates the potential for stratification. However, relationships between temperature differential thermal (stratification) and residence time (Jorgenson et al. 2005) show virtually no thermal stratification in a reservoir with a residence time of 7 days. Some stratification may occur, and a hypolimnion with a low dissolved oxygen concentration may develop. However, with the reservoir bottom at 122 masl and full supply level at 175 masl, it is unlikely that the hypolimnion would extend upward to 162.5 masl, the level from which water is withdrawn for the turbines and the environmental outlet. Consequently, the discharge of surface water from the reservoir through the spillway, tailrace and environmental flow outlet is unlikely to cause any measurable change in dissolved oxygen downstream because these withdrawals are all from what would be the epilimnion in a stratified lake. The Reservoir Management Plan will include monitoring of dissolved oxygen and temperature at multiple depths to provide advance warning of potential water quality problems.

11.3.2.3.3.1 Water temperature

As water flows down a river, it is heated by solar radiation and cooled by evaporation until a thermal equilibrium is reached. If the amount of shade and radiation or ambient air temperatures changes, the water temperature adjusts towards thermal equilibrium. Usually, this will mean that water temperature will increase in a downstream direction.

In the Tina River during the rainy season, measured spot temperatures increased from 24.5°C at the Tina Village to 32.0°C at the Ngalimbiu River Bridge. The Toni River flows into the Tina River just downstream of Tina Village. Water temperatures in the Toni River were 28.4 to 29.4°C so that the Ngalimbiu River water temperature downstream of the Tina/Toni confluence was 26.4 to 27.2°C.

Water temperatures were also measured in the Toni River and in the Tina River between the Toni River confluence and approximately 1.5 km below the dam site over the period 11-15 July 2016. There was no rain over the period 11-15 July 2016. The daily maximum water temperature was 26°C at all sites over the 5 days. The daily minimum temperature was 23°C indicating diurnal variation of about 3°C. The lack of any downstream increase in temperature and the similarity of the water temperatures in the Toni and Tina rivers suggest that the water temperature was in equilibrium and therefore a change in flow would have minimal effect on daily mean water temperature.

The formation of a reservoir will generally alter the seasonal thermal characteristics of the river immediately downstream of the outlet. Since the thermal capacity of a reservoir is greater than that of a river, the reservoir tends to store heat resulting in smaller daily temperature fluctuations, lower summer temperatures, and higher winter temperatures. However, there is little variation in the annual air temperature in the Solomon Islands, so seasonal variation in water temperature is unlikely. Measurements in other lakes suggest that the reservoir water temperature is likely to be less than 28 °C (pers. comm., Robson Hevalao).

A reduction in flow generally does not change the daily mean water temperature significantly, but it does increase the daily maximum and decrease the daily minimum temperature. However, during the wet season at least, water velocities are high and river water temperatures may be below the equilibrium temperature, so that a reduction in flow would certainly increase the daily maximum water temperature and may increase the daily average water temperature in the river between the dam and powerhouse. With a flow of 1 m^3/s in the river between the dam and powerhouse, water temperatures are likely to be similar to those in the Toni River. The fish community in the Toni River is similar to, or better than, that in the Tina River. Thus, an increase in water temperature in the Tina River is unlikely to have any effect on its fish community.

11.3.2.3.4 Fish passage

The dam will create a barrier to the passage of migratory fish species to the catchment upstream of the dam. It is possible to provide fish passage past the dam for most species. The options include a natural stream fish pass (if there is sufficient space), or a trap and haul system. These systems are used in New Zealand for a variety of climbing species and in UK, France, and the US for eels (Paterson & Boubee 2010, Solomon & Beach 2004). Fish pass systems developed in Europe and North America for salmonids and similar species are expensive, difficult to modify and will not necessarily suit the Tina River species. The 5 m operating range of the reservoir would necessitate a complicated system of hydraulic structures at the upstream end of a conventional fish pass to maintain a constant flow under the range of reservoir levels. Details of trap-and-Haul system will be covered in the Biodiversity management plan.

11.3.2.3.4.1 <u>Upstream passage</u>

Because of their climbing ability, it is relatively easy to provide effective upstream passage for gobies and eels using either a natural stream channel[76] pass, or trap and haul system. It is likely that a trap and haul system will be the least costly, most adaptable and most practical option for fish passage. A simplified diagram of the trap is shown in Figure 11-4. A photo of a ramp and trap components of a trap-and-haul system for climbing fish is shown in Figure 11-3. Fish from the trap can and should be released in or upstream of the reservoir at a location that will avoid the possibility of fish being entrained by spillway or power station flows. The ramp allows migratory fish to climb to the trap, where they remain until transferred to an upstream location.

One advantage of a trap and haul system is that fish caught in the trap can be identified and counted before they are transferred to areas upstream of the dam. Thus, a trap system will provide very

[76] A gravel/cobble channel similar to a riffle which would zig-zag up the dam face or abutments with resting pools at the changes of direction.

useful monitoring data on the state of the goby and eel populations which is very difficult, if not impossible to obtain by other means.

Neither a trap-and-haul system, or natural fish pass, is likely to provide passage for *Kuhlia* and grunters, both of which are a swimming species. *Kuhlia* appear to be reluctant to use fish passes (Lewis & Hogan 1987). However, if *Kuhlia* and/or grunters accumulate at either the powerhouse tailrace or the base of the dam, it will be possible to net them and transfer them to a more suitable environment such as the Toni River or upstream Tina River. This is considered to be another variant of the trap-and-haul system. Transfer to the Toni River would be preferable because some mortality would occur when the adult fish migrate from the upper Tina River to the estuary area to spawn.

Figure 11-3 Photo of ramp and trap at dam

Figure 11-4 Principle of Trap and Haul system

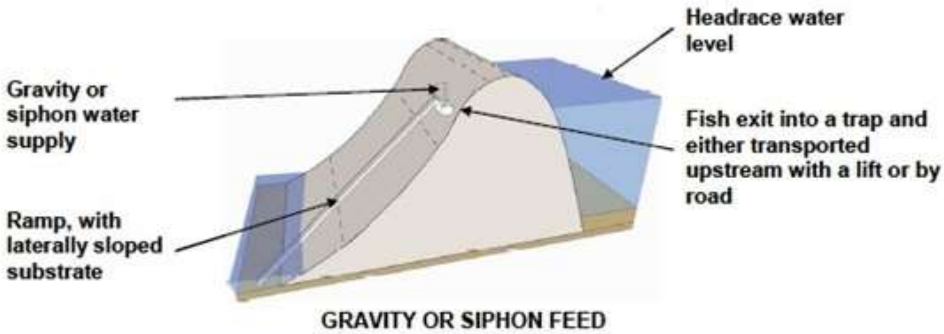


Figure 11-5 An example of Trap and Haul system

Figure 11-3 shows the trap system with ramp leading to a holding tank and piped water supply installed at Waitaki Dam, New Zealand. The ramp can be lined with bristles, gravel or a drainage product called Miradrain or Cordrain (Patterson & Boubee 2010). The optimum slope is about 15 degrees.

While bristles appear to best for eels, gravel or drainage products suit both gobies and eels. New Zealand traps have been used to collect eels, galaxiids, redfin bully (*Gobiomorphus huttoni*) and to a lesser degree torrentfish (*Cheimarrichthys fosteri*). The ramp should also have a transverse slope to provide deep water on one side and shallow water on the other to provide a choice of velocities and depths for the fish that move up the ramp. The climbing abilities and modes of locomotion of these New Zealand species are the same as those used by crawling and climbing species in the Solomon Islands, as described in the ESIA.

11.3.2.3.4.2 Downstream passage

Gobies spawn on substrate in the area in which they live. When the eggs hatch the larvae are carried passively downstream. It is not clear whether goby spawning is seasonal, or occurs all through the year. It is possible that spawning seasonality varies between species. Larval fish return to the estuary during the dry season and this indicates that spawning and downstream migration takes place early in the wet season. Thus, it is likely that hatching and downstream movement occurs during floods and freshets with the high flows ensuring rapid and safe transport to the sea. If so, the dam may be spilling and larval fish will pass over the spillway. Although there are very few studies of larval survival through turbines, it is well known that the length of fish is the primary determinant of survival (e.g., Larinier and Travade 2002) and with larval fish potential mortality caused by striking the turbine blades or wicket gates will be low. Morris et al. (1985) describe quantitative data on entrainment mortalities that were gathered at the Ludington Hydro Plant on Lake Michigan, which has a head of 110m. Survival tests on 9 species of larval fishes indicated that passage through the Ludington turbines decreased survival rates by an average of 15%. Large smelt larvae (15-42 mm) experienced much greater mortality than did smaller (<15 mm) smelt larvae. Some larvae were apparently robust and seemed to survive turbine passage (i.e., ninespine stickleback, lake whitefish, turbot larvae). Goby larvae are small (<10mm) and there is unlikely to be significant mortality through the turbines.

Although the gobies in the Solomon Islands are generally considered diadromous, large numbers of 10 mm gobies were observed in the shallow low velocity margins of the river between the dam and power house sites on 11-15 July 2016. It is unlikely that fish of this size have the swimming ability to make the 25 km journey from the sea and this suggests that these fish are rearing in the river rather than the sea. Shallow low velocity margins are the type of rearing habitat used by non-diadromous bullies in New Zealand.

Adult eels migrate to the sea at the beginning of the wet season. They are likely to migrate on the first fresh so that the deeper swift flowing water facilitates their passage to the sea, similar to the migration of New Zealand eels. The mortality of adult eels through turbines is significant, and screens should be installed at the intake. Releases over the spillway during high flow could be timed to facilitate eel passage downstream.

11.4 Impact Assessment

11.4.1 Impact identification Matrix

Table 11-2 identifies potential impacts on the aquatic environment.

Table 11-2 Potential impacts on the aquatic environment

	Potential impact causing activities	**Impacts on hydrology and sediment dynamics**	**Impacts on water quality**	**Impacts on aquatic life**	**Impacts on water uses**
Pre-Construction and construction	Pre-construction site investigations (hydrological, topographical, geological, geotechnical surveys)	Increase in suspended solids and siltation	River pollution (oil, explosive residues)	Disturbance of aquatic habitats and aquatic life	Disturbance of water uses
	Access road construction	Increase in suspended solids and siltation		Disturbance of aquatic habitats and aquatic life	Disturbance of water uses
	Site clearing (access road, dam and powerhouse sites, quarries, transmission line, work areas)	Increase in suspended solids and siltation		Disturbance of aquatic habitats and aquatic life	Disturbance of water uses
	Traffic movements (heavy haul trucks, heavy machinery, light duty vehicles) crossing the river	Increase in suspended solids and siltation		Disturbance of aquatic habitats and aquatic life	Disturbance of water uses
	Construction/dewatering of the coffer dams and diversion tunnel	Increase in suspended solids and siltation	River pollution (cement leachate, explosive residues)	Disturbance of aquatic habitats and aquatic life	Disturbance of water uses
	Excavation of the river bed and construction of dam foundations	Increase in suspended solids and siltation	River pollution (cement leachate)	Disturbance of aquatic habitats and aquatic life	Disturbance of water uses
	Mining quarries in/near the river bed	Increase in suspended solids and siltation		Disturbance of aquatic habitats and aquatic life	Disturbance of water uses

	Potential impact causing activities	Impacts on hydrology and sediment dynamics	Impacts on water quality	Impacts on aquatic life	Impacts on water uses
	Construction of RCC dam and powerhouse	Increase in suspended solids and siltation	River pollution (cement leachate)	Disturbance of aquatic habitats and aquatic life	Disturbance of water uses
	Construction of off-site facilities (work areas, transmission line)	Increase in suspended solids and siltation			Disturbance of water uses
	On-site maintenance and work areas		River pollution (oil and other hazardous substances)	Over-fishing	Disturbance of water uses
	Reservoir preparation (clearing)	Increase in suspended solids and siltation			Disturbance of water uses
	Reservoir filling	Temporary dewatering of the river downstream of the dam		Disturbance of aquatic habitats and aquatic life	Disturbance of water uses
Operation	Operation of the dam & powerhouse	Reservoir establishment – change from riverine to lacustrine environment Sedimentation - in the reservoir Changes in hydrology - variability of flows Changes in sediment dynamics downstream	Reservoir stratification	Establishment of a lake ecosystem Barrier to migratory fish species Disturbance of aquatic habitats and aquatic life	Disturbance of water uses
	Operation of the headrace tunnel	Reduced flow in the by-passed river section		Degradation of aquatic habitats	Disturbance of water uses

	Potential impact causing activities	Impacts on hydrology and sediment dynamics	Impacts on water quality	Impacts on aquatic life	Impacts on water uses
		Disturbance of amenity values in the reduced flow section of the river		Barrier to migratory species	

11.4.2 Impact Assessment Limitations

Assessment of impacts on the aquatic ecology of the Tina River is constrained by the limited availability of bibliographical data available for Solomon Islands freshwater ecologyand other sources of information dealing with species migratory behaviour and habitat requirements.

11.4.3 Construction Impacts on Aquatic Environment

This section identifies potential construction related impacts on the aquatic environment during construction. Proposes mitigation measures and discusses residual effects and their significance.

11.4.3.1 Increase in Suspended Solids and Siltation

Field observations conducted in August 2013 on the Tina/Ngalimbiu River indicated that low concentrations of suspended solids except following periods of heavy rain. In the upper reach of the Tina River, the water was fully transparent (< 1NTU). In the lower reach (e.g., where the Tina becomes the Ngalimbiu River), it appeared slightly turbid (5NTU to 9NTU), with 5NTU being regarded as the perception threshold. The maximum value during the dry season was observed at the mouth of the river (12.8 NTU). However, peaks in turbidity are known to occur after heavy rains and after cyclones. No turbidity or TSS data was available for immediate post cyclone conditions. However, they are likely to be similar to turbidity levels observed during the rainy season when it was 16.1NTU at Tina village (Tina River), 8.69NTU to 15.5NTU at Ngalimbiu River, and 15.3NTU to 18.4NTU at the mouth of the Ngalimbiu River.

11.4.3.1.1 Impact Identification and Rating

During construction, increased TSS concentration (both base values and peaks) occurs due to: (i) re-suspension of fine streambed sediments due to activities within the river (e.g., gravel extraction from borrow sites located within the river, vehicles crossing through the river, construction works for diversion cofferdams and the diversion tunnel, dam foundations, intake gallery, power-plant, and tailrace); (ii) increased load of soil and organic particles following heavy rains, from runoff and erosion in clearing and earthwork areas (construction work for access road, dam and supporting site facilities, reservoir vegetation clearing); and (iii) dewatering operations during headrace tunnel construction due to intersected water seeps within the rock. The tunnel drainage will contain crushed rock materials.

The increase in turbidity is likely to temporary affect the river far downstream of the dam area. Increased suspended matter will cause significant deposit of fine particles (silting) of the streambed and banks in sections of slow velocity downstream of the dam.

Impacts on aquatic life and water users downstream of the dam are considered to be moderate, since construction impacts will most likely persist only for the short 3-year construction period. Table 11-3 summarises the impact significance rating for suspended sediments on the aquatic ecosystem and water uses.

Table 11-3 Suspended sediment impacts on aquatic ecosystem and water uses during construction

	Impact Significance Rating				
Component value	Magnitude	Extent	Duration	Probability	Overall Rating
Moderate to high	Major	Localised – dam to river mouth	Temporary (3 years)	Moderate	Moderate

11.4.3.1.2 Mitigation Measures

Unfortunately, increased suspended sediment load, as measured by TSS is an unavoidable impact, since most construction work will take place within or adjacent to the river. However, it can be mitigated by implementing best environmental management practices (BEMPs) during construction especially on terrestrial areas. BEMPs for controlling the introduction of sediment into the river include plans for the following (see Section 13 – ESMP):

- Reservoir preparation;
- Point source pollution management, including concrete work;
- Spoil soil management during earthwork;
- Forest clearance practices;
- Stream crossing practices;
- Drainage and erosion control;

11.4.3.1.3 Residual Effects and Their Significance

Notwithstanding that BEMPs will be applied to control sediment entering into the river, moderate residual impacts will continue following application of mitigation measures, since most suspended solids, as measured by TSS, will originate from sources that cannot be fully mitigated. However, due to the effects of heavy rainfall within the catchment and the flashy nature of the Tina River, including tributary streams that enter the Tina River downstream of the damsite, sedimentation will be somewhat masked by the natural situation, as long as best efforts to employ BEMPs are made to prevent soil eroded from the project site from entering the Tina River. Overall, the residual effect is considered to be not significant.

11.4.3.2 River Pollution

Pre-project physico-chemical and bacteriological water quality is considered to be: (i) excellent in the vicinity of the damsite as human activities are almost non-existent here and upstream into the upper catchment (e.g., due to there being no habitation, only selective harvesting of trees in the last 10 years, and no gold placer or bedrock mining); and (ii) slightly degraded downstream, due to community activities (e.g., domestic uses of the river, domestic waste waters, gardening, pig rearing).

11.4.3.2.1 Impact Identification and Rating

Construction works will represent an important additional source of potential river pollution originating from different activities, including: (i) loss of cement leachate from the pug mill, concrete batch plant, and concrete pours on the RCC dam, head race tunnel and powerhouse; (ii) risk of fuel / oil spills and spills of other hazardous substances, and release of explosive residues from blasting; and (iii) release of waste waters from worker cafeteria and toilets (175 staff) and from potential increased population in the nearby villages.

Impact significance is considered to be potentially major in the Tina River downstream of the construction site for a distance of approximately 9km by river. Impacts are likely to be less significant in the Ngalimbiu River, after being diluted with the discharge of the Toni River. The risk of river pollution will last throughout the construction phase, approximately for 3 years.

Overall impact significance is considered to be moderate, as river pollution is considered a potential risk rather than a confirmed impact. Table 11-4 summarises the impact significance rating for potential river pollution and water uses.

Table 11-4 River Pollution impacts on aquatic ecosystem and water uses during construction

	Impact Significance Rating				
Component value	Magnitude	Extent	Duration	Probability	Overall Rating
Moderate to high	Major due to risk of accidental release of pollutants	Localised – dam to river mouth	Temporary (3 years)	Low if BEMPs implemented	Moderate

11.4.3.2.2 Mitigation Measures

River pollution is an avoidable impact if BEMPs are implemented during construction. BEMPs for controlling the introduction of pollutants into the river (see Section 13 – Environmental and Social Management Plan) include plans for:

- Point Source pollution management, including concrete work;
- Spoil soil management during earthwork;
- Forest clearance practices;
- Stream crossing practices;
- Drainage and erosion control; and
- Localization of hazardous material.

11.4.3.2.3 Residual Effects and Their Significance

Even with the implementation of BEMPs, the moderate pre-mitigation impacts will persist as residual impacts, primarily because of the potential risk posed by a release of hazardous substances into the river. However, this residual impact is considered to be not significant if BEMPs are properly implemented.

11.4.3.3 Disturbance to Aquatic Habitats and Aquatic Life

11.4.3.3.1 Impact Identification and Rating

Water quality degradation, including increased TSS, and stream bed siltation due to construction activities and alluvium extraction in the river bed, are likely to affect aquatic life downstream of the construction area, if no appropriate mitigation is applied, especially where ecological conditions are almost pristine.

These changes may affect aquatic habitats and the life of existing aquatic communities: impact on trophic resources, spawning microhabitats and shelters, survival of migrating larvae and pollution-sensitive species. Although, aquatic communities are naturally exposed to habitat disturbance associated with frequent flash floods that result after heavy rain episodes, and exceptional events such as occurred with Cyclone Namu (1986).

In the event of an accidental spill of fuel /oil or other toxic substance, the effects on aquatic life might manifest far downstream.

The potential for impacts on aquatic life will last throughout the construction phase, approximately for 3 years. Overall pre-mitigation impact significance is considered to be moderate, as the spill of hazardous substances into the river is considered to be a potential risk as opposed to a certainty. Table 11-5 summarises the impact significance rating for disturbance to aquatic habitat and on aquatic life.

Table 11-5 Impacts of disturbance to aquatic life and water uses during construction

	Impact Significance Rating				
Component value	Magnitude	Extent	Duration	Probability	Overall Rating
Moderate to high	Major due to risk of accidental release of pollutants	Localised – dam to river mouth	Temporary (3 years)	Low if BEMPs implemented	Moderate

11.4.3.3.2 Mitigation Measures

Disturbance to the aquatic ecosystem is unavoidable, and is the consequence of constructing a hydropower dam. BEMPs will be implemented to minimize disturbance wherever possible. BEMPs for controlling the disturbance to aquatic habitats and aquatic life (see ESMF) include plans for:

- Point Source pollution management, including concrete work;
- Spoil soil management during earthwork;
- Forest clearance practices;
- Stream crossing practices;
- Drainage and erosion control; and
- Localization of hazardous material.

11.4.3.3.3 Residual Effects and Their Significance

Even with the implementation of BEMPs, the moderate pre-mitigation impacts will persist as residual impacts, primarily because of the potential risk posed by a release of hazardous substances into the river. However, this residual impact is considered to be not significant if BEMPs are properly implemented.

11.4.3.4 Overfishing

11.4.3.4.1 Impact Identification and Rating

The presence of workers in the construction area were the fishery pressure is currently low, and the potential influx of population in villages along the Tina River downstream, may represent an additional pressure on the fishery resource, especially on those fish species considered to be particularly valuable (i.e., Khulia, Mesopristis, gobbies, prawns) to communities, which could be potentially overfished.

Impacts will last throughout the construction phase, approximately for 3 years. Although the magnitude of potential impacts is considered to be moderate, it is of short duration and confined to the local area. Therefore, impact significance is considered overall to be low. Table 11-6 summarises the impact significance rating for potential overfishing.

Table 11-6 Impacts of potential overfishing during construction

	Impact Significance Rating				
Component value	Magnitude	Extent	Duration	Probability	Overall Rating
Moderate to high	Moderate	Localised – dam to powerhouse	Temporary (3 years)	Low if BEMPs implemented	Low

11.4.3.4.2 Mitigation Measures

It is recommended that workers be prohibited from fishing in the Tina River, and that the Project's food services / caterers be prohibited from purchasing fish from local villagers.

11.4.3.4.3 Residual Effects and Their Significance

It is expected that the pre-mitigation moderate impacts will be mitigated through worker and camp prohibitions of catching or buying fish. Therefore, residual effects are low and considered to be not significant.

11.4.3.5 Diminished Water Quality and Water Quantity

11.4.3.5.1 Impact Identification and Rating

Water quality degradation, including increased TSS, bacteriological and physico-chemical pollution, and siltation may lead to diminished availability of water for occupants of riparian villages, for which the river represents the major source of water.

Turbid water makes it difficult or impossible to practice subsistence fishing especially using the preferred method of snorkelling / spear fishing, to wash clothes, and to bath. Turbid water is also less attractive for recreational activities.

Bacteriological pollution caused by leaking portable toilets that will be used in the work areas, or urinating or defecating out in the open in areas adjacent to work sites, presents a potential risk of waterborne diseases for people using the river for drinking or bathing.

In the event of a major accidental spill of hazardous material (e.g., fuel / oil) from the construction area all water uses all along the river, including commercial fishing at the mouth of the river, would be significantly affected.

Concrete production from the onsite batch plant will require 30Mm^3 of water from the Tina River to construct the dam over two dry seasons..On average, this will lead to an estimated reduction of flow downstream of the dam ranging from 7% to 10% as shown in Table 11-7.

Only minimal impacts to water quality are anticipated at the mouth of the river as a result of project construction. The use of cofferdams and diversion works will ensure that construction of the dam, and powerhouse tailrace, are undertaken in isolation from the river, thereby preventing introduction of concrete slurry, fine sediments and other potential contaminants. Use of good practice techniques for clearing and grubbing operations, and implementation of sound management plans to control erosion and sedimentation, construction wastes, hazardous materials, and other similar plans, will minimise the threat to water quality. With these measures in place, along with on-site monitoring to identify potential issues, it is unlikely that any construction related adverse water quality impacts would accrue to the estuary.

Table 11-7 Water required for concrete production

Total water extracted for concrete in m3	**Total time for concrete work in months**	**Water extracted for concrete in m3 per month**	**Water extracted for concrete in m3 per second**	**Average Tina flow in dry season at dam site (m3/s)***	**Estimated additional flow between Dam and Tina junction with Toni in m3/s****	**Estimated additional flow from Toni*****	**Estimated total flow during dry season downstream of Toni river**
30,000,000	8 to 9	3,750,000 to 3,333,333	1.29 to 1.45	12.72	1	4.24	17.96
Estimated average flow reduction in % due to concrete work					Between dam and Tina junction with Toni	Downstream of Toni (Ngalimbiu River)	
					9.37 to 10.54	7.18 to 8.07	

* based on gauging station data from June 2010 to September 2013. Dry season range from April to November.

** based on Average specific yield of 0,097 $m^3/s/km^2$ of Tina River

*** based on BRLi field measurement showing that Toni has roughly 1/3 of Tina's flow

Impacts will last throughout the construction phase, approximately for 3 years. Although it is of short duration and confined to the local area, the magnitude of potential impacts water quality and quantity is considered to be moderate, due to the potential for the project water requirements to become a larger percentage of dry season flows, especially in a very dry year, and due to the risk of project related pollution affecting downstream water quality. Therefore, impact significance is considered overall to be moderate. Table 11-8 summarises the impact significance rating for potential water quantity and quality issues.

Table 11-8 Potential water quantity and quality impacts during construction

	Impact Significance Rating				
Component value	Magnitude	Extent	Duration	Probability	Overall Rating

Moderate to high	Moderate due to potential for project water use to become higher percentage of available water, and risk of pollution	Localised – dam to river mouth	Temporary (3 years)	Moderate without BEMPs implemented	Moderate

11.4.3.5.2 Mitigation Measures

Mitigation measures, such as the provision of domestic water supply system to local affected communities, is proposed (see Section 12 – Assessment of Socio-economic / Socio-community Impacts), to offset the of the Project withdrawing a quantity of water during construction that could affect availability of water to downstream communities. In addition, the same BEMPs that would be used for pollution control (see Section 11.2.3.2.2 – Mitigation Measures for river pollution) would apply to protecting water quality.

11.4.3.5.3 Residual Effects and Their Significance

Post-mitigation residual impacts are considered to be moderate due to the potential for affecting the availability of water for downstream communities, and due to the risk that water quality of the Tina River could be adversely affected by a project related spill of a hazardous substance. However, with application of BEMPs to control potential pollution, and compensation measures, such as distribution of water for domestic use, the post-mitigation residual effects are considered to be low (i.e., not significant).

11.4.3.6 Temporary River De-watering During Reservoir Filling

11.4.3.6.1 Impact Identification and Rating

Reservoir filling is estimated to take 7 days, based on a FSL reservoir of 7Mm^3, and an average filling rate of 11.5m^3/s). However, reservoir filling could significantly longer or shorter, depending on the hydrology and occurrence of heavy rains /floods following closure of the dam.

Unless some flow is released, the river will be dewatered during the period of reservoir filling, with severe consequences on the aquatic ecosystem and water uses, especially on the reach between the dam and the confluence with the Toni River.

Impacts will be very short in duration, confined to a short section of river, but severe in magnitude, and are considered overall to be moderate, but recoverable. Table 11-9 summarises the impact significance rating for potential water quantity and quality issues.

Table 11-9 Potential river dewatering impacts during reservoir filling

	Impact Significance Rating				
Component value	Magnitude	Extent	Duration	Probability	Overall Rating
Moderate to high	Severe due to potential complete dewatering of Tina River between dam and Toni River confluence	Localised – dam to confluence with Toni River	Very short (estimated 7 days)	Moderate without EF	Moderate

11.4.3.6.2 Mitigation Measures

To mitigate impact of reservoir impoundment, an environmental flow will be implemented. In its 2014 feasibility Study, Entura recommended that a low level outlet through the diversion plug be provided for this purpose. It is suggested that an environmental low (EF) of 1m^3/s be maintained through this outlet during reservoir filling.

11.4.3.6.3 Residual Effects and Their Significance

With a minimum EF release of 1m^3/s at all time during reservoir filling, the post-mitigation residual impact of dewatering the river is considered to be low (i.e., not significant).

11.4.3.7 Conclusions Regarding Construction Impacts

Table 11-10 summarises the pre-mitigation impact ratings, and the significance of residual impacts that will potentially remain following the application of mitigation measures, for the construction phase of the Project.

Table 11-10 Pre-mitigation and residual impact ratings for construction phase

Impact from construction	**Pre-mitigation impact rating**	**Post-mitigation Residual impact rating**
Increase in suspended solids and siltation	Moderate	Not Significant
River pollution	Moderate	Not Significant
Disturbance to aquatic habitats and aquatic life	Moderate	Not Significant
Overfishing	Low	Not Significant
Disturbance to water uses	Moderate	Not Significant
Temporary river dewatering during reservoir filling	Moderate	Not Significant

Many impacts resulting from dam construction activities are unavoidable and mitigation measures are limited. Residual impacts will, in most cases, reflect the pre-mitigation impact significance ratings. Notwithstanding, it is recommended to maintain an EF during reservoir filling. By employing BEMPs during construction, providing domestic water supplies to all affected communities, and monitoring water quality, construction related impacts can be held to acceptable levels, especially if the construction contractor is required to address any issues that arise during construction.

11.4.4 Operation Impacts on Aquatic Environment

This section discusses potential impacts on the aquatic environment that may accrue during operation, proposes mitigation measures, and assesses residual impacts and their significance.

11.4.4.1 Reservoir Operation

The project will create a reservoir with the characteristics shown in Table 11-11.

Table 11-11 Characteristics of proposed dam & reservoir

Feature	**Measurement**
Location of the reservoir	3.7km upstream of Senge (CH 7km)
Reservoir level & depth	
Max flood level	186masl
Full supply level (FSL)	175masl
Normal operating level.	172masl
Minimal operating level.	170masl
River level at dam	122masl
Reservoir depth at FSL (deepest point) (= dam height above river bed)	53m
Reservoir volume	
Volume at FSL	$7Mm^3$
Active volume (NOL to MOL)	$1.4Mm^3$
Dead storage to spillway gate level	$3.2Mm^3$
Length of impounded river (FSL)	2.5km
Reservoir surface area at FSL	30.52ha
Froude coefficient	0.02 (*)

Feature	Measurement
Retention time	7d
Water intake level to powerstation(head race tunnel)	161-164masl
Mean water inflow	11.5m^3/s
Length of river with reduced flow (dam to powerhouse)	5.7km

Source March 2014: Entura TRHD Phase 3 Report

(*) Froude (F) = 320 (L/D)(Q/V) were L = length of the reservoir (meters); D = mean reservoir depth (for which dam height may be a proxy) ; Q = mean water inflow '(m3/s) and V = reservoir volume (m^3)

Entura's TRHD Phase 3 Report (March 2014), provides a description of the reservoir for the preferred alternative, Option 7C. The reservoir at FSL is approximately 53m (max depth), 150m wide at its downstream end, and 2.5km long, with an estimated volume of 7Mm^3.

11.4.4.1.1 Impact Identification and Rating

The aquatic habitat within the impounded section of the Tina River will change from lotic conditions (fast flowing river with rapids and pools on a streambed of cobbles and pebbles) to lentic conditions (deep reservoir, up to 53 m in depth, with slow velocity).

The predicted exchange period for reservoir water is estimated to be 7 days. This is low compared to other reservoirs on tropical rivers that have a more seasonal flow regime. In terms of minimizing negative impacts on water quality (i.e., increased temperature, oxygen depletion, and other adverse effects), short exchange periods are preferable to long exchange periods.

The reservoir's presence reflects a permanent impact, in a very localized area, having a moderate magnitude on the river system. Therefore, impact significance is considered to be moderate. Table 11-12 summarises the impact assessment rating for reservoir operation.

Table 11-12 Reservoir operation impact rating

	Impact Significance Rating				
Component value	Magnitude	Extent	Duration	Probability	Overall Rating
Moderate for its power generating capacity	Moderate	Localised – over 2.5km length of Tina River	Permanent	High	Moderate

11.4.4.1.2 Mitigation Measures

The reservoir will be operated for many decades in support of a peaking hydropower generating station and, therefore, represents a permanent change to the Tina River. There are no mitigation measures that can be applied to the reservoir operation to reduce the impact of converting 2.5km of riverine habitat to lentic habitat.

11.4.4.1.3 Residual Effects and Their Significance

Loss of 2.5km of riverine habitat is a long-term (permanent) condition that will continue as long as the hydropower project is operational. Therefore, no mitigation is possible, and the residual impacts are considered to be moderate, but not significant.

11.4.4.2 Reservoir Sedimentation

11.4.4.2.1 Impact Identification and Rating

The flux of solid material from the upstream watershed consists of: (i) bed load of coarse materials (i.e., boulders, cobbles, pebbles, gravels, coarse sands); and (ii) suspended sediments (clay, fines and organic particles), the concentration of which is very low except after heavy rains.

All of the bed-load is expected to be trapped in the reservoir, with larger materials deposited at the upstream end of the reservoir, and lighter fractions deposited at the deeper downstream end. However, a significant proportion of suspended sediments will likely pass through the reservoir, either through the power intake and turbines, or spillway (i.e., during floods).

Over time, the trapping of solid material in the reservoir will result in a decrease in its active volume. At a FSL of 175masl, and assuming a sediment inflow of 45,000m^3/y, it is estimated that the dead storage volume would be full within a period of 65 years (Entura, March 2014).l

Impact significance is considered to be moderate. Table 11-13 summarises the impact assessment rating for reservoir sedimentation.

Table 11-13 Reservoir sedimentation impact rating

	Impact Significance Rating				
Component value	Magnitude	Extent	Duration	Probability	Overall Rating
Low as it is an artificial environment	Moderate	Localised – over 2.5km length of Tina River	Permanent	High	Moderate

11.4.4.2.2 Mitigation Measures

Inclusion of large flushing outlets as part of the dam's design has been ruled out, primarily because they are only efficient at removing sediment deposited within relatively close proximity to the dam. Constructing large flushing outlets into an RCC structure is complicated and costly, for very little benefit. However, in place of flushing outlets, an outlet of 3x3m is proposed near the power intake at 160masl, to extend the filling period. Once sediments reach this level, the outlet will be used either for local flushing or for lowering the reservoir to permit dredging/excavating of accumulated sediments.

11.4.4.2.3 Residual Effects and Their Significance

As there is no feasible mitigation, residual impacts are considered to be moderate, but not significant.

11.4.4.3 Barrier to Passage of Migratory Fish Species

As with other Indo-pacific islands, all native fish species in streams and rivers on Guadalcanal (i.e., gobioids, eels, Kuhlia, prawns, and other endemic species) are amphihaline migratory species with a life cycle that shifts between the sea and the river.

11.4.4.3.1 Impact Identification and Rating

The dam and reservoir, and to some extent the associated by-passed section of the Tina River, will represent a barrier to the upstream and downstream migration of all native fish species that currently utilise the river system upstream of the dam site.

As mentioned in Section 7, fish within the Tina River follow either a catadromous or amphidromous lifecycle migration scheme, as follows:

- Catadromous migration involves downstream migration of adults to spawn in the sea, and upstream migration of juveniles to mature within the upper catchment area.

- Amphidromous migration involves downstream migration of larvae and upstream migration of juveniles to mature, reach adulthood, and spawn in the upper catchment area.

Creating barriers to fish migration is not so much an issue of depriving communities of fish resources that support a livelihood as it is an issue affecting fish biodiversity and local cultural experience for those who venture into upstream areas on traditional fishing trips.

Impacts on the Upstream Migration of Juveniles

For both catadromous species (e.g., eels) and amphidromous species (e.g., gobies, prawns), juveniles undertake mass upstream migrations from the sea to colonize rivers and streams to the upstream areas of the watershed.

Juveniles show different migration behaviors according to their taxa. Syciinidae are able to climb a quasi-vertical wet smooth concrete surface whereas eels or prawns need a less steep slope and a rough surface for crawling. Many other species are strict swimmers (e.g., *Kuhlia sp.* / silver fish, mullets, *Mesopristis sp.*).

Unless mitigation measures in the form of trap-and-haul systems are put in place to enable upstream migrating fish to move past the dam, or releasing EFs to enable fish to pass upstream of the powerhouse tailrace to the base of the dam, the TRHDP facilities will present a non-passable obstacle to upstream migrating fish given:

(i) the height of the dam (approximately 53m);

(ii) the absence of water discharge along the face of the spillway (no possibility for Syciinids to climb);

(iii) the length of the by-passed section of river and its reduced flow stage most of the time; and

(iv) the absence of attractive outflow towards the by-passed section and toe of the dam.

Furthermore, Syciinids might be attracted by the power-station outflow and climb up into the turbines were they might accumulate and die in mass, causing a potential maintenance issue.

Without measures to enable fish to move up to, and over, the dam those fish species that currently utilize sections of the Tina River upstream of the dam will disappear from the river above the dam. The catchment upstream of the dam covers approximately 125km^2 and represents 50% of the Tina/Ngalimbiu watershed.

Some short life cycle species, like Gobiidae and prawns, will quickly (within 2 to 4 years) disappear from the upper catchment, whereas eels with a life span of up to 10 years or more, will continue to be found as large specimens many years after the dam is built. There are examples of Anguillidae (e.g., European eels), which are known for their longevity and are able to survive in captivity over a period of 80 years.

Assuming a sufficient EF is released in the by-passed section to attract upstream migrating juvenile fish, to the toe of the dam, an efficient trap-and-haul system will be required to enable climbing / crawling juveniles to pass up over the dam. Since it is technically difficult to reliably design a fish pass for strict swimmers, a trap-and-haul system is recommended. Strict swimmers represent about 40% of the number of identified species in the Tina River.

Impacts on Downstream Migration of Silver Eels and Larvae Of Migratory Species

Assuming an efficient system for moving upstream migrating juvenile fish (e.g., eels, Syciinids, Gobiids, prawns) past the dam is implemented, the downstream migration of mature eels and larvae of migratory species is likely to be significantly affected by entrainment into the power intake and headrace tunnel, followed by mortalities in the turbines due to contact with the runner blades, pressure fluctuation, turbulence and cavitation.

However, unlike Salmonids, these species do not present a homing behavior that sees adults returning to their natal streams. Rather, the upper watershed will be continuously stocked by upstream migration of juveniles that have had a life cycle in other coastal rivers in the Solomon Islands, as long as they can move, or be moved, upstream past the dam. In addition, downstream migrating species will be able to pass the spillway when floods take place since the spillway will release flood-waters in by the by-passed river, on average, 8% of the time (when the flow is higher than 24m^3/s). Otherwise, TRHDP will raise reservoir levels to spill water over the dam spillway during the short windows of seasonal outmigration.

Impact significance pre-mitigation is considered to be major, since without specific measures to enable fish to move past the dam to the upstream Tina catchment, populations will become depleted within a few years. Table 11-14 summarises the impact assessment rating for barrier to fish passage.

Table 11-14 Impact rating for barriers to fish passage

	Impact Significance Rating				
Component value	Magnitude	Extent	Duration	Probability	Overall Rating

High for fish and crustaceans	Major – potential disappearance of fish in upper Tina River catchment	Localised – within Tina River	Permanent	High	Major

Table 11-15 is a synthesis of fish migration impacts on the two types of lifecycle migration schemes (catadromous and amphidromous) due to the dam and the powerhouse. The large bi-sected circles represent total blockage to fish migration, and the small bi-sected circles represent partial blockage or mortality of some fish species.

Table 11-15 Synthesis of fish migration stages and impacts

Catadromous life cycle (i.e. eels, Kuhlia)						
Upstream habitat: maturing and mating	Adult migration	Dam	Adult migration	Power-station	Adult migration	Ocean: spawning and hatching of juvenile
	Juvenile/ maturing migration	Dam	Juvenile migration	Power-station	Juvenile migration	
Anadromous life cycle (i.e. Gobiidae, Sicydiinae)						
Upstream habitat: maturing, mating and spawning	Larvae migration	Dam	Larvae migration	Power-station	Larvae migration	Ocean: larvae maturing into juvenile
	Juvenile migration	Dam	Juvenile migration	Power-station	Juvenile migration	

Impacts on Fish Movement at the Mouth of the Ngalimbiu River

Sicydiinidae juveniles gather en masse at the mouths of rivers before commencing their upstream migration. This massing of fish in a relatively confined area supports important traditional fisheries. This has been described in rivers on other Islands (e.g.,Tahiti, La Reunion), and was observed at the mouth of the Ngalimbiu River during the field survey (see Annex 1 of the Annex report).

Local fishermen have a certain knowledge regarding what the triggers mass gatherings. Concentrations of Sicydiinidae juveniles at the mouths of rivers is said to be triggered by freshwater flow into the marine environment, together with tidal cycles, with the drop in salinity in the coastal zone being the main factor.

At the mouth of the Ngalimbiu river, the daytime (peak hour) operation of the dam will not noticeably affect flow given the short retention time of water in the reservoir. During nighttime, flow will be reduced by up to 66% at the Ngalimbiu River mouth. Considering the long term, the Project is unlikely to affect the baseline situation of juveniles massing at the mouth of the river and subsequently entering the river as they commence their migration upstream.

Overall, the effects of changed water flows between the dam and the powerhouse will have only minimal effects on aquatic ecosystems downstream at the mouth of the river, where the effects will be diminished due to proportional changes that will occur as the river flow is supplemented by contributions from tributaries downstream of the project.

Blockage of the river mouth due to changes in river discharge brought about by the project are unlikely, since the combination of peaking flow releases, E-flow releases during non-generation periods, and periodic flood releases over the dam spillway, will ensure that a channel continues to be cut through the bar at the mouth of the river. This will ensure access into and out of the river for fish species undergoing diurnal or seasonal migration.

11.4.4.3.2 Mitigation Measures

To mitigate impacts, the following measures will be implemented:

- Trap-and-haul system for upstream migration of “target species” juveniles; and
- Fish screens at the power intake to minimise entrainment of adult eels (i.e., silver eels) into the turbines

These measures are detailed in Appendices G and H, respectively.

11.4.4.3.3 Residual Effects and Their Significance

With the installation of a trap-and-haul system, and fish grids to prevent eels from becoming entrained into the power intake and suffering damage or mortality in the turbines, the major pre-mitigation impacts could be reduced to moderate impacts, as long as a minimum EF release is implemented.

11.4.4.4 Changes of Flow Downstream of the Dam

11.4.4.4.1 Impact Identification and Rating

The flow to the powerhouse will be diverted through a 4.5km long power tunnel. The 5.7km by-passed section of river between the dam and the powerhouse, will experience reduced flow most of the time.

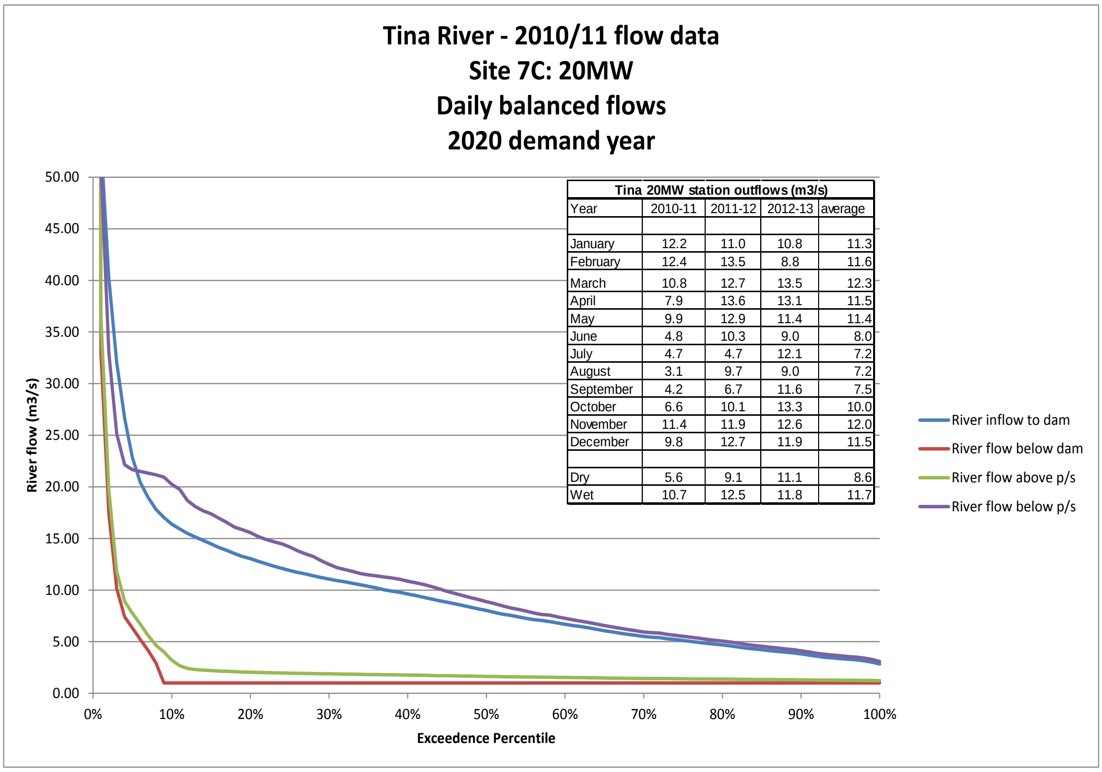
The engineering assessment showed that the power station will generally operate at, or in excess, of historic minimum river flow, supplemented by water from the reservoir when inflow is less than minimum machine flow. The maximum machine flow is 24m^3/s (4 turbines x 6 m^3/s).

Figures 11-5 and 11-6 provide the following information:

- River inflow to dam upstream of the dam (blue line)
- River flow directly downstream of the dam (with the 1m^3/s EF) (red line)
- River flow directly upstream of the powerhouse (with the lateral inflow in the by-passed river section estimated to be about 1m^3/s) (green line)
- River flow directly downstream the powerhouse (purple line).

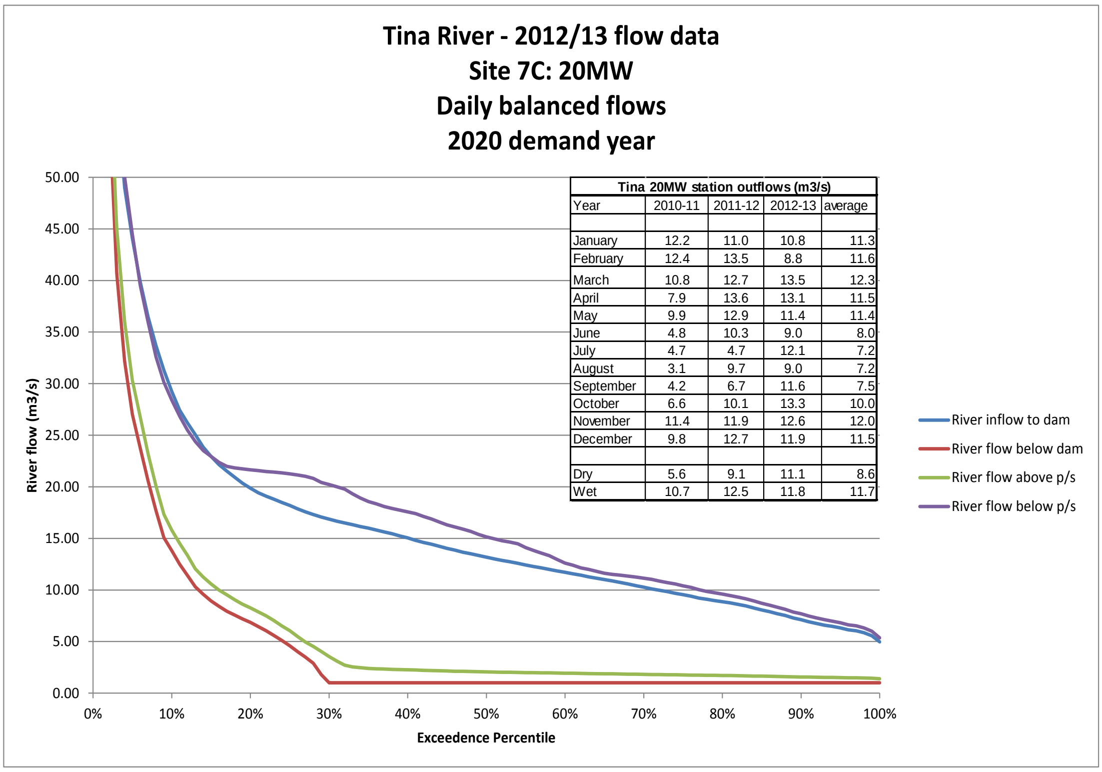
These figures do not show the daily variation in flow pattern due to storage and daily release for peak hours. For the daily variation, see Figure 11-5.

Figure 11-5 Dry year river flows - daily balance operation of Tina Hydro (no peak operation)



Tina 20MW station outflows (m3/s)				
Year	2010-11	2011-12	2012-13	average
January	12.2	11.0	10.8	11.3
February	12.4	13.5	8.8	11.6
March	10.8	12.7	13.5	12.3
April	7.9	13.6	13.1	11.5
May	9.9	12.9	11.4	11.4
June	4.8	10.3	9.0	8.0
July	4.7	4.7	12.1	7.2
August	3.1	9.7	9.0	7.2
September	4.2	6.7	11.6	7.5
October	6.6	10.1	13.3	10.0
November	11.4	11.9	12.6	12.0
December	9.8	12.7	11.9	11.5
Dry	5.6	9.1	11.1	8.6
Wet	10.7	12.5	11.8	11.7

Figure 11-6: Wet year river flows – Daily balance operation of Tina Hydro (no peak operation)



Based on these figures, the following impacts are predicted to occur:

During a dry year:

- River flow directly downstream of the dam (red line) – for 92 % of the time, the River will not receive more than 1m^3/s EF, and 8 % of the time the spillway will overflow releasing floods.
- River flow directly upstream of the powerhouse (green line) - lateral inflow in the by-passed river section is estimated to be about 1m^3/s and will add to the 1m^3/s EF directly downstream of the dam.
- River directly downstream of the powerhouse (purple line) – the flow daily balance will mimic natural flows as seen upstream of the dam (blue line). However, variation within a given day will be significant as shown in Figure 11-6.

During a wet year:

- River flow directly downstream of the dam (red line) - for 70% of the time, the River will not receive more than 1m^3/s EF, and 30% of the time the spillway will overflow releasing floods.
- River flow directly upstream of the powerhouse (green line) - lateral inflow in the by-passed river section is estimated to be about 1m^3/s and will add to the 1m^3/s EF directly downstream of the dam.
- River directly downstream the powerhouse (purple line) - flow daily balance will mimic natural flows as seen upstream of the dam (blue line). However, variation within a day will be significant as shown in Figure 11-6.

Flows will not change upstream of the reservoir as a consequence of the Project.

Flow Variation Within a Typical Day

TRHDP PO has provided an example of a typical weekday flow regime and a typical weekend day flow regime, as shown in Figure 11-7.

Figure 11-7 Flow variation within a typical day

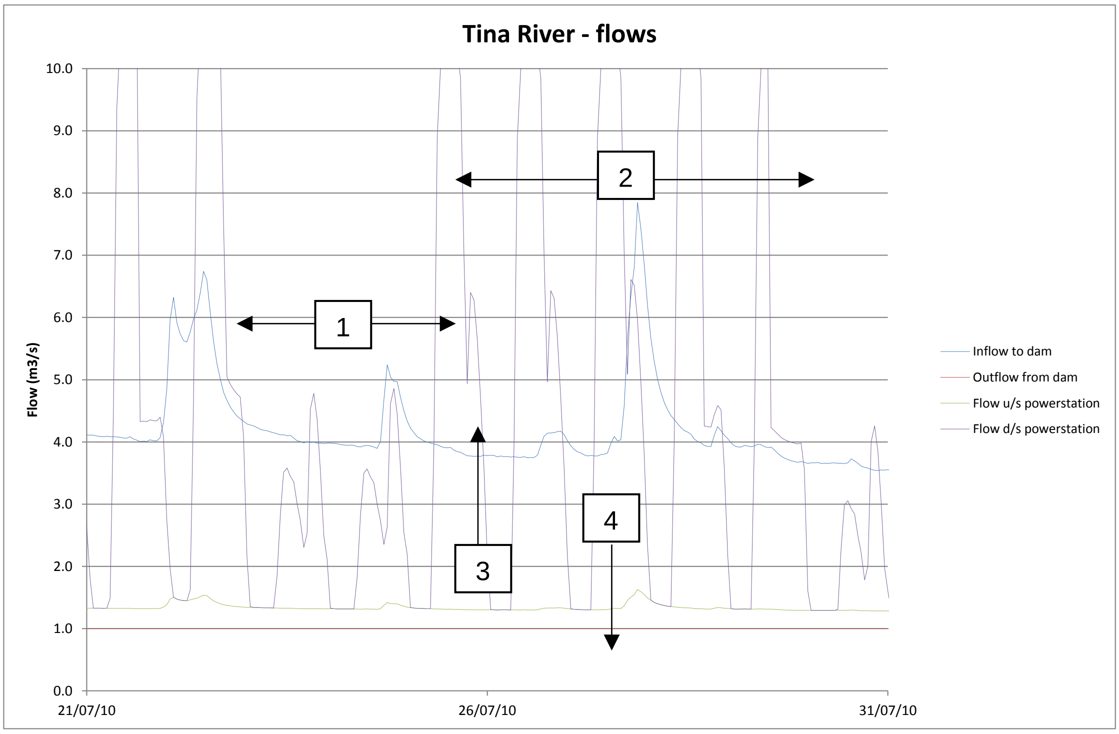


Figure 11-6 can be interpreted as follows:

- Box 1 - during weekends, the powerhouse will generate less power, creating lesser flow releases downstream of the powerhouse ($4m^3/s$ to $5m^3/s$).
- Box 2 - during weekdays, the powerhouse will generate more power, creating higher flow releases downstream of the powerhouse (up to 24 m^3/s)
- Box 3 - shows an example of release during a weekday. These releases will take place during the daytime and evening (peak hours).
- Box 4 - shows an example of powerhouse not producing any electricity during the nighttime (off-peak hours), thus not releasing any water. During nighttime, flow downstream of the powerhouse will equal the $1m^3/s$ EF (red line in Figure 11-5) plus the ~$1m^3/s$ of inflow from the lateral tributaries (green line). During nighttime, the flow will, therefore, be significantly reduced until the confluence with Toni River (~ $2m^3/s$) and will be reduced by 66% in the Ngalimbiu River (i.e., since the Toni River accounts for roughly 33% of the Ngalimbiu River system).

A significant flow reduction, mainly noticeable during nighttime and during dry years, will break ecological continuity of the river and create disturbance for water uses. As mentioned in Section 7 – Biological Environment Baseline - Aquatic, in the Solomon Islands, many aquatic animals, especially eels and prawns, are active at night.

In comparison to current baseline flow conditions, the nighttime flow of 2m^3/s in the Tina River will be slightly lower than the lowest recorded flow of 2.85m^3/s, which is the lowest recorded flow between 2010 and 2013, The daytime flow of approximately 24m^3/s will be higher than the average flow during a typical wet season month (i.e., March with 21.94m^3/s).

Due to a lack of specific details on planned operational regimes, it is still not possible to assess the dam and reservoir operation impact on the river hydrology on a seasonal basis.

Figure 11-6 assumes that the EF will be released during off peak and peak hours, with the bypass valve continuing to remain open to release the EF.

River System Response to Rainfall

Under baseline flow conditions, the Tina/Ngalimbiu River system is highly responsive to rainfall on the upper watershed. The flow varies over short periods of time and the river is subject to several flash floods throughout the year.

The operation of the hydropower systems is driven by power demand and is unlikely to mimic natural flow regimes. As such, schemes typically result in major changes to flow patterns from baseline conditions.

Once the dam is operational, the flow regime will be attenuated due to the presence of the reservoir, with low flows being supported and high flows being reduced.

The design of the dam may allow a certain regulation of flash flood events, especially if a storage capacity is planned to store these peak inflows for energy production. Entura (2014) anticipated such a management regime - the dam is designed a normal operating level (NOL) of 172masl three meters lower than full supply level (FSL) of 175masl), giving a flood storage volume of approximately 1Mm^3.

It should be noted that this regulation effect is only valid for a moderate rainfall event. The regulation volume of 1Mm^3 corresponds to a runoff volume after 8mm of rainfall on the whole watershed

Beside this regulation, exceptional discharge of storage water from water outlets may occur (e.g., to create a storage capacity or for maintenance or safety reasons), resulting in an artificial flash flood effect.

11.4.4.4.2 Impact Identification and Rating

The impact is considered to be major as the change to the flow regime is permanent and will lead to:

- Major modifications of the 5.7km by-passed river reach; and
- Noticeable changes at night, downstream of the powerhouse.

In addition to this, there is some health and safety risk associated with the sudden release of flows downstream of the powerhouse as power is dispatched. A warning system that reaches as far as the river month would need to be implemented (Section 12 – Assessment of Socio-economic / Socio-community Impacts, and ESMP).

Table 11-16 summarises the impact on changes of flows downstream of the dam.

Table 11-16 Impact rating for river flows downstream of the dam

	Impact Significance Rating				
Component value	Magnitude	Extent	Duration	Probability	Overall Rating
Moderate – for river ecosystem	Major – impact on ecological continuity	Localised – 5.7km section of the Tina River	Permanent	High	Major

11.4.4.4.3 Mitigation Measures

To mitigate the effects of peaking operation dewatering of the Tina River between the dam and the powerhouse, it is proposed to release an EF of $1m^3/s$ into the by-passed section of river.

The main rationale for EF release is to create an environment within the by-passed section of the river current that enables fish to move to the toe of the dam, and an attraction flow at the top of the dam, to entice fish to enter a trap-and-haul fish pass system.

The release of an EF is a necessity required to maintain spatial and temporal hydraulic continuity in the by-passed river section to provide for the needs of aquatic life and riparian communities. This EF must be maintained day and night expect during flood spill events.

If no EF is released, the 5.7km section of by-passed river is likely to be severely dewatered most of the time (i.e., approximately 92% of the time) (see Entura Phase 3 report, March 2014) as the capacity of the 4 turbines ($24m^3/s$) will exceed the Tina River inflow.

11.4.4.4.4 Residual Effects and Their Significance

With the implementation of EF of $1m^3/s$ EF, combined with an expected additional $1m^3/s$ dry season inflow from smaller lateral streams, and designing the system to release up to $2m^3/s$ based on an adaptive environmental management approach, the pre-mitigation impacts that were noted as major, would be reduced to moderate and, therefore, are not significant.

11.4.4.5 Conclusions Regarding Barriers to Fish Movement

11.4.4.5.1 Fish Passage and Exclusion

Various types of mitigation measures were considered for maintaining upstream and downstream fish passage, and protecting fish from physical damage. These include:

- Upstream migration of juveniles of targeted fish species:
    - Trap-and-haul system – trap juvenile fish that have congregated at the toe of the dam, and haul them up over the dam by tanker truck to be released in the upper catchment area. This would require an EF of $1m^3/s$ to facilitate movement of fish upstream through the 5.7km of by-passed section of river and provide sufficient attraction water to entice fish into the trap.

A variant of this mitigation method would involve capturing juvenile fish at the mouth of the Ngalimbiu River, when they congregate to commence their seasonal upstream migration, then trucking them to a point upstream of the dam.

- Fish barrier – fish screens or other form of barrier would be installed at the turbine tailrace to exclude upstream migrating juvenile fish of climbing species from entering the turbines.

- Downstream migration of adult eels:
  - Adjust reservoir level – during the period when adult eels move downstream on their annual migration, the reservoir would be filled to the point where water is spilled over the spillway, drawing adult eels with it.
  - Install fish screens – fish screens would be installed at the power intake structure to exclude eels from being entrained into the power tunnel and turbines (see Appendix H).

A trap-and-haul system combined with an EF of $1m^3/s$ is considered the only potentially viable system to ensure fish can continue to populate the upper catchment area and, therefore, warrants additional study. The EF of $1m^3/s$ has the further advantage of ensuring river users along the by-passed section or river (i.e., at Choro, Koropa, Sengue) continue to have access to water, that ecotourism at Sengue is maintained, and that the aquatic ecology of the by-passed stretch of river is supported.

A fish barrier or repelling system is recommended for installation in the powerhouse tailrace to prevent mortality of upstream migrating juvenile Syciinids when they enter the turbines.

Further, it is recommended that the potential to farm fish within the reservoir be considered if this could be accomplished using species of fish that are native to the Ngalimbiu river system, and which could thrive in a lentic environment. Monitoring of species would need to be done to verify the efficacy of such a program.

Although, none of the fish species utilizing the Tina/Ngalimbiu River system will be permanently lost from the Solomon Islands if these mitigation measures are not implemented, the loss of viable fish populations from the upper Tina River catchment is an unnecessary impact, given the apparent efficacy of mitigation measures that are available.

11.4.4.5.2 Adaptive Environmental Management

An adaptive environmental management approach will be implemented in support of the proposed trap-and-haul fish passage system. This will involve the implementation of new or modified mitigation measures in response to unanticipated environmental effects. This could include the need to modify environmental flows at given times of the year, or modify the location, timing or design of trap structures to improve the efficiency of the trap-and-haul fish pass system.

The adaptive environmental management approach will follow that suggested by the European Bank for Reconstruction and Development (EBRD)[77], and includes to following five steps:

[77] EBRD, Environmental and Social Guidance Note for Hydropower Projects (undated).

1. Incorporating structural and operational mitigation measures into project design and construction, that are tailored to the fish population(s);
2. Maintaining mitigation structures (e.g., attraction water flows, trap structures, tanker trucks, etc.) to ensure functionality;
3. Monitoring fish populations throughout project development (pre-, during, and post-construction) to identify residual impacts;
4. Modifying structural components (e.g., location and design of trap-and-haul system) or operations (e.g., quantity, ramping, timing of flow releases; timing of trap-and-haul activities), to mitigate significant unexpected impacts; and
5. Striving for no net loss, and preferably net gain, of fish biodiversity and abundance within the Tina River.

11.4.4.6 Changes in Sediment Downstream Dynamics

11.4.4.6.1 Impact Identification and Rating

Suspended sediment and bed-load will enter the reservoir from the upper catchment. A significant proportion of suspended sediment is likely to pass through the reservoir through either the powerhouse or. However, bed load will be trapped in the reservoir. According to Entura (2014) the dam could accumulate approximately 50,000m^3/y of suspended sediment, and 45,000m^3/y of bed load material.

Dams interrupt the action of the conveyor belt of bed load sediment transport. Typically, downstream of a dam water will have enough energy to move lighter sediment fractions (i.e., silts, sand), but has little or no capacity to transport the heavier (pebbles, cobbles and boulders) bed load sediment, thereby starving the river below the dam of the lighter sediment fractions. The effect will be to erode the channel bed and banks, and produce a river channel that is incised and comprised of coarse bed material.

The lack of sediment recruitment, downstream of the dam, especially sand and gravel sized particles, is associated with the changes in hydrologic and hydraulic conditions, including a decrease in occurrence and magnitude of flash floods. The effect is a significant change in sediment dynamics on the riverbed and banks downstream of the dam.

These changes may occur over the long term, since in the short term, unrestricted sediment inflows will continue from below the damsite and from the Toni River. Potential increased erosion and geo-morphological changes of the banks and riverbed may have consequences on river dependent biota (terrestrial and aquatic), and river uses (see Section 12.8 – Impacts on Natural Capital).

Effects on gravel recruitment will be somewhat augmented by the periodic flood releases over the dam spillway. Although gravel recruitment into downstream reaches will be regulated by the dam, there is a significant amount of gravel remaining within the river bed and along its banks, such that recruitment will continue downstream to the mouth of the river with each flood release. An assessment by a fluvial hydrologist will be undertaken to determine the approximate time period before these processes may have a negative impact on the mouth of the river. Periodic flushing or dredging of sediments from the reservoir will be required to control reservoir sedimentation. The assessment to be undertaken by the fluvial hydrologist will help to determine the extent to which reservoir sediment removal will mitigate the issue of downstream gravel recruitment.

Impacts associated with changes in downstream sediment dynamics are considered to be moderate. Table 11-17 summarises the impact assessment.

Table 11-17 Impact rating for downstream sediment dynamics

	Impact Significance Rating				
Component value	Magnitude	Extent	Duration	Probability	Overall Rating
Moderate – for river ecosystem and resource users	Minor	Localised – damsite to Toni River confluence	Permanent	Moderate – but difficult to predict	Moderate

11.4.4.6.2 Mitigation Measures

According to Entura (2014), provision of large flushing outlets at the base of the dam would be expensive and technically complicated due to the RCC type of dam. The feasibility study proposes a local flushing outlet (scour outlet) in front of the headrace tunnel intake, which would enable flushing material from within the vicinity of the intake tunnel. The beneficial effect of flushing on sediment continuity would be limited, since flushing would affect only a localised area nearby the tunnel intake and would only be done once the tunnel intake is threatened by buildup of sediments.

The design of the dam does not provide for a low-level outlet to sluice sediments. To mitigate impacts of reduced sediment transport and recruitment an equal amount of sediment that is retained within the reservoir could be artificially added downstream by dredging or excavating from within the reservoir, hauling the material to locations downstream of the dam, and depositing it along the riverbed. According to Entura (2014), mechanical removal of trapped sediment or upstream sediment from gravel bars to inject into an area downstream would cost roughly US$1m every 5 years, based on a few US$/m^3. By comparison, sediment removal from California reservoirs ranges from US$15/m^3 to US$50/m^3 (Kondolf, 1997). When required, the reservoir level could be lowered through the outlet during the dry season to expose the sediment beds, which could then be excavated and removed from the reservoir and injected downstream of the powerhouse or provided to downstream affected communities that rely on gravel extraction as a source of cash income. This measure would mitigate the impact on sediment dynamics downstream.

Monitoring of river geomorphology and sediment transport could be done to study long terms effect of sediment recruitment downstream and to follow up on erosion downstream. Parameters that could be studied include:

- Quantity of gravel extracted along Ngalimbiu River by local industries, versus quantity that would need to be artificially injected;
- Sand and gravel inputs from upstream areas;
- River bed sediment grain size analysis; and
- Depositional areas and pattern of sediment-starved water erosive behavior.

11.4.4.6.3 Residual Effects and Their Significance

The residual impact is considered to be low if sand and gravel is artificially deposited downstream and is, therefore, not significant.

11.4.4.7 Reservoir Stratification

11.4.4.7.1 Impact Identification and Rating

Stratification in a reservoir occurs when the upper zone of the reservoir (epilimnion), which is characterized by well-oxygenated water, is thermally divided from the deeper zone (hypolimnion), such that the hypolimnion becomes stagnant and is lacking in dissolved oxygen. This results in an anaerobic environment.

According to Entura (2014), a rapid estimate of stratification tendencies in a reservoir can be obtained with the Densimetric Froude Number (F):

F = 320 (L/D)(Q/V) with L = length of the reservoir (meters); D = mean reservoir depth (for which dam height may be a proxy); Q = mean water inflow (m^3/s) and V = reservoir volume (m^3)

Therefore, for the TRHDP reservoir, the Froude number is:

F = 320 (L/D)(Q/V) = 320 x (2,500 / 53) x (11.5 /7,000,000) = 0.024

If the Froude number is less than 1, some stratification is expected, the severity of which increases with a smaller F. If the Froude number is greater than 1, stratification is not likely to occur (Ledec and Quintero, 2003).

The Froude number for the proposed reservoir, calculated based on the characteristics of the preferred alternative (Option 7c) is 0.024.

This rapid assessment suggests stratification is possible and a further analysis of reservoir residence time is required. The more detailed analysis of residence time (Jorgenson et al. 2005) suggests that reservoir stratification is not likely but may occur.

The residence time of the proposed reservoir when full is approximately 7 days at median flow of 11.1 m^3/s and the average flow depth is approximately 10 m (Entura 2014). Relationships between temperature differential thermal (stratification) and residence time (Jorgenson et al. 2005) show virtually no thermal stratification in a reservoir with a residence time of 7 days. Some stratification may occur, and a hypolimnion with a low dissolved oxygen concentration may develop. Stratification will be more likely during the lower inflows of the dry season. There is a significant possibility of short-lived periods (weeks to months) of stratification during periods of low flow. Higher flow periods are likely to break down the stratification.

However, with the reservoir bottom at 122 masl and full supply level at 175 masl, it is unlikely that the hypolimnion would extend upward to 162 masl, the level from which water is withdrawn for the turbines and the environmental outlet. Consequently, the discharge of surface water from the reservoir through the spillway, tailrace and environmental flow outlet is unlikely to cause any measurable change in dissolved oxygen downstream because these withdrawals are all from what would be the epilimnion in a stratified lake.

A variable-depth outlet for the environmental flow is under consideration, and the Reservoir Management Plan will include monitoring of dissolved oxygen and temperature at multiple depths to provide advance warning of potential water quality problems.

Based on this analysis, the impact is considered to be moderate. Table 11-18 summarises the impact assessment.

Table 11-18 Impact rating for reservoir stratification

	Impact Significance Rating				
Component value	Magnitude	Extent	Duration	Probability	Overall Rating
Moderate – for aquatic life in the reservoir	Minor	Localised – reservoir	Permanent	Low - Moderate	Moderate

11.4.4.7.2 Mitigation Measures

No mitigation is required to address reservoir stratification since the location of the water intake for the headrace tunnel and the outlet valve for the EF are both located in the epilimnion of the reservoir, not the deeper hypolimnion. EF releases downstream of the dam and released from the powerhouse will not be affected by low oxygen concentrations.

11.4.4.7.3 Residual Effects and Their Significance

As long as the water intake takes water from the epilimnion there will be no appreciable impact on water quality and, therefore, no impacts to downstream ecosystems. Residual impact significance is low and, therefore, not significant.

11.4.4.8 Reservoir Water Quality

11.4.4.8.1 Impact Identification and Rating

Unless the reservoir area is cleared of vegetation, reservoir filling will inundate rainforest covering the slopes and bottom of the valley.

The decomposition of organic matter can result in depletion of oxygen levels in the hypolimnion layer of the reservoir, and produce greenhouse gases and other reductive compounds (ammonium, hydrogen sulfur, carbon dioxide and methane).

Even with most of the vegetation removed, water quality in the hypolimnion layer is likely to be significantly altered, at least during the first months after impoundment.

However, impact significance is considered to be low, as this impact is temporary. Table 11-19 summarises the impact assessment.

Table 11-19 Impact rating for reservoir water quality

	Impact Significance Rating				
Component value	Magnitude	Extent	Duration	Probability	Overall Rating
Moderate – for aquatic life in the reservoir	Moderate	Localised – reservoir	Temporary – first few months after impoundment	Moderate – based on the Froude Number	Low

11.4.4.8.2 Mitigation Measures

To mitigate impacts on reservoir water quality and production of GHG, vegetation will be cleared from the area of the future reservoir. This vegetation consists mainly of herbaceous and woody stemmed (bushes, vines and tree) plant communities. Their removal will mitigate impacts on water quality by reducing oxygen demand as vegetation disintegration consumes oxygen. Vegetation clearance will be carried out during the dry season. Organic matter in the riverbed and sediment matrix will also contribute to some oxygen depletion. However, relative to the amount of organic material bound up in vegetation, the amount of organic material in the river bed and sediments is low.

Access in the forest to allow for vegetation clearing within the future reservoir area is an issue since:

- Access from the river valley to clear vegetation will be difficult due to the tography of the steep-sided river gorge, where flash floods would pose a threat to worker safety; and
- Two possible quarry sites have been identified by Entura (2014) in the reservoir area without defining any access road. Once access roads have been identified, they could be used to provide access for vegetation clearing and timber removal.

Due to the steep topography, it is recommended that vegetation be manually removed by workers hired from local communities, and that the relatively thin layer of organic topsoil be left in place. Sawn timber could be transported either by access road or by river as it is currently done from Choro and Koropa.

11.4.4.8.3 Residual Effects and Their Significance

By removing most vegetation from the reservoir prior to inundation, the residual impacts resulting from decomposition effects on water quality are considered to be low, and not significant.

11.4.4.9 Alteration of Water Quality Downstream of the Reservoir

11.4.4.9.1 Impact Identification and Rating

The intake to the headrace tunnel at 161masl to 164masl will be situated a few meters below the MOL (170masl). The operation of the powerhouse will release water from the epilimnion layer. Although the reservoir will be stratified, by taking water from the upper oxygen rich layer, water quality issues will be avoided. The lower oxygen concentration and toxic reduction compounds found in the hypolimnion will not affect downstream water releases.

Nevertheless, in comparison with the baseline condition, the presence of the reservoir may induce a small increase in water temperature, a higher concentration of organic matter and nutrients, and a lower concentration in suspended solids during heavy rain periods. On those occasions when accumulated sediment is expelled from in front of the power tunnel intake, sediment-laden waters will be released downstream. Otherwise, the water released downstream will be clear.

Water released as EF from the dam and from the powerhouse tailrace is unlikely to have significant impacts on aquatic life and water uses. Therefore, impact significance is considered to be low. Impact duration will be temporary, likely lasting only a few months after impoundment. Table 11-20 summarises the impact assessment.

It is not anticipated that reservoir operation will have a deleterious effect on water quality at the mouth of the river during operation. Rather, the reservoir will act as a sediment filter, settling out sediments and organic debris, as water it enters and passes through the reservoir. The exception will be during major flood events, when suspended sediment laden water will be released over the spillway and through the powerhouse tailrace. However, this condition is already part of natural storm events that regularly affect the Tina River

Table 11-20 Impact rating for downstream water quality

	Impact Significance Rating				
Component value	Magnitude	Extent	Duration	Probability	Overall Rating
Moderate – for aquatic ecosystem and water uses downstream	Minor – in the hypolimnion	Localised – river downstream of dam and powerhouse	Temporary – first few months after impoundment	Moderate – based on the Froude Number	Low

11.4.4.9.2 Monitoring Measures

No mitigation is anticipated to manage quality of water released as EF and power generation flows from the reservoir. However, dissolved oxygen and temperature will be monitored at multiple depths in the reservoir and water quality monitoring will be undertaken downstream (see Section 13 – Environmental and Social Management Plan) to confirm this prediction.

11.4.4.9.3 Residual Effects and Their Significance

No residual impacts are anticipated and, therefore, impacts are low and not significant.

11.4.4.10 On-Going Disturbance to Downstream Aquatic Habitats and Aquatic Life

11.4.4.10.1 Impact Identification and Rating

Changes in flow patterns and sediment dynamics downstream of the dam, have the potential to affect aquatic life in this part of the river, with possible loss of breeding and rearing habitats. However, aquatic life downstream of the powerhouse is naturally adapted to rapid flow changes and should be quite resilient to new flow patterns caused by the TRHPD facilities.

Assuming water quality is not appreciably affected during operation of the dam, no significant impacts should accrue to the most sensitive species or life stages, or to the commercial fisheries at the mouth of the river.

Therefore, impacts are considered to be moderate, it is a permanent impact. Table 11-21 summarises the impact assessment.

Table 11-21 Impact rating for disturbance to downstream aquatic habitats and aquatic life

	Impact Significance Rating				
Component value	Magnitude	Extent	Duration	Probability	Overall Rating
Moderate – for aquatic life and habitats downstream	Low – no significant disturbance	Localised – river downstream of dam and powerhouse	Permanent	Moderate – based on the Froude Number	Moderate

11.4.4.10.2 Mitigation Measures

Measures mitigate impacts on downstream aquatic habitats and life of aquatic organisms will include:

- Water quality monitoring, including for suspended solids downstream of the construction site;
- Ensuring EF releases to the by-passed section of the river;
- Maintaining a minimum flow of at least 3.43m^3/s below the powerhouse plus inflows (equivalent to the minimum operational discharge of one turbine (2.43 m^3/s), in addition to the by-passed reach environmental flow (1 m^3/s)); and
- Installation of fish screens to prevent entrainment and mortality of silver eels.

It is recommended that as part of the Stakeholder Engagement Plan downstream communities who depend on the fishery at the mouth of the river be consulted on a regular basis.

11.4.4.10.3 Residual Effects and Their Significance

Since mitigation is primarily in the form of monitoring to ensure problems are avoided, residual impacts will persist as moderate impacts, but are not significant.

11.4.4.11 Establishment of a Lake Ecosystem in the Reservoir

11.4.4.11.1 Impact Identification and Rating

The construction of a reservoir usually leads to a change in the baseline fish assemblage, with development of pelagic or low velocity/stagnant water species and regression of rheophillic species.

In Guadalcanal, some native species are likely to benefit from the reservoir environment, assuming that trophic resources are available. These species include Kuhlia, Mesopristes (silver fish), and mountain mullet. These are usually strict swimmers that are not expected to migrate upstream of the dam if a fish pass was available. However, with a trap-and-haul place is implemented, these fish species will potentially be moved above the dam and continue to produce within the upper catchment area.

Invasive aquatic plant macrophytes such as Water Hyacinth, are unlikely to become well established in the reservoir if accidentally or intentionally introduced, given the short water retention time with its expected low concentration of nutrients, and the daily fluctuations in water levels. Nonetheless, a prevention and control plan will be prepared and implemented.

Impact significance is considered to be moderate. Table 11-22 summarises the impact assessment.

Table 11-22 Impact rating for lake ecosystem in reservoir

	Impact Significance Rating				
Component value	Magnitude	Extent	Duration	Probability	Overall Rating
Moderate – for aquatic life and habitats in the reservoir	Low – assuming no introduction of invasive species	Localised – reservoir	Permanent	Moderate – based on the Froude Number	Moderate

11.4.4.11.2 Mitigation Measures

Aside from proposing a plan to prevent / control the introduction and growth of invasive aquatic plant macrophytes within the reservoir, no other mitigation measures are considered. Reservoirs generally provide an opportunity for a fishery to be developed. Such fisheries have the potential to be more productive than the previous riverine fisheries, depending on whether native or invasive fish species are to be introduced.

In the Tina River, native species such as silver fish (*Kuhlia* or *Mesopristes*), which grow to relative large size, and are appreciated by local communities, may potentially thrive in the reservoir and might support a fishery. However, due to their freshwater / ocean life cycle that will be interrupted by the dam, it will be necessary to stock the reservoir by collecting fry at the toe of the dam, or at the mouth of the Ngalimbiu River and then transfer them into the reservoir.

11.4.4.11.3 Residual Effects and Their Significance

Restocking native Tina River fish into the reservoir to maintain a viable population, if successful, will reduce potential residual impacts to a level where they could be considered not significant, notwithstanding that the species assemblage will change.

11.4.4.12 Ongoing Disturbance to Water Uses

11.4.4.12.1 Impact Identification and Rating

Though people in local communities are used to flash floods on the Tina River, the flow variations induced by the dam and powerstation operation - and to a lesser extent, the alteration of water quality - might disturb the way people use the river for subsistence fishing, collection of drinking water, washing clothes, and recreational activities, especially between the dam and the confluence of the Tina/Toni rivers. This will require that people their activities. Another challenge will be to ensure the safety of people downstream of the powerhouse as flow releases ramp up in response to peaking generation flow releases.

Impact of disturbance to water uses is considered to be moderate, based on it being a permanent impact. Table 11-23 summarises the impact assessment.

Table 11-23 Impact rating for disturbance to water uses

	Impact Significance Rating				
Component value	Magnitude	Extent	Duration	Probability	Overall Rating
Moderate – water uses	Moderate	Localised – river downstream of dam and powerhouse	Permanent	High	Moderate

11.4.4.12.2 Mitigation Measures

Proposed mitigation measures to address disturbances to water use are provided in Section 12 – Assessment of Socio-economic / Socio-community Impacts. In summary they include:

- Providing river-based supply with appropriate treatment systems and supply points for each village;
- Providing rainwater collection and storage tanks;
- Establishing alternative supplies from local streams, and;
- Providing borehole / ground water supplies, piped to several villages / hamlets.

Transportation and distribution of clean water will be done by tanker truck on a regular basis. The water will be stored in tanks at the village level.

11.4.4.12.3 Residual Effects and Their Significance

Although the proposed mitigation measures will help to reduce impacts, residual impacts will continue. They are considered to be moderate, but not significant.

11.4.5 Conclusion Regarding Operation Impacts

Impacts on aquatic ecology during operation are related to the presence of a dam, which presents an impassable barrier to all native fish due to its height. In addition, the by-passed section of the river, with its modified flow will also affect fish migration. Unless mitigation is implemented, all native fishes will disappear from the upstream Tina River catchment. In addition, fish mortality in the powerstation turbines is foreseen as some larvae will be entrained into the power intake and juvenile fish will be attracted to the tailrace outflow of the powerhouse.

With the implementation of an EF of $1m^3/s$ (almost $2m^3/s$ when combined with inflow from the intermediate catchment area), a trap-and-haul system to move eels, silver fish and Gobidea over the dam, use of fish screens or barriers at the powerhouse outlet, and fish monitoring, impacts may be reduced to an acceptable level.

Due to the limited efficacy of fish pass systems the fish pass option was rejected. However, combining an EF of $1m^3/s$ with a trap-and-haul system to move upstream migrating juvenile target fish species past the dam remains a potentially viable mitigation option, especially when combined with an adaptive management approach. The minimum flow of $1m^3/s$ will also be maintained in the by-passed reach to ensure that social impacts are mitigated (see Section 12 – Assessment of Socio-economic / Socio-community Impacts) and fish stocking/farming program will be developed for reservoir fishery as a separate study.

Long-term operation of the Project should not adversely affect on the baseline situation regarding juvenile fish entering en masse the mouth of the Ngalimbiu River from the sea. Since observed species do not present a homing behavior, juveniles can colonize any river, not only their natal stream, so the Ngalimbiu River will continue to support fish.

Table 11-24 summarises impacts as well as residual impacts during operation of the Project.

Table 11-24 Summary of aquatic impacts

Impact from operatio	Impact before mitigation	Residual impact
Establishment of a reservoir	Moderate	Not Significant
Sedimentation of the reservoir	Moderate	Not Significant
Changes of flow downstream of the dam	Major	Not Significant[78]
Changes in sediment dynamic downstream	Moderate	Not Significant
Stratification in the reservoir	Moderate	Not Significant
Alteration of water quality in the reservoir	Low	Not Significant
Alteration of water quality in the river downstream	Low	Not Significant
Barrier to migratory fish species	Major in the upstream catchment. Minor in terms of overall fish biodiversity in the Solomon Islands	Potentially significant if recommended mitigation is not successful – follow adaptive management approach
On-going disturbance of aquatic habitat	Moderate	Not Significant
Establishment of a lentic biocenosis in the reservoir	Moderate	Not Significant
Disturbance of water uses	Moderate	Not Significant

[78] Pending results from ongoing Project monitoring

12. ASSESSMENT OF SOCIO-ECONOMIC / SOCIO-COMMUNITY IMPACTS

12.1 INTRODUCTION

This section addresses the potential socio-economic / socio-community effects of construction and operation of the preferred project alternative (Option 7c), while taking into account the issues identified by the local communities, stakeholder agencies and organisations, and the potential funders of the project. This section also presents the potential means of avoiding, mitigating, and managing project impacts that are consistent with policies and regulations of the SIG, World Bank, and donor agencies. It also addresses compliance of the TRHDP planning process with the World Banks Operational Policies and WB Performance Standards, including PS 7 on Indigenous People.

12.2 APPROACH

Each hydro development project has its own particular characteristics and features and will, therefore, generate specific beneficial and adverse social impacts. A Social Impact Assessment (SIA) was undertaken, the aim of which was to identify opportunities to maximise the benefits of the Project for the project-affected communities, and to minimise problems.

To assess the TRHDP, identification and evaluation of the social and cultural impacts were based on:

- Analysis of the records of consultations and awareness campaigns undertaken by the Project Office;
- Analysis of the project features and the social context by the ESIA team, drawing on experience of similar projects elsewhere, and international research (e.g., the World Commission on Dams), and;
- Several rounds of consultation via community workshops, and a householder survey, carried out by the ESIA team with the potential project-affected communities, individuals, and stakeholder agencies and groups

The SIA was prepared as part of the SIG's project environmental approvals. The assessment report ensures that the proposed development will comply with the World Bank *Performance Standards for Projects Supported by the Private Sector* (e.g., Performance Standard 7 on Indigenous Peoples).

A separate report, the Land Acquisition and Livelihood Restoration Plan (LALRP), sets out the impacts of the land acquisition for the Project. As the Solomon Islands' Government is responsible for land acquisition, the LALRP is prepared in compliance with World Bank Operational Policy 4.12 (involuntary resettlement).

12.3 SOCIAL IMPACT ASSESSMENT METHODOLOGY

The social impact assessment methodology included the following:

- Review of the project planning documents, including the social impacts scoping study conducted by Entura, the fieldwork and background reports by the Pacific Horizons Consulting Group (PHCG), and other reports and briefing materials prepared for the project;

- Review of existing information (secondary data) covering the project area, its population and local customs, recent history of conflict, available census and other quantitative data related to population and resources as well as a review of any recent hydroelectric developments in Melanesia and in the South Pacific region;
- Review of the records of the three-year awareness raising/education programs and consultations conducted by the PO with local communities, organisations, agencies, and individuals;
- Rapid fieldwork visit in mid-2013 combined with consultation with key agencies and community leaders in the project area. This fieldwork enabled the project area to be zoned into 3 areas for social assessment: Downstream Area, Infrastructure Impacts Area and Wider Impact Area.
- Four-week interview program and participatory workshops in July-September 2013 with the Tina and Ngalibiu River communities, and adjacent land owner's communities in Malango. The 15 community focus workshops covered all of the villages in the project area, and had a total recorded (minimum) attendance of 511 people, 45% of whom were females, and covered the full range of age groups. In the Bahomea district at least 48% of participants attending the workshops were females. The workshops were arranged in advance with the help of the TRHDP PO and involved directly the locally-based community liaison assistants (CLAs);
- Rapid fieldwork visit in mid-2013 combined with consultation with key agencies and community leaders in the project area. This fieldwork enabled the project area to be zoned into 4 areas for social assessment: Direct Impact Area (DIA), Downstream Area, Infrastructure Impacts Area and Wider Impact Area.
- Four-week interview program and participatory workshops in July-September 2013 with the Tina and Ngalibiu River communities, and adjacent land owner's communities in Malango. The 15 community focus workshops covered all of the villages in the project area, and had a total recorded (minimum) attendance of 511 people, 45% of whom were females, and covered the full range of age groups. In the Bahomea district at least 48% of participants attending the workshops were females. The workshops were arranged in advance with the help of the TRHDP PO and involved directly the locally-based community liaison assistants (CLAs);
- List of all of the households in the villages that were involved in the community workshops. This was done by the local indigenous member of the ESIA team in discussion with senior women of each village;
- Face-to-face survey of over 50 female householders from across the villages within the project area. Survey questions covered the following topics: household's livelihood/s; division of labour; food and nutrition; health issues; access to resources; and anticipated issues with the TRHDP. The survey interviews were conducted, for the most-part, by the female community liaison assistants for the project in Bahomea and Ghaobata districts, and by the cultural issues specialist on the ESIA team.
- Face-to-face interviews and discussions with male and female officers of government agencies and non-government organisations having a direct or indirect interest in the Project;
- Review of the results of the community public awareness, consultation and mitigation workshops (e.g., in Bahomea (x2), Malango (x2), and Ghaobata (x1) in January-February 2014). These ESIA findings provided information on the potential impacts of the project and proposed responses to those impacts. Senior TRHDP officers were present to respond to technical questions or policy issues.

12.3.1 Village Community Workshops

All consultations, including workshops, were preceded by local announcements of the timetable, the purpose and the program. They were facilitated locally by members of the TRHDP PO CLAs and by community relations officers.

During the brief introduction of the village community workshops (which was given in English, Pidgin, and relevant indigenous language), participants were advised that:

- The ESIA team was independent of the TRHDP PO;
- Individuals' comments and viewpoints would be treated anonymously in the assessment; and
- People were free to stay or leave the meeting as they wished.

A consent form was distributed by the village chief/s.

During the workshops, questions were asked regarding peoples' awareness of the proposed project, and whether the participants and their communities supported the proposed Project, or not. As shown by the following photographs (see Figure 12-1 and 12-2), the community workshops were participatory and interactive. Each key topic of the project was discussed and displayed on a whiteboard.

Figure 12-1 Young people discussing the Project's impacts during the village workshops (Antioch (left) and Pachuki (right))

Figure 12-2 Householder’s interviews

12.3.2 Mitigation Workshops

Mitigation workshops were used to discuss and obtain input on opportunities to mitigate potential project related impacts. The mitigation workshops followed the same methodology as the village community workshops: prior announcements, on the ground organisation by the project liaison officers and community liaison assistants, a brief introduction of the Project and meeting, and the distribution of consent forms.

The mitigation workshops were district-wide and were, therefore, larger than the village community workshops with larger venues (e.g., meeting halls). The workshops were attended by the TRHDP PO technical personnel who answered questions and provided technical explanations, when required. A buffet meal was provided by the TRHDP PO, in keeping with local custom. The minutes of these meetings are provided at Annex 14.

Figures 12-3 and 12-4 present photographs of mitigation workshops held in Bahomea and Malango.

Figure 12-3 Mitigation workshop in Bahomea

Figure 12-4 Mitigation workshop in Malango

12.3.3 Requirement for Free, Prior, and Informed Consent

The World Bank Performance Standards 1 and 7 stipulate that Free, Prior, and Informed Consent (FPIC) (see Appendix J) is required for the affected indigenous peoples at each stage of the project development. The TRHDP PO was responsible for planning delivery of the program and for informing, and consulting with, local communities and other stakeholders regarding the Project, including the overall project concept and design, generation option investigations and selection, detailed proposals, and matters related to the use of land and resources belonging to local communities. As noted in PS 1, paragraph 32, FPIC is also required for the assessment of the project's adverse and beneficial impacts.

12.3.3.1 Free, Prior and Informed Consent and Project Planning

As part of the ESIA, the question must be asked regarding whether the project processes have been consistent with the WB PS requirements for FPIC. This assessment can be made in two ways: a) by evaluating the awareness raising and stakeholder engagement plans of the TRHDP PO and the records of its meetings and interactions with stakeholders, combined with observations of field practice by the TRHDP PO's offices, and b) by noting feedback received from the communities and other stakeholders regarding the TRHDP PO's activities.

The TRHDP PO's community-wide engagement began in July 2010 with a program of awareness raising in the Bahomea and Malango districts, working with members of the then Land Owner Council (LOC). Prior to these activities, the TRHDP PO had been working with local leaders to establish processes and terms for involvement and land identification, and had participated in the establishment of the LOC, which included landowners from Gold Ridge, Bahomea and Malango.

Since 2012, consultations were largely guided by MMERE's 'Tina River Hydro Development Project's Stakeholder Engagement Plan, March 2012', supplemented by additional activities as required. Annex 14 contains an overview of the TRHDP's community engagement activities. The objectives of the stakeholder engagement, as stated in the plan, included:

1. Deliver accurate, free and timely provision of information, manage expectations, and promote widespread awareness of the project;

2. Facilitate two-way communication with communities directly affected by the Project to:

(a) Understand the views and opinions of the community, including vulnerable, social and cultural groups regarding ways the Project may affect people, how these impacts can be limited or mitigated, and ways the project may provide benefits;

(b) Ascertain the level of broad community support for the Project at all stages;

(c) Ensure those being resettled (if any) by the Project have ample avenues to participate in resettlement planning and implementation, including their location and housing structure; and

(d) Address project concerns in a timely manner (MMERE, 2012).

As noted in the Socio-economic / socio-community Baseline, the engagement plan, MMERE's records of meetings with communities and their representatives, and other engagement activities since 2010, together suggest an ethical, well-organised, well-resourced, adaptative, and culturally appropriate ongoing program of consultation and involvement by the TRHDP PO with the project-affected people and communities.

With respect to "free" consent, the TRHDP PO's activities and program suggest that there has been no coercion or intimidation on the part of the developers, and there has been no evidence of bribery or inducement for local people to be involved in discussions about the project. Conversely, some landowners and their tribal/clan leaders have demanded and received sizeable "access payments" from the government, to allow site investigations, consultations, and related planning activities and meetings to proceed in the proposed project areas. In keeping with local custom and the expectations of local communities, the TRHDP PO has presented chupu (customary presentations) and extended hospitality to local chiefs and communities, as part of its activities.

Since the Ethnic Tensions, expectations of 'compensation' payments by communities, and expectations of cash benefits derived from project planning steps, appear to have become the norm for any development in the Solomon Islands. This is in part born out of a concern that projects will not reach an operational stage, (exacerbated by repeated closures of Gold Ridge Mine and neighbouring oil plantations), and a concern that communities which lose access to natural resources will not receive adequate benefits from operational stages. This mentality, sometimes referred to as 'rent seeking' is a considerable problem for ethical developers. Since the TRHDP represents a significant development for Guadalcanal and Solomon Islands, from time to time aspiring clan leaders, politicians, and "big men" have attempted to utilize the community engagement and internal tribal consultation processes for their own purposes. So far as these attempts affect the sharing of cash benefits from the land acquisition, they are discussed and considered in the Land Acquisition Livelihood Restoration Plan. Local awareness-raising (information sharing) and consultation activities have been strongly supported by communities and local leaders.

Among the Ghaobata communities and their HOC, which have a lot of experience in dealing with industrial and resource developments within their region of the Guadalcanal plains, requests for payments to engage in project planning have been quite explicit. Under advice by knowledgeable senior people from this area, the TRHDP PO has avoided being drawn into direct negotiations with the HOC, and has instead been working through a Guadalcanal provincial government officer, and its own CLAs to provide information and to encourage local people to consult about the Project among themselves.

The flow of information from the TRHDP PO to the affected communities appears to have been of a high standard. The TRHDP PO recruited a well-known indigenous media person to develop and document the information sharing and awareness raising activities of the TRHDP PO. The presentation of information briefings to local communities and various groups of stakeholders at key points in the project planning process has been done in local languages, and has been accompanied by the use of audio-visual aids. Examples of material produced for communicating with stakeholders and the public generally included a project website, information booklets in English and Pidgin, posters, satellite and aerial photographs, and a DVD. Engagement activities by the TRHDP PO were recorded, lists of attendees were taken, and minutes were prepared of consultations, meetings, and issues arising. The TRHDP PO has also made a photographic record of its community awareness raising and consultation activities within the indigenous communities.

The awareness raising and consultation activities by the TRHDP PO commenced in the Tina/Ngalimbiu River catchment early in the development process (2009-10), prior to any investigations of suitable dam sites. Initially, consultations focused on landowner consent to undertake geological and hydrological investigations in the catchment. This involved identifying all the relevant clans and developing processes and arrangements for consultation with them. These arrangements evolved over time, and - as noted above - consultation processes were formalized in a stakeholder engagement plan, which was made available to the public. Project planning, including environmental and social assessment, has been ongoing, with information about the project design and its potential impacts being regularly provided to the relevant communities and stakeholders. At the time of this assessment report application for project approvals had not been made, nor had construction commenced. The early and sustained engagement with the affected communities has enabled the development of a good working relationship between the Project and local people, and for the inclusion of their concerns and knowledge into the consideration of various options for the hydro development.

The TRHDP PO has made use of a variety of culturally acceptable means for communicating with local communities and stakeholders. Important communications have been, and continue to be, done face-to-face, starting with clan and village chiefs, and senior women, and then extend out to the wider village communities. Local communications are undertaken by the project's indigenous community relations staff and CLAs, and endorsed by community leaders. A wide variety of communications tools have been used to inform the communities, and to receive comment and advice in return. Among these are: printed materials, including a project booklet; face-to-face briefings and discussions with groups of community leaders, individuals, community interest groups (e.g., mother's clubs, and church groups) and agency representatives; and mobile phone and SMS, presentations using video, photographs, maps, and posters and site visits.

Based on the records of the TRHDP PO, discussions with TRHDP PO staff and CLAs, observations, and explicit comments from participants during the 2013 ESIA village community workshops and 2014 mitigation workshops, it appears that:

- There is broad support among local communities for the Project and there is no clear direct opposition to it. A minority of clan leaders and aspirants objected publically to the land identification and acquisition process. A discussion of some of the current issues raised by a minority of clan leaders with respect to compensation is provided in the LALRP;
- Hydroelectric development is widely seen as the most preferred and least destructive development opportunity for the Tina/Ngalimbiu River catchment (others being gold mining and logging of primary forest);
- community concerns about the project are generally confined to the mitigation of potential impacts and the securing of benefits;

- There has been a comparatively high level of participation of community members of both genders and all ages in the TRHDP PO's activities.
- There is wide-spread understanding of the purpose of the TRHDP, and what it generally involves, although the details of particular hydropower generation options are not well understood, especially by women;
- There is a high degree of trust of the TRHDP PO and the information it has provided, and a sense that local peoples' concerns are being heard and dealt with, even though there is little trust in government, generally; and
- There has been considerable discussion within the communities about the Project, including its benefits and potential impacts.

In addition, written consent to the Project was provided by the five landowning tribes who negotiated with SIG for the acquisition of the land to construct and operate the Project ('Process Agreement'). This is discussed further in the LALRP.

Further to the common or mutual concerns outlined above, the particular concerns of each village, relating to the preferred alternative, are presented in Annex 15 of the Annex Report, along with the perceived benefits of the development. These were recorded in the participatory workshops and in the follow-up mitigation workshops.

A summary of the feedback received in the 15 ESIA mitigation workshops and the manner in which the feedback has been incorporated into project design and key safeguard documents is set out in Appendix N – Resoultion of Community Feedback.

In summary, the TRHDP planning process appears to comply with the requirement of FPIC and, to date, community consent has been achieved at each stage.

12.3.3.2 Free, Prior and Informed Consent and the Social Impact Assessment

The ESIA process has been described in the Socio-economic / socio-cultural Baseline and above. As noted, the community workshops and consultations conducted by the ESIA team with the people of the project area were consistent with FPIC. That is:

- The community workshops and interviews were preceded by a briefing on the forthcoming ESIA, and then advanced notice was given of the workshop date, program, and the purpose of the meeting;
- Meeting organisation, selection of venue and timing was brokered by local members of the TRHDP PO's team of indigenous CLAs and agreed with the relevant communities. Women were specifically encouraged to attend and to participate;
- local community leaders agreed in advance for the ESIA team to visit and engage with local people on the impacts issues, to record the participants' comments and information, and to make observations in the community. Village and clan chiefs attended the meetings. One of the mitigation workshops was held for the members of the Bahomea HOC;
- a verbal briefing about the ESIA was provided to workshop participants in English, Pidgin, and the local language. Participant consent was explicitly sought to proceed with the workshop and individual interviews, to record discussions, and make use of the findings, and;
- the workshop process also included specific questions on whether the participants and their communities broadly supported the proposed hydroelectric development, or not.

12.3.4 Women's Participation

The TRHDP PO's records on awareness raising and consultation activities indicate that women have attended and participated in community level activities and stakeholder consultations. This was facilitated by the recruitment of mature local women as CLAs. In general, women in Solomon Islands tend to have a lower status than men and are often unable to attend workshops due to their home duties. This means that younger women are not always able to attend presentations to receive information and to engage in discussion regarding the Project during meetings. However, older women, especially those with a higher level of education, tend to be more actively involved. In addition, due to customary gender roles, women may not be encouraged by men to state their point of view or raise issues in larger gatherings. This issue did not seem to be a significant problem during the ESIA workshops.

It appears that women were successfully involved in workshops, awareness raising programs and consultation activities. Ninety-three percent reported they attended community meetings (see Annex 16 of the Annex Report). On the other hand, the household surveys suggest that women are less involved in land acquisition discussions, as only 41% of adult women reported that they were involved in deciding on land issues in their household. By comparison, in a national survey in 2007, 55% of adult women reported that they were involved in land decisions.

For example, 45% of the participants of the ESIA community workshops in 2013 were indigenous women and girls. Although it seems that women have limited decision-making power in Guadalcanal societies, their active involvement in the ESIA process is a positive sign, especially when looking at their willingness to participate in the household survey. Finally, the SIA takes into account women's perceptions and concerns about the proposed TRHDP as well as their preferences for mitigations and benefits sharing. Measures to incorporate gender inclusion in land acquisition discussions and agreements are set out in the LALRP.

12.4 CONSTRAINTS OF THE SIA

A lack of or delay in information sharing in some key areas limited the conduct of the ESIA and of the mitigation workshops. This information included:

- The preferred project option and its location, scale, and access road alignments;
- Ownership and use rights for the "core area"; and
- Current census statistics.

12.4.1 Preferred Project Option

The SIA for the TRHDP was commenced at a time when Option 6E was being evaluated, but when Option 7C was being discussed as a lower impact alternative, as described in Entura's Phase 3 Report (2014). This uncertainty presented some challenges for the workshop consultations in Senge Communities that could be impacted by the choice of dam and power station location, in particular whether they would experience physical displacement. The workshop discussions therefore had to cover the impacts of Option 6E and Option 7C. In practice, the choice of option made little difference to the impacts likely to be experienced in the Infrastructure Impact Area, Downstream Area, and the wider Malango district (Wider Impact Area), providing the basic project parameters were similar. Despite the uncertainty, the discussions in the Senge Communities helped the TRHDP PO to refine the project's concept and parameters, design policies, and ultimately the preferred option (Option 7C), which was announced as the preferred alternative in early 2014.

In late January 2014, the TRHDP PO provided a verbal briefing prior to the community and agency consultations on proposed impact mitigations. The draft ESIA was subsequently updated to reflect specific requirements and potential impacts of Option 7C. However, opportunities to conduct additional SIA fieldwork were not available.

12.4.2 Land Ownership

At the time of the SIA and of the Socio-economic / socio-cultural Baseline, no details on land ownership were available for either Option 6E or Option 7C.

The new, localised land identification process was underway at the time of the draft ESIA preparation. Since it had not been completed, its findings had not been disclosed beyond the TRHDP PO and the particular landowners. Direct consultation with the landowners in the Core Area was therefore not possible, with "the impacts resulting from land acquisition" only being covered at the community or village level. In practice, however, SIA workshops, householder interviews, and follow-up consultations on mitigations were conducted in those communities where most of the landowners for the Option 7C Core Area reside.

Since a LALRP was necessary for the loss of livelihood assets acquired for the Project, relevant data needed to be subsequently collected to enable the Plan to be prepared. This additional research was done in 2015 by means of a Livelihoods Assets survey and through fieldwork for the creation of the Tribal Register.

12.4.3 Census Data Availability

Despite several attempts by the TRHDP PO, individual government officers, and ESIA team members, it was not possible to obtain project area or village level data from the 2009 Census of Population and Housing in time for the initial preparation of the ESIA report. This data became available in 2015 for all census enumeration areas and has been integrated into the ESIA where possible.

12.5 POTENTIAL ADVERSE SOCIAL IMPACTS AND MITIGATION

Below is a summary of the construction and operations phases of the Project, and the potential socio-economic / socio-community impacts that may potentially accrue.

12.5.1 Potential Impact Causing Activities

12.5.1.1 Construction Phase

Specific activities are likely to generate impacts during the construction phase of the TRHDP, include:

- Building the RCC dam, including installing temporary diversion works within the river, excavating the dam site, and upstream and downstream quarrying of materials;

- ▶ Constructing new access roads, one from Managikiki[1] to the core land and then to the dam site, and a second road from near Managikiki to the power station and tailrace site upstream of Pachuki. Construction of both roads will require felling and clearing forests and disposing of vegetation, earthmoving (cutting/benching and filling to create a roadway), and installing culverts and drains. Some of the roadways may interact with existing tracks, household food gardens, and/or areas where materials are collected;
- ▶ Presence of road works to improve and widen the existing Black Post Road, from the Black Post (on the Kukum Highway) to Managikiki;
- ▶ Movement of equipment, materials, and people to and from the construction sites, using the new and improved roads;
- ▶ Excavating the headrace tunnel;
- ▶ Clearing forested areas within the hydro storage reservoir, and possible recovery of the logs and/or timber;
- ▶ Erecting the transmission line pylons and conductors from the powerhouse along the Black Post Infrastructure Corridor, and;
- ▶ Employment and management of local and non-local workers to undertake the various tasks involved in building the hydro scheme and in mitigating its impacts.

12.5.1.2 Operation Phase

Once constructed and commissioned, the Tina River hydro scheme could cause long lasting impacts on local communities. Operation activities that may affect them include:

- ▶ Modifying the natural flow of the Tina/Ngalimbiu River between the storage reservoir and the ocean in the dry season - mainly arising from peaking operation that will involve reservoir filling and refilling and releasing water through the headrace tunnel to the powerhouse. The reservoir will be refilled at night and water will be released for power generation during the peak daytime power demand periods;
- ▶ Diverting much of the Tina River's flow from the natural river course into the head race tunnel, located between the dam and the powerhouse, leaving the river with a supplementary environmental flow (EF) from the dam, combined with inflow from lateral streams;
- ▶ Using the access roads by workers and contractors working on the maintenance of the dam, reservoir, power station, and transmission lines;
- ▶ Employing and managing local and non-local workers to undertake various tasks involved in operating, protecting, and maintaining the hydro scheme, and;
- ▶ Possibly using the storage reservoir and the access roads by non-project personnel, including local community members and outsiders.

12.5.2 Types of Social Impacts

During the three-year construction phase and the long-term operation phase of the TRHDP, a combination of direct, indirect, positive and negative social impacts on local communities may arise.

Several types of social impacts may occur. These include:

- ▶ Direct physical impacts on nearby communities (e.g., intrusive noise, vibration, explosion shockwaves, dust, air and ground discharges, and visual intrusion) some of which could have potential health consequences and negative impacts on way of life and local amenities;
- ▶ Loss of access to abundant clean fresh water;
- ▶ Damage to and/or loss of access to livelihoods assets, including fishing areas, food garden areas, hunting areas, plant and related materials, planted and wild fruit and nut trees, and timber woodlots and plantations, with potential negative impacts on household and community wellbeing;
- ▶ Opportunities for improved incomes due to increased employment opportunities;
- ▶ Opportunities for improved quality-of-life, through the upgrading of services and facilities.
- ▶ Increased risk of accidents due to project related vehicle traffic;
- ▶ Improved road mobility between villages in the project area, and with Honiara; and
- ▶ Threats to indigenous lands, natural resources, security, community health and well-being, and local culture.

The communities that are most likely to be negatively affected by the project are those located adjacent to, and make livelihoods-related use of, the Core Land area, and/or the low-flow section of the Tina River.

12.5.3 Health, Safety and Wellbeing - Impacts and Mitigation

12.5.3.1 During Construction

The construction of the TRHDP may present threats to local people's health and wellbeing. These threats include:

- Outbreaks of gastrointestinal and skin infections arising from run-off and contamination of drinking and washing water from the Tina/Ngalimbiu River and local streams;
- Increase in malaria outbreaks due to more standing water around construction sites;
- Rise in road accidents, lost loads and spillages due to more traffic on Black Post Road, as well as work related accidents;
- Social threats arising from inappropriate behaviour of outside construction workers, and local people employed on the Project. Issues of concern are associated with a potential increase in:
  - unwanted pregnancies;
  - sexually transmitted diseases such as HIV/AIDS;
  - domestic financial issues due to gambling or drinking; and
  - alcohol and drugs consumption by men, leading to domestic conflict and violence, and sexual abuse.

Nevertheless, with sufficient preparation and investment by the TRHDP PO and the SIG, each of these potential health threats may be avoided or mitigated, as follows:

- The construction of the project (and access roads) should be planned and executed according to good international industry practice (GIIP) to avoid any physical or biological contamination of water sources. This should be explicitly addressed in a Construction Environmental Management Plan (CEMP), along with cleanup procedures. Alternative drinking water supplies should also be installed throughout the project area, prior to the beginning of the construction phase.
- Unfortunatelly, some social threats cannot be completely avoided, as they involve individual personal choices of community members (e.g., level of alcohol and drug consumption). However, it is the responsibility of the Project to prohibit disruptive behaviours and one means of prohibiting such behaviors is the decision already taken to avoid the establishment of a workers camp in the Tina/Ngalimbiu River catchment.
- The threat of anti-social behaviour by local male workers could be minimized by the TRHDP PO and the construction contractor implementing strict drug and alcohol prohibition for all workers. This prohibition may also help reduce the risk of work related accidents and road accidents on Black Post Road.
- In addition, the development of a Health and Safety Plan by the construction contractor, for both workers and villagers living near the site, could minimize the potential risks for road accidents, injuries and property damage resulting from lost loads. The Plan should include measures such as:
  - For work-related accidents, the construction contractor will need to provide tailored workplace health and safety training and personal protective equipment (PPE) (helmet, safety boots, gloves, goggles or safety glasses, hearing protection) for construction workers prior to the work commencing; provide a full-time first aide/nursing post on site and arrangements for medical evacuation (including helicopter transport) for serious injuries.
  - Ensuring that all drivers and plant operators are appropriately qualified and trained for their work;
  - Installing protective roadside fencing (particularly in the most vulnerable areas such as Mangakiki/Verakuji), and hamlets (in the Grassy hill area);
  - Installing a separate pedestrian walkway and well-marked road crossing points in the vicinityof Mangakiki/Verakuji, Marava, Rate, Verakabikabi, and on the roadside hamlets in the Grassy Hill area;
  - Enforcing speed limits for all traffic on the upgraded Black Post Road;
  - Using good international industry practice for the transport of dangerous goods, and;
  - Developing a protocol for managing contractor-related road accidents and injuries, including compensation and compensation arrangements.
- The TRHDP PO and the Construction Contractor will have to conduct awareness on HIV/AIDS and STD to prevent and mitigate the impacts of social behaviors which will encourage sexual behaviours. The TRHDP PO and construction contractor may have to engage outside parties to carry out these awareness programs if these issues are sensitive and cannot be discussed openly by project area parties such as the community Liaison Assistant currently engaged by the TRHDP PO.

12.5.3.2 During Operation

Stakeholders' are concerned about water quality in the Tina/Ngalimbiu River once the project is operational, especially with respect to the water in the reservoir and in the stretch of river that will have a significantly reduced flow on which three villages depend.

Communities are concerned about increased water-borne diseases, especially diarrhea and malaria. Downstream communities are concerned about water borne diseases from human waste and have requested independent water quality monitoring and reporting. The monitoring of water quality and the incidence of water borne diseases should begin just prior to commencing construction and should be part of an ongoing environmental management and monitoring program.

It is unlikely that the operation of the hydro-scheme will cause any noise disturbance to local households. Locally, the project operation will have no effect on air quality. Owing to reduced diesel being consumed for power generation, the air quality should improve in the Lungga area, which may have positive impacts on villagers' health.

Despite repeated awareness raising and consultations regarding the dam design and dam safety, local communities, especially women, are still concerned about the potential risk of possible dam failure during earthquakes or cyclones. Some community members expressed a lack of trust in the SIG to safely manage the hydro facility and are asking the SIG and the TRHDP PO to resettle them away from the river. However, according to the TRHDP PO, the risk of a dam failure is extremely low and there is no need for resettlement. This position is consistent with the World Bank's policies on resettlement. However, it remains crucial to implement carefully tailored awareness programs to educate communities about hydro dams, the TRHDP design, and and the provisions being made for dam safety in order to prevent unnecessary fears amongst local communities and to avoid any unnecessary resettlement.

Finally, the sudden release of up to 24 m^3/s of water from the powerhouse tailrace is seen as a potential safety hazard to local communities, particularly for persons who use the footpaths along the rivers bars and riverbanks. At times, the powerhouse will operate during daytime (peak hour) and will shut down during the night, with the potential ramping flow releases occurring during the daily startup of power generation. To mitigate this hazard a staged release of flows is proposed to alert people to the rising water level, together with awareness on the staged releases and approximate proposed release times.

12.5.4 Women - Impacts and Mitigation

During the village household surveys, women were asked to indicate their thoughts about potential adverse and beneficial impacts of the proposed TRHDP on them and their household.

The greatest concerns expressed by women include: water pollution, reduced river use/amenity, children's safety, bad influence of outsiders, loss of fish stocks and noise (see Figure 12-5). In terms of the long-term adverse impacts of the TRHDP, women were most concerned about catastrophic failure of the dam, and potential for social and cultural disruption arising from increased outside influences and access to money, by youth and men (see Figure 12-6). Measures to avoid or mitigate short and longer terms impact concerns are outlined in the relevant sections.

Figure 12-5 Women's perception on potential adverse impacts of the TRHDP

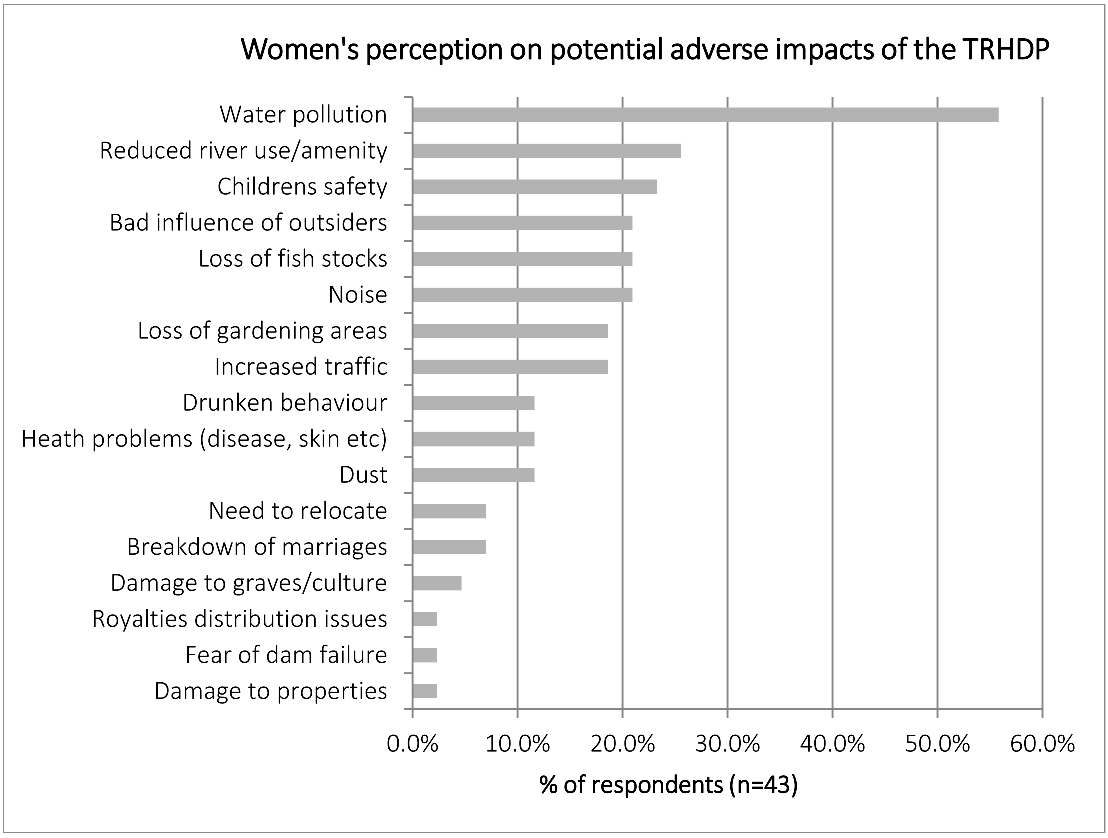
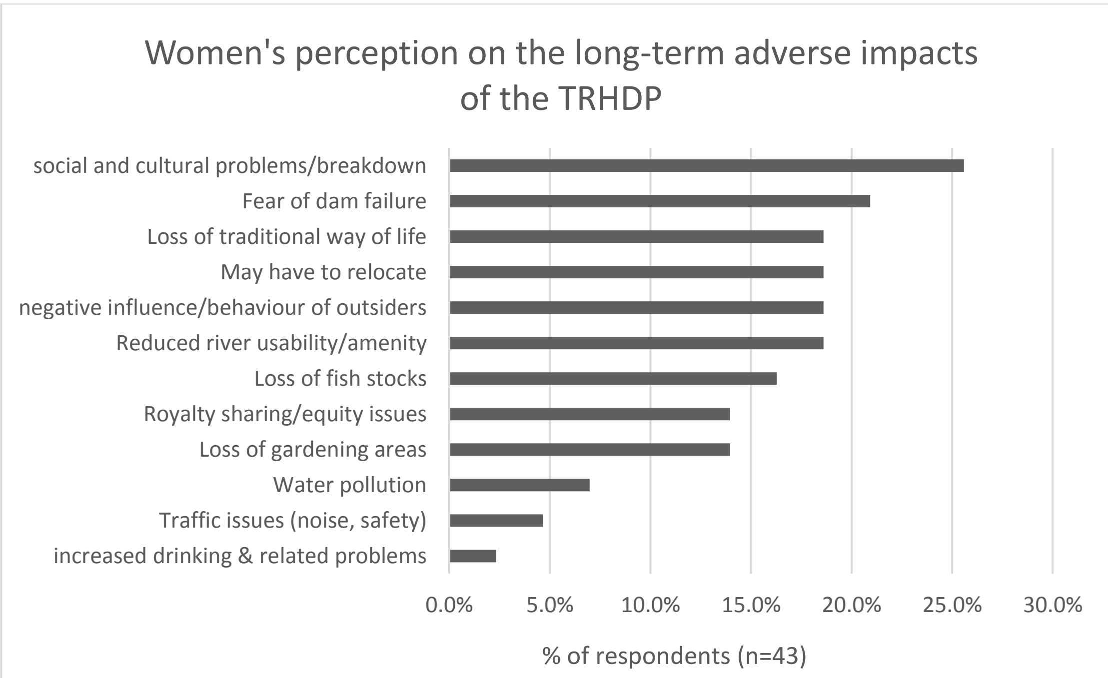


Figure 12-6 Women's perception on the long-term adverse impacts of the TRHDP



12.5.4.1 Women's Safety and Wellbeing

Women in the project area are concerned about possible risks and threats to their overall safety and wellbeing, as well as that of their children. Their primary concerns include:

- Disaster caused by dam failure;
- Sexual or other assault by outside workers or strangers involved in the Project;
- Road accidents;
- Negative social influences coming from people that are unfamiliar with, or are not sensitive to, local customs;
- Family breakdowns due to potential increase of alcohol consumption, drug use, promiscuity, and gambling associated with increased incomes of men employed on the Project.

According to Slovic's findings on risk perception, people tend to rate the risks of new technology (such as a hydroelectric dams and household electricity in the Solomon Islands context) greater than the actual risks. To avoid or reduce feelings of anxiety associated with the dam's safety, the TRHDP PO and/or the construction contractor and operator should carry out, prior to the start of construction, educational programs about dams and their risks, safety around power transmission lines and powerhouse outlets. Prior to electrification of villages, which will occur under the proposed benefits sharing program, public education about electricity and its safe use in the home and community will be proposed for communities and children in local schools.

No workers camp shall be established for the TRHDP. Security jobs will be given to local villagers. To avoid potential social and cultural issues for women, the construction contractor should maximize as much as possible the employment of local people on the project, develop and enforce a Code of Conduct for appropriate behavior for incoming workers, and provide cultural awareness training for all staff. To minimize potential social disruption due to increased amounts of cash in the community, budgeting and money management education should be provided as part of the induction and training of locally recruited workers.

Local communities adjacent to the Black Post Road have suggested a number of measures to improve the safety of children travelling to and from school at Rate and Valesala. These measures include footpaths, boundary fencing at Vera'ande, Marava, Verakuji, and Mangakiki, and speed controlled areas and/or a police checkpoint near the beginning of the road. The TRHDP PO, construction contractor and transport providers for the Project should be required to ensure that all their drivers are suitably qualified and skilled and enforce strict codes of practice and road safety rules.

12.5.4.2 Women's Work and Roles

The household survey included questions on the division of labour and on the responsibilities within the household. These findings have been summarised and presented graphically in Annex 16 of the Annex Report. The data clearly show that women are heavily involved in working in the household (e.g., laundry, growing, preparing and cooking food, caring for the household yard, cleaning the house, and selling produce and cash crops), whereas men tend to be involved in building and maintenance of the house, clearing forest, hunting, fishing, and dealing with land issues.

Potential adverse impacts that may especially affect women and girls and, therefore, require additional work to avoid or mitigate the effects, include:

- Deterioration of the river water quality and supply, and/or damage to other water supplies;
- Increased amount of dust from exposed river bed, road building, and additional road use;
- Loss of nearby gardening area; and

- Loss of forest resources (materials, foods).

As a result of the TRHDP, women's quality of living may improve due to the provision of safe and reliable water supplies, safer roads and more reliable public transport. As part of a benefits package, women's and girl's lives are expected to be made easier by the provision of education and health facilities, and electrification of houses (with labour-saving devices, home entertainment, and opportunities for home-based small businesses). The mitigation measures and the benefits package are crucial to women's welfare and development in the TRHDP area, and arrangements should be included in project implementation for ongoing consultation with local women, perhaps through existing women's groups and associations.

12.5.4.3 Minority and Vulnerable Groups

Potentially the most vulnerable group in the Wider Area is comprised of people who lack formal rights to the land they occupy and to local resources (e.g., 'squatters'). These people are primarily located in the lower part of the catchment adjacent to the northern section of Black Post Road and on abandoned or government land between Grassy Hill and Kukum Highway Road. Squatters are vulnerable to attacks by landowners who accuse them of consuming local resources.

The second most vulnerable group in the project area is comprised of the 'settler' communities. While they lack formal ownership of land and local resources, their occupancy is legitimate because they have made customary agreements with landowner tribes. Their vulnerability is primarily due to limits of the land and resources available to them for their livelihoods, as well as their lack of participation in local tribal decision-making. Despite being Guale people, they remain vulnerable to occasional attack by community members from villages in Bahomea. These communities could be affected by the construction and use of the Transmission Corridor(s). The effects are discussed in depth in the LALRP.

As the project progresses, issues affecting the communities will need to be dealt with through procedures such as the grievance mechanism and nominated community representatives for project liaison.

The main concern noted by the Bahomea villages is the loss of their lands. Landowners and the PO/SIG are responsible for avoiding and resolving these issues by actively engaging with the informal settlers during the detailed design of the transmission corridors.

12.5.5 Social Relations and Social Organisation – Impacts and Mitigation

12.5.5.1 Identification of Potential Social Conflicts

Participants of the community workshops highlighted the existence of potential social and political conflicts and their concerns about trusting local leadership and the central government. The planning, construction, and operation phases of the TRHDP may affect local social organization.

Members of the consulted communities expressed their anxiety about the potential risk for social conflicts between landowners groups and the SIG over various issues including: land and resource ownership and access rights; rent sharing; royalties; compensation payments; and access to development opportunities and benefits. Construction and operation of the TRHDP have the potential to generate both beneficial and adverse impacts on social capital in the project area. According to consulted communities, there are two main concerns regarding social relations:

- Potential internal tribal conflicts over the distribution of benefits, which may lead to social fragmentation; and
- Potential conflicts between local clans and the SIG.

According to the members (especially women) of the Bahomea communities (those closest to the main construction area) the main concerns about impacts on social relations are:

- Possible disruption of the local customary way of life and values due to the impacts of outsiders working on the TRHDP and passing through local communities. These disruptions may affect dress codes, behaviour, crime rates, and may represent a possible moral danger to young women;
- Possible social and family problems caused by local men having greater access to cash and, therefore, potentially greater access to prostitutes, alcohol, drugs, and gambling. These concerns are based on the previous experience with Gold Ridge mine.

To avoid the conflicts identified above, local inhabitants requested greater input and transparency on issues related to identification, monitoring and evaluation of land and resources that will be affected by the TRHDP. It is also important that development of the Project be undertaken in an inclusive and participatory manner with all of the affected communities. Chiefs and village leaders need to be reassured that all landowners in the project area will receive a share of the benefits. Conflicts and social disruptions may arise if these matters are not dealt with sensitively, and they may pose potential threats to the viability of the Project. These social matters have been dealt with so far by the TRHDP PO, government leaders, and the traditional Chiefs of Bahomea, in accordance with indigenous customs and practices. The process of engagement on land identification, and measures to ensure fair distribution of benefits between land owning tribes and within each tribe, are documented in the Land Acquisition and Livelihood Restoration Plan.

International and domestic development agencies could assist by providing training in conflict identification and resolution to church, community leaders and NGOs. The churches and existing civil societies have an important role to play locally in conflict avoidance and conflict resolution. Finally, the implementation of a social impact management plan and the benefit-sharing program aims to deal positively with the issues raised above.

12.5.5.2 Project Construction Workforce

The TRHDP PO has indicated that the peak construction workforce for the TRHDP will include approximately 175 workers. However, at the time of reporting, no definitive information was available on the proposed construction or operations workforce, its timing, occupational structure, required levels of skill and experience, and origin.

It is envisaged that residents of Bahomea, Ghaobata, and Malango would be employed as semi skilled and unskilled labour in the construction of the Project, along with non-local technical specialists and tradespeople. Entura suggested that the construction of the dam would take place at least six days per week, with work suspended during the rainy season, when the river is high. The Project shall have no workers camp on site. It is anticipated that expatriate staff, and workers outside of Central Guadalcanal, will be housed in Honiara and local staff will be bussed to the site from their villages. The size and characteristics of the population of the project area will, therefore, not change due to the project construction.

Suitable accommodation will need to be planned for well in advance, by the construction contractor, to cope with a temporary (seasonal) increase in Honiara’s population.

12.5.5.3 Uninvited Visitors, Jobseekers and Settlers

As a significant construction project, the TRHDP may attract uninvited visitors, jobseekers and settlers, who are otherwise unable to find employment in Honiara, or in Solomon Islands. This is believed especially to be the case for young men. Some may squat on government-owned land within the Tina Valley if they are able to obtain indirect employment. In such cases, the whole family may move to the area, putting additional pressures on local services such as health clinics, schools, and water supplies. The TRHDP PO should investigate what occurred during the establishment of the Gold Ridge mine, to obtain better knowledge and understanding of what occurred on the Gold Ridge Mine Project, so that it is better able to manage the impacts of the potential migration and settlements issues in the Tina RiverValley

The project construction contractors could limit the influx of transient jobseekers and squatters by establishing a policy that would prioritise the recruitment of construction workers from: a) the existing registered members of the customary tribes within Bahomea and Malango; and b) local settler communities. Finally, when it is necessary to recruit others, the project construction contractors should publicize and use a formal application and vetting process through a recruitment office to be located in Honiara, thereby discouraging job-seekers from going directly to the construction site. The participation of local workers and youth should be promoted through the provision of relevant job skills training programs.

12.5.6 Local Customs and Way of Life – Impacts and Mitigation

12.5.6.1 Local Communities

The migration of Malango people from the slopes of the central mountain range into the river valleys and ridges to the north has meant increasing exposure to multicultural Solomon Islands life and to Western cultural influences. The traditional hill peoples' mixed livelihoods strategy of shifting subsistence agriculture, combined with hunting and gathering, has been supplanted by wage labour, royalty payments from large-scale logging, purchased goods and food, increasing contact with Honiara, and the use of Solomon Islands Pidgin. In the process, older people of Bahomea say that their traditional culture has changed considerably.

From the 1950s onward, such changes were resisted through the Guale cultural revival advocated and practiced by the followers of the Moro Movement (see below). In some cases, families have relocated away from larger settlements to quieter, and more natural areas, where they can practice a subsistence way of life, for example, in the upper part of the Tina valley. However, they remain quite strongly connected to modern day northern Guadalcanal and its urban influences and dependencies.

Some members of local communities expressed concern that developments such as electrification of houses and other lifestyle changes would lead to the loss of the traditional way of life. Others are fearful that construction workers and other outsiders will disrespect local customs and standards of behavior.

As noted previously, the likelihood of outsiders causing offence through culturally inappropriate behavior, or being inappropriately dressed, shall be largely avoided by preventing contractors from establishing a workers' camp within the project area. In addition, the TRHDP PO and construction contractor should put in place an enforceable Code of Conduct for workers and require all non-local employees to undergo cultural awareness training as part of their induction. This training should be provided with the assistance of the indigenous people of Bahomea. Households or groups that wish to follow a more isolated and traditional way of life will still have ample opportunity to do so. Local residents will be somewhat inconvenienced by construction activities, such as by periodic construction and traffic noise, and delays on roads related to construction traffic. However, these are likely to be minor and temporary.

In the longer term, the TRHDP, and the proposed package of benefits, could catalyze the process of exposure to other communities, and of cultural and social change that is already occurring. Increasing and more intense contact with the outside world could accelerate the loss of the Teha language, traditional knowledge of the natural environment and how to obtain a living from it, of tribal genealogy and history, and of the ancestors and spirits. Conversely, most people in the community have indicated that they welcome the possibility of an improved quality of life through electrification, improved water supplies and incomes, better services, and better quality roads. The most effective way to mitigate the impacts of cultural and social change, including loss of language, is to prevent a workers camp which would otherwise involve outsiders in the day to day lives of nearby communities. Given the remoteness of the key work sites, aside from road and transmission line construction, outside workers are expected to have limited daily interactions with all but the closest villages. The majority of awareness meetings and consultations will be undertaken by Solomon Islanders.

Impacts on the nature of traditional livelihoods are also expected to eventuate from the paid employment of local workers, and the possible paid engagement of local groups for catering or security services. Staff for semi-skilled construction positions are expected to draw from previous workers of the Gold Ridge, many of whom remain unemployed following the closure of the mine in April 2014. In this context, many of the project's workers will have had existing exposure to working with outsiders and to engaging in cash employment in lieu of traditional livelihoods. Baseline studies show an existing dependence on cash incomes in the area (with a weekly average income of SBD$870 per household), and a higher than average paid employment rate. While the Project embodies a growing trend towards greater involvement with Honiara and outside cultures, the temporary nature of the majority of jobs and impacts (during the construction period) will limit social and cultural change to an extent.

In part, TRHDO PO's method of customary land identification, and the involvement of a committee of elders and storytellers (the Bahomea Land Identification Committee), has created an increased emphasis on tribal genealogies, histories, ancestors, spirits and cultural sites, not just in the Core Land, but in the wider Bahomea area considered by Bahomea Land Identification Committee (BLIC).

12.5.6.2 Gaena'alu (Moro Movement)

The TRHDP has the potential to disrupt the lives of those residents of the area who follow a less western influenced and more traditional way of life, such as the followers of the "Gaena'alu Way" (also known as the Moro Movement).

Fear of disruption to, and loss of, culture is the primary concern for the senior Moro/Gaena'alu priest and village leader of Koropa and its related community of Namopila. With the selection of the preferred alternative (Option 7C) for the Project, much of the feared disruption to the quiet traditional Gaena'alu lifestyle, and to sites of cultural significance, will be reduced. Fear that the customs and lifestyle of the Gaena'alu followers will be disrespected will be avoided by not having a workers camp located within the Tina/Ngalimbiu area, and by the TRHDP PO and construction contractor enforcing a strict Code of Conduct for its workers with respect to contact with local minorities (see Annex 18 of the Annex report).

12.5.7 Livelihoods and Key Resources – Impacts and Mitigation

The TRHDP is likely to affect the livelihoods of households using resources located close to the dam, reservoir, headrace, powerhouse, power transmission line, or access roads.

Based on the fieldwork and consultations with local people, stakeholders and experts, the impacts on local livelihoods of the development of the Project can be expected to mainly come from:

- Loss of, or damage to the natural assets upon which local communities' livelihoods depend, including the Tina /Ngalimbiu River, food gardens, forests, and areas used for hunting, gathering and fishing;
- Damage or improvement of physical assets and infrastructure, such as tracks, roads, and water supplies, and;
- The opportunity for paid employment and provision of services to the project.

Most households of the study area rely on their own local natural capital as the basis of their livelihood and to meet their basic needs. However, they are increasingly tied into the modern urban-based economy. This is evident in the growing role of cash, which is needed for goods and services, such as food, household fuel and consumables, telecommunications, transport, and school fees. The construction and operation of the TRHDP could bring about change or opportunities for change, in the way some people obtain their livelihoods.

12.5.7.1 Infrastructure

The main impact of the TRHDP on the physical infrastructure of local communities is likely to be unintentional damage to infrastructure (e.g., houses, fences, foot tracks, village access roads, bridges, and water supplies), due to the construction and upgrading of the Black Post Road to allow the construction traffic. Once completed, the proposed road is expected to accommodate 25 to 40 project related vehicle trips per day, during the construction season, over a three-year construction period (Entura, 2014). Project traffic will mainly consist of light, medium and heavy vehicles, including vehicles carrying workers, materials, and heavy equipment. Most traffic movements will be confined to daytime.

Infrastructure damaged as a result of construction activities will be repaired or replaced by the TRHDP. A water system will be installed to provide villages with clean potable water. In addition, the access road will be an improved transportation infrastructure facility connecting villages in the project area with Honiara. Access to electricity will be provided through electrification of villages.

12.5.7.2 Small-Scale Timber Harvesting and Timber Milling

Small-scale timber milling represents a major financial input for indigenous communities of Bahomea. Forested lands, currently accessed for small-scale timber production, will be affected by the land acquisition process.

Landowners engaged in timber extraction in the Tina Valley (mainly between Senge and Choro) expressed their concerns regarding the impacts of an altered river flow on their ability to raft sawn timber downstream from the harvest sites to various transport pick up points. Non-timber forest products, including wild foods, medicinal plants, and building materials that are currently available in areas that may be required for the Project (e.g., near Mangakiki and Senge where new access roads will be built) will be lost and become locally scarcer.

Construction of the Project will require permanent clearing of 115.49ha of native vegetation, of which 51.0ha is forest (see Table 12-1). The majority of forest will be removed from within the reservoir area and along the access roads. In addition, the Project will modify the river hydrology, affecting the ability to transport sawn timber from the areas where it has been harvested, downstream to village haul out sites.

The potential impact of forest clearing is low; the amount of forest that will be cleared represents 0,9% of the total area of non-montane forest in the catchment. In the short term, the loss of timber will be partially offset by the plan to engage local workers to clear trees from the reservoir are

Table 12-1 Area of vegetation permanently lost due to project

Grasslands (ha)	Undisturbed forests (ha)	Disturbed forests (ha)	Remnant forests (ha)	Montane forests (ha)	Riparian (ha)	Cliffs (ha)	Garden (ha)	Fallow brush land (ha)	Total surface of habitat directly lost to construction activities
20.30	**9.54**	**29.65**	**11.87**	**0**	**21.62**	**16.12**	**0**	**6.40**	**115.49 ha**
	51.06ha total forest area removed								

The reduction in the river flow between the dam and the powerhouse, will make it impossible during normal flow to float timber down the river from where it is harvested in the Choro and Koropa areas to the traditional haul out sites that are located near villages downstream. The TRHDP PO has suggested that, if necessary during periods of extended natural low flow, additional water could be released down the river channel to assist in timber rafting. If this is done, it should be preceded by warning to the public, since villagers, may increasingly use the dry banks created along the Tina River as walking paths. Other arrangements are also feasible, such as timber rafting during the anticipated dam spillover events, and if necessary, the creation of regular truck-accessible haul out sites beside the river and at the future reservoir, using the dam access road.

In the long term, the creation of a new dam access road could provide better access to areas in the upper catchment for small-scale timber production by local landowners. Use of the road for this purpose will depend on the proposed management by TRHDP, and the land-owning/holding company to be established as part of the Project. At present, it is proposed to limit the use of the road to Project related activities to prevent increasing logging of native forests.

12.5.7.3 Extraction of Aggregates from the River

The following discussion is predicated on the assumption that the proposed TRHDP dam may significantly reduce the recruitment of construction grade aggregates (i.e., sand and gravel) in the lower Ngalimbiu River where they are currently mined. However, the recent study by Ian

Jowett predicts that changes to downstream gravel levels, if any, will not eventuate for a considerable period of time.

Communities in the lowest part of the catchment are particularly concerned about the potential effect of the dam on the transport and deposition of aggregates. Were the dam to have such an effect, the construction of the dam may also have an impact of sale of sand and gravel, which is an important source of income for many communitities in the project area.

The Ghaobata people, located in the lower part of the catchment on the Guadalcanal plains, rely on royalties from gravel extraction from the Ngalimbiu River. This particular material is of high quality and is a key source of aggregate on northern Guadalcanal[79]. Gravel extractions by communities located in the Upper Ngalimbiu River and in the lower part of the Tina River catchment are sporadic, of low volume, and for domestic use. Throughout the Bahomea district, people occasionally use gravel and sand from the riverbed to make concrete for building their houses, or other types of construction. These extractions do not appear to be a source of revenue for the Bahomea landholders.

Participants in the ESIA workshops, household surveys (with the Ghaobata communities at Ravu and old Selwyn) and the mitigation workshops (held by the GPPOL settlement) expressed their concerns about the future of gravel resources once the upper part of the Tina River is dammed and once the flow regime is altered. They also expressed their willingness to provide more information about the gravel extraction rates and the royalties paid to local tribes.

Sand and gravel is excavated by loaders and trucks directly from several places in the lower river near Ravu, and downstream of the Ngalimbiu Bridge. There are stockpiles of sand and grit near old Selwyn, and there is a gravel yard, screen, and elevator at the Lee Kwok Kuen and Co (LKK) farm. In mid-2013, the Ghaobata landowners received royalties ranging from SB\$390/m^3 to SB\$500/m^3 of material. The main client was Dalgro Ltd, which was sourcing approximately 200 m^3 per day during the dry season. Solomon Sheet Steel Ltd was also reported to be sourcing gravel from the Ngalimbiu. Apart from the commercial operation of LKK, the communities involved in gravel extraction include Ravu (with about 16 hamlets) and Old Selwyn/Popoloi.

As confirmed from Geotech investigation at site option 6A, the alluvium depth at this site is 25 meters. As such, the river will continue to replenish gravel for the downstream communities, and the impact of reduced gravel may not be experienced, if at all, by the downstream communities for a very long time. A regular monitoring program to confirm gravel levels at intervals downsteam of the dam should be carried out to confirm whether any impacts on downstream gravel users are likely to occur.

[79] According to Tawake (2005:17), in the Ngalibiu River near the bridge, “the river aggregate deposits are composed largely of igneous rock fragments with lesser limestone constituents. Igneous rock fragments comprise plutonic rocks and slightly less volcanic rocks”. The surface area of the resource at the extraction site in 2005 was estimated at 10,000 sq. m. Tawake also noted that there was “No standard compensation and royalty rate paid to resource owners to compensate for the use of sand and gravel on traditionally-owned land” (p25).

12.5.7.4 Natural Capital

12.5.7.4.1 Access to Natural Capital

The loss of natural livelihoods assets is one of the main concerns of local communities. All the indigenous people of Bahomea and Malango have rights to utilise natural resources of the Tina/Ngalimbiu River catchment, though it is mainly the people of Bahomea who actively exercise those rights for their livelihoods. These include the people residing in the Downstream Area and Infrastructure Impact Area. However, only a limited number of local clans have ownership rights of the land and resources of the 4.288km^2 project Core Area[80].

Most of the permanent loss of natural capital will result from the creation of the hydro storage reservoir, the creation of the access roads and, to a lesser extent, the construction of the dam and powerhouse. Temporary loss of access to natural resources within the upper Tina River watershed will occur during construction.

12.5.7.4.2 Land Use

The land required for the project includes:

- Partially logged and intact forest lands, used by some households as a source of wild foods, building and craft materials, traditional medicines, hunting, and bush tracks;
- Sections of the Tina River, including:
  - the water of the river, along with the environmental and human-related services it provides (e.g.washing, bathing, water supply, transporting timber, and gravel extraction);
  - the riverbed, including rock pools, and other locations used for fishing, tracks, and sacred sites;
  - tributary streams, used as sources of wild foods, and as ownership markers, and;
  - riparian margins, used as sources of wild foods, and containing former habitation and sacred sites.

The creation of the proposed access road above Mangakiki is likely to require only minimal disturbance to garden land or areas for collecting forest resources, since the area has already been harvested for its timber and modified by logging. Building the road section down into the dam site from the ridge will require the removal of small amounts of relatively intact natural forest. Land for the access road, dam site, quarries, and the storage reservoir will be acquired by the project[81]. No land used directly for human occupation will be required for the construction of the project.

The powerhouse will require an area of very steep land several hundred meters downstream of Senge on the left bank of the Tina River. This area does not appear to be used by existing villages. The proposed powerhouse access road, which begins at the logging road south of

[80] The identification of the relevant landowners was completed subsequent to the preparation of the SIA report. According to a press release (dated 17 July, 2014) it was determined that the Core Area belongs to 4 landowning tribes: Kochiabolo, Roha, Buhu Garo, and Vuralingi, who together consented to make their land available to the SIG for the project.

81 Subsequent to the SIA, the identified landowners and the SIG entered into an agreement for the government to acquire the land for the project, and the formal declaration for acquisition by the Minister of Lands was gazetted in August 2014 (project office press release, 3 September, 2014).

Mangakiki, on the ridge above Senge, is likely to require land containing trees and plants that are used by local households, and will possibly subsume parts of the main bush track to Senge (see Figure 12-8). Satellite imagery from August 2013 suggests that the road may affect land previously cleared for food gardens. The earthmoving required to construct the road, which traverses the ridge and slopes above Senge, could potentially damage resources belonging to the village if not carefully managed.

Section 12.4.2 – Land Ownership, noted that all of the customary land taken for the project was previously owned by local indigenous people and is valued by them. The LALRP sets out the process and measures for identifying and compensating for land value and loss of resources (plants/hunting etc.). However, it is not expected that the loss of the land required for the project will have significant adverse impacts on local livelihoods.

The LALRP assesses and addresses the livelihood impacts of the land acquisitions and covers the impacts of acquiring title to the Core Land.

The TRHDP PO has proposed that the land in the designated Core Area become legally owned/leased and registered to a Tina Core Land Company – a 50:50 joint venture between the traditional land owners and the SIG. This company would then lease the various sites to the developer and would then determine future rights of access and uses of the Core Area, including the storage reservoir.[82]

12.5.7.4.3 Water Use

Water Quantity

Notwithstanding that there will be reduced flows in the Tina River between the proposed damsite and the powerhouse, the TRHDP PO reports that there will be sufficient permanent flow to meet the consumption needs of villagers from Choro, Koropa, and Senge, once the project is operational. As noted, at minimum flow there will not be sufficient water or current in this section of the river to float rafted timber downstream to haul out sites at Habusi, Antioch, and Tina Village. The powerhouse tailrace structures and outflow may also present a physical barrier to timber rafting and a safety hazard. Reduced river flow for most of the time will make the riparian areas between Senge and the dam site more accessible to landowners, and possibly encourage an expansion of livelihoods activities in that area.

The reduced nighttime flows downstream of the powerhouse will likely to be noticeable during periods of natural low flow in the Tina/Ngalimbiu River catchment. There are implications for communities living adjacent to the river downstream of the powerhouse in terms of timing and safety of river-based activities such as bathing, washing and recreation. A staged release of flows through the power station in the mornings is proposed to minimize safety risks.

Water Quality

The construction, upgrading, and use of the road, during the project construction period, may disturb and damage existing water resources used by villages adjacent to the road (e.g., Marava, Vera'ande, Verakabikabi, Valesala/Antioch, Verakuji, and Mangakiki) (see Figure 12-7). In addition, the construction of the new section of road at Rate may also damage the catchment area for the Verakabikabi water supply, and minimally, will pollute the water (see

[82] See Project Office press release, "Tina River Core Land Owners Give Consent" dated 17 July, 2014)

Annex 17 in the Annex Report). Water quality could also be reduced due to fuel spills, sewage disposal, and chemical leaching and spills at the dam and powerhouse construction sites, or the incorrect management of concrete waste water or sediment run-off from cleared areas.

Almost all of the communities in the Tina/Ngalimbiu catchment rely on the Tina/Ngalimbiu River for their domestic water supplies. Consequently, the potential loss of access to clean and potable water due to river pollution and sedimentation during the construction of the dam, is a major health concern for all the riverside communities of the Downstream Area, especially for women. While villages along the Tina Road get their water from other sources, they are still concerned that construction activities, such as road building, will disturb and contaminate these sources of water. Water pollution problems often occur after heavy rains, due to land disturbances, such as logging.

In addition to concerns about the water taken from the Ngalimbiu River for domestic purposes, the Ghaobata communities of the lower catchment on the Guadalcanal Plain, are worried about the effect of the dam on the water levels in their wells and boreholes, especially in the dry season. Throughout the project area, members of all riverside communities noted the potential impacts of reduced water quality and availability on bathing, washing of clothes and food, recreation, and fishing. Women expressed particular concern about these matters.

The TRHDP PO has agreed to provide alternative water supplies to local communities. Options include:

- River-based supply with appropriate treatment systems and supply points for each village;
- Rainwater collection and storage tanks and/or regular transportation and distribution of clean water by tanker truck;
- Establishment of alternative supplies from local streams, and
- Borehole / ground water supplies, piped to several villages / hamlets..

Figure 12-7 Locations of the known water supplies adjacent to the Tina Road (blue drops)

Source: base map from Google Earth, 2014

12.5.7.4.4 Hunting and Fishing

As described previously, all of the indigenous communities of Bahomea and some of the adjacent Malango communities occasionally use the rivers, streams and forests of the upper Tina River catchment for hunting, fishing and camping. The household survey found that game animals and fresh river fish are no longer common in local peoples' diets. Hence, hunting - and to a lesser extent fishing - tend to be seen as a cultural activity involving young people and to provide wild pork for church and community feasts, rather than as an essential part of peoples' livelihoods. In contrast with some Ghaobata households, fishing is not a source of income for people of Bahomea.

The extent of the loss of fishing, hunting and gathering opportunities will depend on the access arrangements for and future management of the upper catchment.

Some fishing spots could be permanently lost. Conversely, the proposed storage reservoir may provide future aquaculture and fishing opportunities.

Downstream of the dam site, the river will become more turbid due to reservoir clearing, cofferdam installation and removal, and other riverbed disturbances during construction, and will be less suitable for spear fishing using snorkel diving gear. Conversely, the new access road will enable landowners (and potentially outsiders) to access fishing spots upstream of the construction area more easily. The TRHDP PO has suggested that access to upstream areas via the new road, would ultimately be determined by the Core Land Company, subject to the mitigation measures recommended in the ESIA.

Poorer water quality caused by construction could also have a negative impact on the fishery at the mouth of the Ngalimbiu River, although this is considered unlikely. Gravel mining in the lower Ngalimbiu River bed already introduces sediment to the river, yet fishing appears to continue.

During project operation, the main effect on fishing will be the reduced number of rock pools where people spearfish. This will occur in the reach of the Tina River covered by the reservoir, and in the reach that will have reduced flow. In addition, there may also be changes in the fisheries due to the barrier to migration of the dam and powerhouse turbines. The study by Ian Jowett suggests that the reduced flow in the river will be advantageous to certain fish species, detrimental to others, and provide an overall increase in fish densities. Proposed mitigations include using trap and haul methods to move fish over the dam.

Hunting areas will also be lost, although the reservoir may provide better access to areas in the upper Tina River catchment, where hunting effort seems to be concentrated.

Specific hunting-related impacts mentioned by villagers include:

- Displacement of wild pigs, the main game animal, from riparian areas and possibly pushing them downstream and closer to settlements and gardens as occurred with logging. This migration of pigs could be accelerated by the creation of the new road, and;
- Displacement of waterfowl that rely on the river and adjacent streams for their habitat.

Measures to address livelihood impacts of reduced access to hunting and fishing, including providing ongoing access for local communities during the operational period, are set out in the LALRP.

12.5.7.4.5 Food and Materials Gathering

The riparian area (micro-wetlands) between Senge and Choro is reported to be a source of wild fruits, edible ferns, nuts, medicinal plants, plants deemed to have magical properties, and bush materials. These plants will be affected by the reduced river flow, since floods that periodically replenish the riparian areas, will be controlled by the dam. This could have consequences on the livelihoods and wellbeing of the four households in the two villages. It seems, from discussions with local people, that most materials should be available in other locations. The creation of the dam access road will reduce the availability of some materials and plants (e.g., in the road corridor), but will also make it easier to access alternative areas and supplies.

As part of any resettlement planning for the project, SIG has, in close cooperation with the affected landowners, investigated the occurrence of culturally or economically important plants in the core project area, that may be destroyed by the Project and for which compensation would be payable. A process for compensation and retained access for local users of the Core Land Area is set out in the LALRP.

12.5.8 Cultural Heritage – Impacts and Mitigation

The local indigenous people of Bahomea and Malango have traditional authority and use rights over the project area, and are concerned about the potential desecration and damage to their cultural sites as a result of the Project.

The most significant cultural impact of the project will be the loss of, and/or damage to, sites of importance to the indigenous people. The potential adverse cultural impacts include:

- the permanent loss of tambu sites, including natural features and objects, rock pools, streams, and former habitation sites within the proposed project area (Core Land); and
- during construction, disturbance to or desecration or destruction of tambu sites, graveyards and other places of social and cultural importance located next to the Black Post-Tina Road, and in the new road corridors.

The construction and operation of the TRHDP could have direct physical effects on several types of culturally sensitive sites. These include places of:

- long term cultural significance such as archaeological sites, historical places and former village sites; and
- religious or spiritual significance and associated with custom stories and ancestors (e.g., tambu sites, graves, custom houses, places of worship, and boundary markers such as special trees, rocks, streams). For example, people from Marava, Vatupaua, Rate CHS, Ngongoti communities noted that several burial places may be affected if the existing Tina-Black Post Road was to be enlarged.

Sacred sites may be owned by, or have particular importance to individual groups or clans, and underpin notions of identity and land ownership. Knowledge of the location and meaning of tambu places can, therefore, be a proof of land ownership. Thus, the information can be highly confidential. Unfortunately, only the very old members of a clan may have such knowledge, and there is “no effective system” for the management and protection of ancestral and scared sites and objects (Ministry of Culture and Tourism, 2012).

The protection of sites and cultural materials is covered by the “Nasinol Policy Framework *blong* Kalsa” (The National Cultural Policy Framework, 2012), which sees protection and preservation of Solomon Islands indigenous languages, arts, customs, traditional knowledge, and heritage as crucial for maintaining Solomon Islands peoples’ dignity and identities, and as ‘an essential component of the socioeconomic, political, and spiritual development aspirations of the

Solomon Islands" (SIG, 2012: 3). Policy goals listed in the framework document that are relevant to the TRHDP include:

19.1 The country has a proper and effective system for the management and protection of ancestral and sacred objects and sites;

19.2 The cultural heritage of the country is protected and preserved for the cultural education of today's youth and future generations;

24.1 The country has a national database and effective system for the management and protection of cultural landscapes of archaeological and historical significance;

24.2 Cultural landscapes of archaeological and historical value are integrated into cultural tourism development; and

24.3 Cultural education, historical knowledge and field research are enhanced and facilitated through the availability of well-protected and well-managed sites throughout the country.

Other than proposing a database, the Framework proposed no concrete steps for protecting culturally important sites.

The ESIA is limited as far as baseline studies of cultural heritage in the project area are concerned. Because most of the knowledge is kept confidential, investigators were not able to gain detailed information to locate all sacred or cultural sites for the potentially affected communities and landowners. In some cases, broad descriptions were provided during interviews with senior men. Riparian surveys conducted by Pacific Horizons Consulting Group (PHCG) in 2011 noted and mapped the locations and names of various streams and features between the upper end of the Tina River catchment and Pachuki (see Section 5 –Physical Environment Baseline). In addition, the approximate locations of some old villages were recorded. During the ESIA village workshops, the names of originating villages and the sequence of village settlements prior to the current settlement patterns were recorded, though exact locational data was not obtained. Also, the existence of present day graves and other cultural features were noted during the village workshops, though except in the case of Mangakiki and Verakuji villages, their exact locations were not recorded.

It is recommended that, prior to commencing any construction on the access roads or on the hydropower development sites, the SIG or project developers carry out a more detailed cultural heritage and sites monitoring program within the designated Core Area, and in the communities adjacent to any road building or upgrading. This monitoring should be undertaken by a suitably qualified heritage expert, working closely with the landowners, accompanied by an advisor from the National Museum. All sites should be recorded, mapped and photographed. Also, prior to construction, the TRHDP should be required to implement a protocol for managing cultural heritage (see Annex 18 of the Annex Report and the ESMP).

12.6 POTENTIAL BENEFICIAL SOCIAL IMPACTS

During the mitigation workshops, participants were asked to share their expectations and hopes on the benefits of the Project to them and their communities.

12.6.1 Access to Electricity

According to the communities, bringing electricity to villages, churches, and houses is the main benefit of the TRHDP. This is a strong indicator that local people understand the nature of the proposed hydroelectric development and the benefits of having electricity.

Based on the workshop consultations and the householder surveys, electric lighting is the most sought after benefit of the project because it will:

- Enable children and adults to study in the evenings;
- Provide security in the home and around the village, especially for women;
- Increase levels of community interaction, by facilitating evening gatherings and, thus enriching the community life.

Having their own electricity supply will enable households to take advantage of modern electrical appliances and machines, specifically:

- Refrigeration, providing greater food hygiene and security and, therefore, providing financial and health benefits;
- Electric cookers and washing machines, which will reduce the level of manual labour and resources currently required for cooking and washing, and improve the quality of women's lives;
- Home and community entertainment systems, which are seen as providing educational, psychological, and socio-political benefits, and reducing the sense of isolation; and,
- Use of power tools and machinery, especially for carpentry and building, sewing, and craft work, which will enable the establishment of small businesses and workshops, and provide additional income opportunities for both males and females. Power tools will also considerably reduce some of the heavy labour for men in building, improve efficiency and productivity, and improve working conditions.

12.6.2 Increase in Employment Opportunities

The principal benefit to human capital from the TRHDP will be additional employment opportunities. Stakeholders believe that the construction of the project will provide opportunities for direct and indirect employment, for both males and females, and for landowners. The TRHDP PO anticipates that the construction of the TRHDP will require up to more than 300 workers at its peak. The percentage of locals in the workforce is expected to be high, as the developer for TRHDP will not be permitted to employ any semi-skilled or unskilled foreign workers and training is to be provided to improve local residents' opportunities. The actual number of people recruited locally will depend on the skills required and the availability of jobseekers.

The landowners and communities of Bahomea and Malango are expected to be given priority for employment on the Project and to receive training in plant and machinery operation, administration and security work. Some local people will take advantage of providing goods and services to the project such as food preparation, cleaning, and security. On the operations side of the project, young people may see opportunities of developing new careers and providing ongoing services. New opportunities associated with the new reservoir (e.g., tourism and possibly fish farming) are also possible. Finally, these potential business and employment opportunities could improve income diversification and standard of living.

The World Commission on Dams (WCD) notes that the wages paid to construction workers represent the single largest social benefit during the construction phase of a hydropower project. The social benefits have positive consequences on the workers' families and community. Jobs may be created to provide support services to workers and to the Project (e.g., accommodation, meals, transport and retail). Off-site jobs may also be created in the manufacture, supply of construction materials, and transportation.

Priority is given to employment of people from the project's immediate area of influence. Workers from outside the host community will also be needed, chiefly for technically specialised skills which may not be available locally An influx of job-seekers into rural and isolated areas can have an adverse impact on local communities and the environment; to preclude this induced effect the developer will provide for accommodations for all non-local workers in Honiara.

Some local residents may be trained to fill operational positions. There may be a small number of other paid jobs (e.g., site security) for local people during the operations phase of the Project once it has been commissioned. Routine maintenance will be done under an Operations and Maintenance contract with the THL. The required operational workforce is still under consideration.

12.6.3 Livelihoods Strategies

During construction of the Project, people who are working on the TRHDP are likely to spend less time producing food from their gardens. Findings of the community workshops highlighted a variation in nutrition, with an increase in intake of imported carbohydrates. These variations were attributed to an increased reliance on cash from paid employment, timber sales, rents and royalties from Gold Ridge mining and from natural forest logging.

Finally, in the longer term, the TRHDP is likely to have a positive benefit in local people's livelihoods. Improvements to the road infrastructure could make life easier and provide better access to Honiara's markets. The much-desired electrification of local villages could bring diversification in household livelihoods, with the opportunity for home-based manufacturing and artisan activities. This would reduce household income vulnerability. Provision of other benefits, such as reliable water supplies within the villages, would reduce the domestic workload on women and girls, and free them up for other income-generating work.

12.6.4 Improved Education and Skills

If suitable training and learning arrangements are put in place, the Project offers an opportunity for developing new skills for the indigenous people through pre-employment job training through institutions, and on the job training[83].

The local landowners anticipate that the SIG will provide education and training sponsorships and scholarships as part of a benefits program. The opportunities for education and training will become clearer once project planners have identified the workforce requirements, and employment policies have been developed.

It is recommended that the TRHDP PO survey local villagers to identify people interested in working on the project construction, and that the survey include a preliminary skills and experience audit. On the basis of the survey and the workforce requirements, the contractors,

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[83] Don Bosco Technical Institute and the Solomon Islands Association of Rural Vocational Training Centres offer village-based and residential training in relevant areas (See http://www.siartc.org.sb/publications.html)

working with SIG and local training providers, should facilitate community participation in the project, by providing:

- Project work-readiness courses to job seekers/aspirants in the project area, including resume preparation, work safety and health, and money management, and;
- Training, where possible, in specific skills (e.g., driving, plant operation, trades assistants, etc).

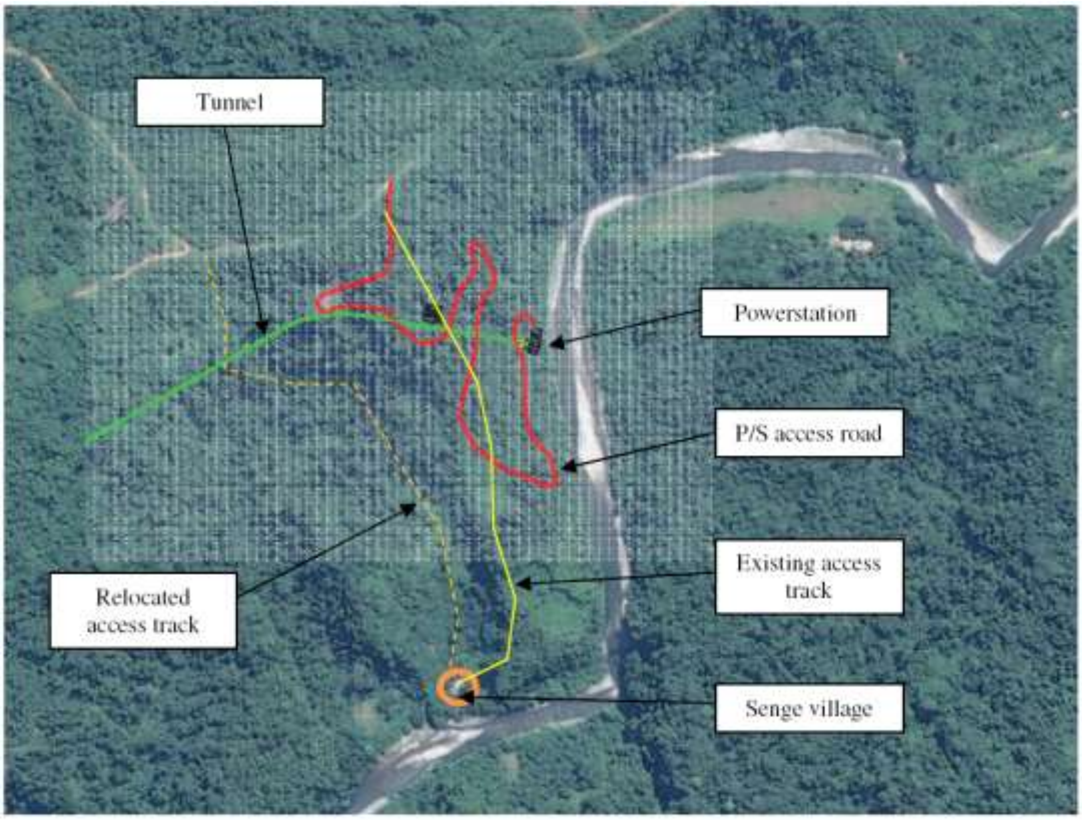
As part of a promised benefits sharing program the SIG has begun implementing a much needed and well-received $2 million upgrade to schools in the Bahomea area. The project could also support transportation to the schools.

12.6.5 Ecotourism Opportunities

One on hand, tourism could be enhanced as a result of improved roads and access to the upper catchment. However, the reduced flow in the by-passed section of the Tina River could reduce the site's attractiveness for eco-tourists.

The access track to Senge Village (see Figure 12-8), which used to run a small-scale ecotourism operation[84] (receiving over twenty international visitors in 2013), will be disrupted by the access road to the powerhouse. Sadly, the manager of the Senge operation passed away and the homestay is no longer running.

Figure 12-8 Relocation of the footpath to Sengue



[84] See http:// www.sengevillage.com.

Various tourism development opportunities may be available for tribes/clans that are owners of the core land as well as neighbouring lands. These tourism opportunities are associated with the creation of the hydro reservoir and the possible future creation of a forest reserve in the upper Tina River catchment. Tourism could become a source of employment and revenue for these people. Over the long term, such development could be linked to a potential development of a trans-Guadalcanal trail, linking the North coast with the central mountains and the Weather Coast.

12.6.6 No Population Displacement or Resettlement

One of the main concerns of local people regarding the TRHDP is the change in the size and composition of the population in the project area. People fear that they will be swamped by squatters, and by workers from other islands. There are two ways in which hydroelectric developments typically affect the size, character, and distribution of the population by:

- Displacing existing residents from particular locations; and
- Introducing a construction and/or operations workforce which becomes temporarily or permanently resident in the host area.

The potential for such effects is discussed below.

12.6.6.1.1 Damsite and Reservoir

No houses or community facilities are located within the Core Area or the land required for the Infrastructure Corridor. For example, the village of Choro, is the closest settlement to the dam site, but is located 2.3km downstream outside the project Core Area, and has two elderly part-time residents. Senge Village is located 4.8km downstream from the dam site and has 3 households and approximately 16 residents. Although the construction of the powerhouse access road may cause disruption to people from Senge Village, no households will need to be relocated to make way for construction of the dam, quarries, or storage reservoir.

12.6.6.1.2 Powerhouse Site and Access Road

The proposed powerhouse will be located 5.7km downstream of the dam. Habusi settlement, which is located on the right bank of the river, is approximately 0.5km downstream of the proposed powerhouse site. Pachuki lies on the left bank 1km downstream of the powerhouse. Neither Habusi or Pachuki will require temporary or permanent relocation due to the construction of the powerhouse and tailrace.

Upgrading and realignment of the main access road to the project area (Black Post Road) will not require the resiting of any individual houses. Houses located very close to the road reserve could experience temporary disruption (vibration, noise, dust, physical danger) during the construction period.

In summary, the construction and operation of the preferred alternative (Option 7C) will not require any current villages to be relocated or residents to be displaced from their homes. Physical resettlement is, therefore, not required.

12.6.7 Improved Roads and Accessibility

The Black Post Road provides access to several communities located around the Tina village but not to settlements adjacent to the Ngalimbiu/Tina River. Settlements between the Tina village and Senge village can only be accessed on foot by bush tracks or along the river bed.

The upgrading of the existing Black Post-Tina-Mangakiki Road are seen by local people as a considerable benefit to the community. The improvement of the road will allow:

- Better and more reliable transportation services throughout the area;
- Reduce the maintenance costs for those who already have vehicles; and
- Improve access to health and other public services, facilities, markets, events, and employment opportunities both within and outside of the immediate district. Women see considerable benefits in being able to better access health services for themselves and for their children.

In the longer term, and providing the roads are maintained, the people of Bahomea will benefit from having a much higher quality and safer road than at present, which will enable the provision of better public transportation services to and from Honiara. Better quality roads will also mean shorter travel times and higher service reliability, especially during wet weather. Accessibility should, therefore, improve for all local rural communities, with flow-on effects to people's welfare and development.

12.6.8 Local Financial Capital and Economic Development

Local communities have considerable expectations that the TRHDP will be accompanied by a SIG funded benefits program, which aims to improve local services and facilities, such as schools, health centres, roads, water and electricity supplies. New schoolrooms and road improvements have already been provided by the SIG, which has fostered a degree of confidence in the ability of the Project to deliver benefits to local communities.

The fund will constitute a combination of a fixed annual sum and a variable component calculated from annual energy production. Annual payment into the fund is a part of the contractual agreements between THL, SIEA and SIG.

Based on previous and ongoing experience of developments in the Central-north Guadalcanal area, people in the wider project area believe that the TRHDP may be a good (and perhaps easy) source of income. Local people expect this to come from access fees, meeting fees, compensation (for the purchase of land and loss of livelihood assets) and community or individual payments for agreeing to the project. Some also expect to receive cash rather than traditional 'compensation' payments for damages to their land and resources. According to the local communities, such payments are seen to potentially improve their standard of living and status.

The TRHDP has already contributed - and will continue to contribute - to the amount of financial capital available to the communities of the project area. This contribution has come from:

- Payments to land owners for access fees, and for provision of services during planning and feasibility studies, and;
- Payments for the acquisition of the rights to use the Core Area.

Unfortunately, it is often reported in Solomon Islands that the distribution of royalties or other project payments is not done properly. Solomon Islands newspapers regularly feature articles about intra and intertribal conflicts and legal battles over land ownership, resource sales, and royalty entitlements. Research shows that only a fraction of the cash from logging royalties goes to the actual owners of the forest resources[85]. As a case in point, only a small amount of

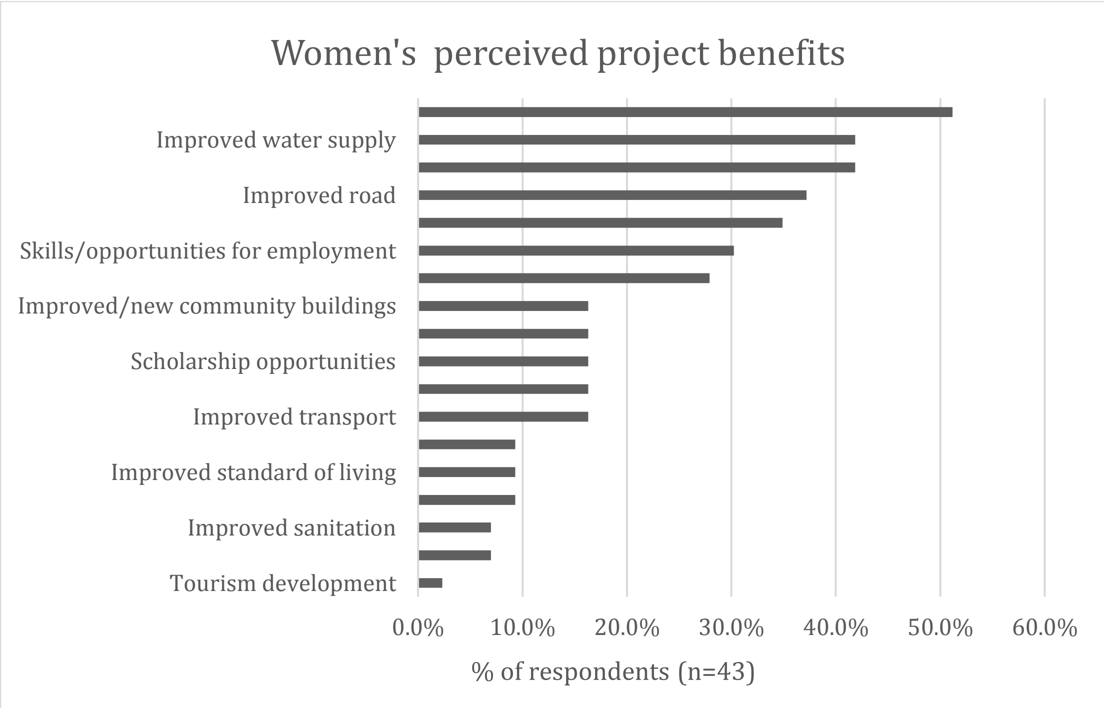
[85] Wairiu (2007) outlines a typical situation for Solomon Islanders with respect to logging income: 60% of the return goes to the contractor (often foreign owned), 25% goes to the government, and the rest (15%) goes to

the SB$2.7 million paid by the SIG to the 27 tribes/clans of the Landowners Council to obtain access to the project area for geotechnical and other studies appears to have found its way to individual households. The PO has terminated working with the Landowners Council and has addressed potential distribution problems. This is addressed through the arrangements in which compensation and acquisition payments have been and are being distributed directly to individual tribal members, set aside for investment, or paid transparently towards cultural expenses as set out in the LALRP.

12.6.9 Potential Project Benefits for Women

According to women's perception on the benefits of the TRHDP, the main benefits are: electric lighting; improved water supply; electric supply; improved roads; community facilities (e.g., clinic); and skills and opportunities for employment (see Figure 12-9). Other potential benefits of the Project are reflected in the survey results.

Figure 12-9 Women's perception on the benefits of the TRHDP



the 'fixer' – the local licensee (commonly a local leader/chief and deal organiser who obtain the legally required Government Timber Right – who in theory distributes the money to the land owners).

12.7 ECONOMIC ASSESSMENT

This section describes the economic and financial analysis for the project based on the feasibility study report, completed by Entura in March 2014. The economic assessment of the TRHDP is described in detail in Chapter 11 of the Feasibility Study Report.

12.7.1 Economic analysis

The Phase 3 feasibility study report conducted the economic analysis of the project based on the following parameters:

a) Diesel Capital and Operating cost – The capital and operating cost for diesel is based on Solomon Power's capital and operating cost from the Lungga power station. The analysis looks at future diesel forecast, diesel replacement and for the capital cost it looks at diesel plant investment and also the maintenance cost for existing diesel plants.

b) Hydro Operating cost – The hydro operating cost has considered both the fixed and operation cost of the project for the concessional period of the project. Furthermore, mid- life refurbishment has been included after 25 years.

c) Demand and Load Growth- Historical demand from Solomon Power Data has been captured in the feasibility study and this has also been used to project future growth demand.

d) Available Hydro energy – Due to the short duration of capturing hydrological data for the project (3 years), the economic model for the project also reflected this short duration and allows conservative estimates of annual energy due to the sensitivity of the hydrology.

e) Hydro Capital cost – The capital cost analysis looks at contract prices based on price estimates for Asian and Australian Contractors which allows for a low cost estimate and higher end cost estimate. The analysis considers capital expenditure to be spread over the construction period.

The Unit cost for electricity from the project is considered to be high for a hydro power project and this is due to the requirement for a medium height dam, a significant length of tunnel and also the project is in a country with significant high cost due to the remoteness of the country to the rest of the world. Tina River flow are low during the dry season, reducing energy production from the scheme. However, energy will be fully utilised by Honiara after commissioning of the scheme and will directly replace most of diesel generation. Due to the unpredicted nature of international diesel prices the scheme has a significant economic advantage over the current diesel generation for Honiara. The financing arrangement of the scheme also makes the scheme a viable economic option for the Solomon Islands.

13. ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

13.1 INTRODUCTION

This section sets out TRHDP's Environmental and Social Management Plans. It is, among other things, the basis for the construction (CESMP) and operations (OESMP) ESMPs that will be prepared by the Project Company. Information is provided on environmental and social mitigation measures, monitoring programs, capacity development and training, implementation schedule and budget, and project integration.

The developer is to prepare a CESMP and an OESMP as stand-alone documents, regarding this ESMP as setting out the minimum requirements. The developer is also to prepare a number of management sub-plans in accordance with section 1.1. The detailed management plans will identify specific measures for environmental protection and for mitigation of social impacts in line with this ESMP and the applicable policies of the World Bank and ADB and will provide specific actions to be taken during construction and operation, including roles and responsibilities, and timeframes.

In addition to World Bank assessment and approval, the developer's CESMP will be reviewed and assessed as a component of the developer's Environmental Impact Statement under the *Environment Act* and the OESMP will be prepared and submitted to the Ministry of Environment, Climate Change and Disaster Management prior to commissioning.

Overall responsibility for environmental and social management of the Hydropower Project will rest with the THL managed by K-water, which will, in turn, contract the construction day-to-day environmental and social management to the EPC contractor (HEC).

Solomon Power will have primary responsibility for the implementation of measures applicable to the construction and operation of the transmission lines. Solomon Power shall separately apply for the development consent for the transmission line works. SIG (through the TRHDP-PO), and WB, will undertake monitoring and oversight of environmental and social management, and project finance is allocated to supporting SIG in this role.

13.2 MITIGATION MEASURES

Mitigation measures are identified as those aimed at protecting the natural (physical and biological environment) and those that are focused on protecting the social (socio-economic / socio-community) environment, during construction, operation and post-operation phases, and ultimately, project decommissioning.

13.2.1 Measures to Protect the Natural Environment

This section presents good international industry practice (GIIP) for activities such as forest clearing, vegetation control, earthworks, and access road construction, that may adversely affect terrestrial and aquatic ecosystems.

In addition to the specific measures outlined in this section, it is recommended that the following information sources be consulted:

- Best Management Practices presented in the document “Low-Volume Roads Engineering Best Management Practices Field Guide, USAID (2013); and
- Roads in Rainforest: Best Practice Guidelines for Planning, Design and Management. Guidelines prepared for the Queensland Department of Transport and Main Roads and the Australian Government’s Marine and Tropical Sciences Research Facility (2010).

13.2.1.1 Reservoir Preparation, Filling and Operation

Reservoir vegetation clearing will reduce the emission of GHG from the reservoir. The level of reduction is, however, impossible to predict since GHG are also produced from organic matter trapped in river bed load material and sediment. Clearing will also reduce the amount of biochemical oxygen demand resulting from decaying plant material that can impair reservoir water quality.

Impacts Addressed:
Reservoir Preparation: Impacts of GHG Emissions on physical environment (see section 9.2.3.5) Impacts of increased suspended solids and siltation on aquatic life (see section 11.4.3.1) Impacts of River Pollution on aquatic life (see section 11.4.3.2) Disturbance to aquatic habitats and aquatic life (see section 11.4.3.3) Impacts of temporary diminished water quality and quantity on aquatic environment (see section 11.4.3.5) Temporary de-watering impacts on aquatic environment (see section 11.4.3.6) Reservoir Water Quality (see section 11.4.4.8) *Reservoir Impoundment:* Impacts on Surface Hydrology (see section 9) Impacts on aquatic life of reduced flow (see section 11) Impacts on water users (see section 12)
Measures:
Reservoir Preparation: Prior to reservoir impoundment, trees with a diameter larger than 10cm will be cleared from within the reservoir area up to an elevation of 186.5masl, which corresponds to Maximum Flood Level (11.5m above FSL 175masl). Loose rocks and rubble along the steep faces of the river gorge will be removed where possible.

Reservoir vegetation clearing will be conducted during the latter phase of the construction program, as the dam and powerhouse are nearing completion, just before reservoir inundation is set to commence. The timing is critical so as not to enable vegetation to regrow or become re-established before water is impounded. Depending on the schedule for reservoir filling, vegetation clearing may proceed in distinct phases, with the lowest elevation areas of the future reservoir inundation zone being cleared first, followed by the higher elevation inundation zone. Ideally, all plants and topsoil should be stripped off of the future reservoir to limit organic matter decomposition in the lower layer of the reservoir creating anaerobic conditions. Due to the steep topography, vegetation is to be manually removed by workers hired from local communities, and that the relatively thin layer of organic topsoil be left in place. Sawn timber could be transported either by access road or by river as it is currently done from Choro and Koropa. Vegetation clearance will be carried out during the dry season where possible. Use of Glyphosate or any herbicide to kill trees is strictly forbidden during all vegetation clearing activities including vegetation control under the transmission line. Reservoir clearing will not involve grubbing (removal of stumps) and soil stripping, since only manual work will be feasible. Reservoir to be demarcated with spray paint to avoid encroaching on additional natural habitat *Reservoir Impoundment:* ▪ Maintain an environmental flow of 1m^3/s during reservoir impoundment at all times.

Implementation Actor:	**Oversight Actor:**	**Costing/Funding Source:**
Developer Local Community (for reservoir clearing)	TRHDP PO	PPA

13.2.1.2 Hydro Facility Operation

Impacts Addressed:

Reduced Flow Between Dam and Powerhouse: Physical impact of reduced flow between the dam and power station during normal operations on surface hydrology (see section 9) Indirect impacts on fauna species (see section 10.6.1.2.1) Impacts of changes of flow downstream of dam on aquatic life (see section 11.4.4.4) On-going disturbance to downstream aquatic habitats (see section 11.4.4.10) Impacts on water users (see section 12) *Reduced Overnight Flow:* Impacts of reduced river flows downstream of dam site during overnight reservoir refill on surface hydrology (see section 9) Impacts on aquatic life of reduced flow (see section 11) Impacts on water users (see section 12) *Reduced Sediment Transport:* Impact of physical reduction of sediment transport (see section 9) Impact of reduced sediment transport on aquatic life (see section 11) Impact of reduced sediment transport on gravel extraction activities (see section 12) Impacts of reservoir sedimentation on aquatic environment (see section 11.4.4.2)
Measures:
Reduced Flow Between Dam and Powerhouse: Maintain a minimum environmental flow of 1m^3/s at all times in the bypassed section of river between the dam and power station *Reduced Overnight Flow:* Recommended to maintain a minimum flow of 3.4 m^3/s flow below the power station during over night reservoir refill. One option for achieving this is to maintain the 1m3/s environmental flow and continue to run 2.4m3/s through the power generators. *Reduced Sediment Transport:* Flushing to be undertaken periodically. An outlet of 3x3m is proposed near the power intake at 160masl. Once sediments reach this level, the outlet will be used either for local flushing or for lowering the reservoir to permit dredging/excavating of accumulated sediments. Storage operation to be designed to enable occasional dewatering for the purposes of excavating or dredging accumulated bed load sediments. The design study should consider access to the reservoir to excavate the accumulated bed load.

Implementation Actor:	**Oversight Actor:**	**Costing/Funding Source:**
Developer	TRHDP PO	PPA

13.2.1.3 Barrier to Fish Passage, and Fish Entrainment

Impacts Addressed:
Barrier to Fish Passage: Barrier to passage of migratory fish species (see section 11.4.4.3) *Fish Entrainment:* Barrier to passage of migratory fish species (see section 11.4.4.3) On-going disturbance to downstream aquatic habitats (see section 11.4.4.10)
Measures:
Barrier to Fish Passage: Implement a trap and haul system in accordance with section 11.3.2 *Fish Entrainment:* Proposed to increase the normal operating level to near full supply level, during the first month of the wet season, to facilitate the downstream movement of adult eels over the spillway during floods. The loss of generation resulting from increasing spill would be partially offset by the increased generation from the extra head on the turbines. Proposed to install 15-25 mm screens in front of the intake structure to prevent the ingress of large eels.

Implementation Actor:	**Oversight Actor:**	**Costing/Funding Source:**
Developer	TRHDP PO	PPA

13.2.1.4 Access Road Location, Design, Construction and Operation

Impacts Addressed:

Location and Design:

Slope stability and geological impacts (see section 9)

Erosion (see section 9)

Human encroachment to upper Tina (see section 12)

Installation of Drainage Works and Stream Crossings:

Construction and operation impacts on fauna (see section 10.5.2.1)

Impacts of hydrological changes on flora (section 10.5.1.2.1)

Impacts of increased suspended solids and siltation on aquatic life (see section 11.4.3.1)

Impacts of River Pollution on aquatic life (see section 11.4.3.2)

Impacts of diminished water quality and quantity on aquatic environment (see section 11.4.3.5)

Disturbance to aquatic habitats and aquatic life (see section 11.4.3.3)

Environmentally and Culturally Sensitive Areas:

Impact of deforestation on environmentally and culturally sensitive areas (see section 9)

Road Access Restrictions:

Operational impacts on flora (see section 10.6.1.2.1)

Measures:

Location and Design:

Retain structures, such as gabion walls and remove of upslope colluvium to minimize the risk of landslides occurring during both access road construction and operation.

Upgrading of Black Post Road to be carried out in close consultation with the relevant villages, including with respect to village water supply locations.

Access roads to quarries to be unsealed to allow vegetation to regrow after use and to avoid encouraging human settlement in upper Tina areas.

Temporary roads to be permanently closed at Project completion. This requires removal of all stream crossings, breaking of road surface (scarification) to allow vegetation to regrow and installing earth mound at road entrance. Important cut areas to be refilled with excess soil.

Road shall have surface drainage and subsurface drainage. Proper compaction of the subgrade and pavement will improve subsurface drainage. If necessary, under-drains to be installed.

Sufficient cross drains will be installed to avoid erosion. Drains will not be hydraulically connected to streams. Instead, they will exit via ditches into stable, vegetated areas or discharge into settling ponds.

The period of time between forest clearing and sealing of the road will be minimised to avoid erosion of exposed soil. Sediment control structures (e.g., silt fences, settling ponds, blind ditches, French drains, etc.) will be installed as earthworks progress along the access road. Along earthworks and work areas where disturbed soil may remain exposed during construction, ditches will installed to receive stormwater, and to drain exposed soils. These ditches will drain to vegetated areas or, in the case of spoils disposal sites or soil stockpile areas, to settling ponds. Settling ponds will be built to allow for percolation and dimensioned to receive stormwater inflows during heavy rainfall events, and to allow sediment to settle out of suspension. Wherever small channels of stormwater are identified during construction, they will be temporarily diverted away from areas to be cleared of vegetation. However, this does not apply to permanent streams whose channels will not be diverted. After initial clearing, culverts will be installed within small channels.

Ditches along the access road will never directly drain water to water bodies or wetlands. Surface drainage will be directed to silt fences, vegetated areas or erosion control mats.

Keep haul roads off sloping terrain wherever practical.

Depositing soil outside the limits of access road earthworks prohibited within 100m of nearby streams.

Design the slope of a cut to minimise the angle of incline.

Installation of Drainage Works and Stream Crossings:

A watercourse crossing management plan will be produced by the construction contractor prior to construction

Surface watercourses in vicinity of access road shall be geo-referenced and physically delineated during the rainy season, to ensure that crossings are properly sized taking into account high flows.

All identified tributary streams in the vicinity of construction activities to be protected by fences.

Sites for crossings shall be identified prior to forest clearing to ensure that they are excluded from alignment clearing since clearing at stream crossings will be undertaken within a narrower corridor. Deeply anchored silt fences will be positioned to avoid sediment from entering streams during earthworks.

Where a road will cross a stream the road crossings shall be constructed perpendicular to the stream to reduce the area of disturbance

Culverts shall be equipped with head walls to ensure long-term stabilization of the crossing and their outlet shall be protected with riprap to avoid erosion. Culverts will be open bottomed, and not alter stream bottom elevations.

Culverts and stream crossings will be constructed with the use of an excavator, instead of a bulldozer, to avoid excessive soil disturbance and to avoid sediment laden soils from entering into the watercourse.

Fauna friendly underpasses/culverts shall be constructed under access road at stream crossings. Culverts shall be large enough to provide dry passage for terrestrial animals (i.e., reptiles and small mammals). In addition, it is recommended that wildlife passage culverts be installed in such a manner as to allow wet passage for amphibians and fish, and dry passage for amphibian, reptiles, and small mammals (see Figure 13-1).

The dry passage will provide suitable cover such as rock piles, logs, and brush. For example, ledges will be large enough to allow Cuscus to cross (with a width of 1m).

Size and type of stream crossing will be designed to avoid affecting the flow (i.e., the crossing will be large enough to pass design flood flows), to allow debris to pass and to miminize environmental impacts. In addition, due to the nature of the environment, metal trash-rack should be installed just upstream from stream crossings to prevent debris from blocking culverts.

Figure 13-1 Culvert with dry passage for reptiles

Source: Vinci autoroute, 2014

Environmentally and Culturally Sensitive Areas:

Once the final access road alignment has been determined, and all areas that require forest clearing have been identified, a botanist will walk the full length of the road (starting from Mangakiki) and other areas where construction will take place to geo-reference and fence environmentally and culturally sensitive areas such as:

- Wetlands;
- Streams;
- Rare, endangered plants and culturally or economically important plants colonies; and
- Large trees that need to be kept to maintain canopy closure to decrease the amount of edge-effected forest.

Fencing will be done using orange plastic construction fencing material supported on wooden or steel pickets.

Once fenced, each environmentally or culturally sensitive area will be mapped. The map of these protected sensitive areas will then be presented to a committee comprised of the resident engineer for the dam construction, construction contractors and forest clearing subcontractors, and the independent environmental expert. This committee will discuss potential solutions for protecting each sensitive area identified, including:

- Wetlands located in the right-of-way – if road alignment bi-sects a wetland then culverts shall be installed. If the work areas are located in a wetland, they shall be relocated nearby.
- Streams located in the right-of-way – sites where the road will cross streams will be fenced to denote the site of the crossings, the areas outside of which would be “no go” zones. Work should not occur within the wetted perimeter of any streams. Stream crossings requiring bridging should be clear-spanned.
- Rare or endangered plants in the right-of-way – in case of encounter avoidance measures will be discussed to adapt road alignment or to relocate work area. If measures to avoid endangered plants are not possible, then transplanting plant colonies should be considered an option. Plants would be relocated as far as possible away from the area of disturbance under the supervision of a botanist.

Large canopy trees – large trees that provide canopy cover will be protected from unnecessary clearing, wherever possible. Fencing will be placed around these trees.

Road Access and Land Occupation Restrictions:

Extension of Black Post Road from Mangakiki to dam site to remain a private access road that will be gated. Access will be restricted by the Project Company and the TCLC to local population and hydropower facility operator. Commercial logging trucks will be prohibited.

The TCLC and Developer will not permit anyone to live or construct housing within the land leased for the project, except where strictly necessary for project activities, including housing fort rangers or security staff.

These measures will be developed and implemented with the assistance of the TCLC, and set out in the Biodiversity Managemept Plan and Construction ESMP. The plans will include enforcement measures to prevent the use of the land for a workers camp. The

BMP will also address restrictions on the use of the private project road through the Core Area by people seeking to build new settlements beyond the Core Area.		
Implementation Actor:	**Oversight Actor:**	**Costing/Funding Source:**
EPC contractor (HEC)	THL	Part of the main Project

13.2.1.5 Vegetation and Forest Clearance

Impacts Addressed:
Extent of Clearing: Physical impact of soil compaction and erosion (see section 9) Impact of sediment run-off on aquatic life (see section 11) *Clearing and Grubbing:* Impacts of vegetation burning on regional and local air quality (see section 9) Physical impact of soil compaction and erosion (see section 9) Loss of or disturbance to terrestrial natural habitat (see section 10) Impacts of increased suspended solids and siltation on aquatic life (see section 11.4.3.1) Impacts of River Pollution on aquatic life (see section 11.4.3.2) Disturbance to aquatic habitats and aquatic life (see section 11.4.3.3) Impacts of diminished water quality and quantity on aquatic environment (see section 11.4.3.5) Construction impacts on grassland dependent birds (see section 10.5.2.1) Construction impacts on river dependent birds (see section 10.5.2.1)
Measures:
Extent of Clearing: Coordinate work schedules so no delays in construction activities resulting in disturbed land remaining unstabilised. Program construction activities so that the area of exposed soil is minimised during times of the year when the potential for erosion is high, for example during rainy season when intense rainstorms are common. During any pause in construction, stabilise site and install and maintain erosion controls so that they remain effective during pause. This is particularly important if project stops during the wetter months. *Clearing and Grubbing:*

Forest and vegetation clearing activities shall be strictly limited to the minimum footprint required. Work areas to retain riparian forests where possible. Contractors may be tempted to fell trees of commercial value that will remain close to clear-cut areas. However, this activity is prohibited, even if requested by landowners. An independent environmental expert will monitor clearing activities to ensure compliance with this measure. The developer's Biodiversity Action Plan will provide for an offset to achieve no net loss of biodiversity as a result of conversion of natural habitat. It will include protection of remaining natural habitat in the Core Area and rehabilitation of modified habitat at least equal in area to the amount of natural habitat that is cleared.

Where vegetation clearance subcontracted to logging company, work shall be subject to strictest contractual measures to ensure compliance with environmental plans and shall be monitored by the independent environmental expert.

Cleared vegetation shall not be stored or dumped into streams.

Use of Glyphosate or other herbicides to kill trees or other vegetation will be strictly prohibited during all vegetation clearing activities, including vegetation control under the transmission line.

Vegetation control shall be carried out during the dry season to limit erosion and sediment-laden runoff from disturbed ground.

Existing vegetation or revegetating and mulching disturbed areas to be done as soon as possible.

Wherever possible, clearing areas of highly erodible soils and steep slopes which are prone to water and wind erosion to be avoided.

Work areas to be clearly delineated near riparian habitats prior to commencement of work.

Revegetate and mulch progressively as each section of work as completed. The interval between clearing and revegetation should be kept to an absolute minimum.

Wetlands in the transmission line right-of-way not to be drained, unless they represent a threat to stability of the access road and will be protected from machinery.

Use of machinery to control vegetation to be limited to stable areas.

Close to streams, machinery will not be used to clear vegetation to minimise disturbance to stream banks;

Workers in charge of vegetation control will be trained on health and safety issues and will wear suitable personal protective equipment, when removing or cutting vegetation, especially when felling trees.

For safety reasons, local communities will be notified prior to vegetation control activities in the vicinity of residential areas.

Non-merchantable vegetation shall be shredded rather than burned and shredded materials used to produce mulch to assist with erosion control.

Wherever possible, the canopy shall be "sealed" by minimizing large tree clearing to maintain canopy connectivity and reduce the edge effect. Along the road alignments, a botanist will identify large canopy trees that will be retained to maintain canopy closure (see Figure 13-2). However, for the transmission line, electrical grid protection prevails over this measure.

Figure 13-2 Monitoring canopy closure to mitigate edge effect

Source: Goosem et al., 2010

Transmission Line - After the initial vegetation clearance, Solomon Power or its contractors will carry out vegetation control to cut back vegetation that could potentially grow to a height that would interfere with the electrical conductors of the transmission line. Training shall be conducted to ensure workers identify and leave low-level native vegetation to prevent spread of invasive weeds.

Implementation Actor:	**Oversight Actor:**	**Costing/Funding Source:**
Developer (including botanist for demarcating environmentally and culturally sensitive areas) Solomon Power	TRHDP PO	PPA

13.2.1.6 Drilling and Blasting

Impacts Addressed:
Construction impacts on physical environment of noise and vibration (see section 9) Construction impacts on fauna (see section 10.5.2.2.2)
Measures:

The Project Company will prepare a Drill and Blast Management Plan that includes specific drill and blast methods to reduce noise and vibration. Hydraulic rock drill equipment will be used instead of pneumatic equipment because it produces less noise. Moreover, blasting and drilling equipment will be equipped with silenced masts, which can reduce noise levels by up to 10dBA. Blasting charges will be covered with blasting mats and screens to reduce generation of noise, fly rock and dust.

Implementation Actor:	**Oversight Actor:**	**Costing/Funding Source:**
Developer	TRHDP PO	PPA

13.2.1.7 Accidental Release of Sewage and Other Wastewater

Impacts Addressed:		
Impacts of Point Source Pollution on Flora (section 10.5.1.2.1) Impacts of River Pollution on aquatic life (see section 11.4.3.2) Disturbance to aquatic habitats and aquatic life (see section 11.4.3.3) Impacts of diminished water quality and quantity on aquatic environment (see section 11.4.3.5)		
Measures:		
The presence of on-site toilet facilities for workers mandatory. All sanitary wastewater will be regularly transported outside of the study area for treatment.		
Implementation Actor:	Oversight Actor:	Costing/Funding Source:
Developer	TRHDP PO	PPA

13.2.1.8 Hazardous Materials, Explosives and Concrete Works Handling

Impacts Addressed:
Impacts of Point Source Pollution on Flora (section 10.5.1.2.1) Impacts of increased suspended solids and siltation on aquatic life (see section 11.4.3.1) Impacts of River Pollution on aquatic life (see section 11.4.3.2) Disturbance to aquatic habitats and aquatic life (see section 11.4.3.3) Impacts of diminished water quality and quantity on aquatic environment (see section 11.4.3.5)

Measures:		
A hydrocarbon (fuel, oil, lubricant) management plan will be prepared and implemented by the construction contractor(s) prior to commencement of construction. Facilities for storing hazardous materials, including fuel, lubricating oil, concrete curing agents, form releasing agents, sealants, and other hazardous products, will be approved by the resident engineer. The resident engineer will also approve a separate secure "bunkered" facility for storing explosives. Secondary containment will be required for all hydrocarbon products (fuel, oil, lubricants) used on the Project. Hydrocarbons will be stored on flat ground at least 100 meters from any water body or wetland. Any hydrocarbon storage tanks or oil/fuel drums will be free of rust and cracks. Bund walls shall be provided and maintained around hydrocarbon storage areas within the Site. These bund walls will be of a sufficient height to contain a volume equal to one and one half (1.5) times the entire contents of its fuel storage facilities. Fuel dispensing areas and machinery maintenance areas will be built with concrete hard standing surface, which will drain to oil separators. The oil will be pumped by a tanker and sent to Honiara for treatment. Wash water from concrete works not to be directly or indirectly released in waterbodies or wetlands. Must be reused, stored and treated on site or collected and transported by road tankers for treatment in Honiara. A designated impermeable containment area must be used for concrete activities. To treat concrete washout onsite, a combination of settling ponds can be useful: ▪ Coagulants or flocculants will need to be added before discharging the water into the first or primary pond. This will help to reduce the size of ponds. Water must flow over small weirs from one basin to the next until the quality is good enough to be reused as plant water (closed loop system). The first pond will require periodic cleaning. The hardened concrete that is removed can be crushed and sent to a landfill in Honiara or reused on site as non-structural aggregate for road ballasting or surfacing works yards. The capacity of each pond must be greater than a full day supply of wash water and will take into account that the area often receives considerable rain. Due to the sensitive nature of the area, wash water will never be released in the Tina River. ▪ Each settling pond could allow for seepage and evaporation. For seepage, the water table needs to be low enough so that the water can be filtered without escaping. Settling ponds will need to be well sealed to limit any risks of infiltration of groundwater. ▪ Water levels of settling ponds will be inspected daily. Before intense rain, the water levels will be lowered. Suitable cover will be installed to cover the pond in the event of intense rain (e.g., folding tarps). Tarps will cover the pond at night to keep birds and bats from drinking unsafe water. When excess water becomes a disposal issue, its pH will be adjusted with automatic pH neutralizer using $C0_2$ gas (the use of acids for that purpose is prescribed) prior to a potential discharge off-site in Honiara.		
Implementation Actor:	**Oversight Actor:**	**Costing/Funding Source:**
Developer	TRHDP PO	PPA

13.2.1.9 Excavation and Movement of Soils

Impacts Addressed:
<u>Soil Stripping and Stockpiling:</u> Construction impacts of soil management on flora (section 10.5.1.2.1) Impacts of increased suspended solids and siltation on aquatic life (see section 11.4.3.1) Impacts of River Pollution on aquatic life (see section 11.4.3.2) Impacts of diminished water quality and quantity on aquatic environment (see section 11.4.3.5) Disturbance to aquatic habitats and aquatic life (see section 11.4.3.3) *<u>Accidental Colonisation by Invasive Species:</u>* Impacts of Colonisation by Invasive Species on Flora Species (see Section 10.5.1.2.1) Impacts of invasive species on Fauna Species (see Section 10.5.2.2.2)
Measures:
<u>Soil Stripping and Stockpiling:</u> Salvaging topsoils with high organic content, and mineral soils (i.e., subsoil not capable of supporting plant growth) - prior to commencing construction of the access road, the contractor will be required to do soil coring to assess the depth of organic soil in the right-of-way in cleared forested areas, from Mangakiki to the dam and quarry sites. This will determine the depth of soil stripping that is required. Collection of soil cores, and the management of soil stripping, will be done under the supervision of a soil expert. The aim is to conserve the topsoil for future use in rehabilitation of disturbed areas and to reuse subsoil for road embankments. Usually, machinery will be used to strip topsoil layers to a depth of 1m. Storage of topsoil – topsoils having a high organic matter content, that have good potential for plant regrowth, will be stored within a soil stockpile area. Topsoil storage will be done away from all water bodies on a flat terrain, and close to work areas. Stockpiles will be either compacted and covered with geo-fabric tarps to avoid unwanted prolific plant or seeded with indigenous herbaceous plant species to maintain the organic content of piles. If the supply of native plants to vegetate piles is limited then stockpiles will be covered. In both cases, stockpiles slopes will not exceed a horizontal to vertical ratio of 5H:1V, and will be surrounded by sediment control structures, such as deeply anchored sediment fences, ditches, or berms around the stockpiles. In addition, stockpiles and all disturbed areas, including those adjacent to road alignments, will be drained to enable sediment control structures, such as settling ponds, to prevent sediment laden runoff flowing into water bodies. Stockpiles of topsoil will be maintained at a pH of greater than pH5.5. Monitoring of stockpiles will be done throughout the construction phase. Exact location being determined by the construction contractor, a botanist, and the independent consultant.

Recommended that spoils be stored in the remnant forest habitat to minimize forest clearing In addition to soil spoils, non-organic (mineral subsoil spoils) and rock will also need to be removed and disposed, or reused, as follows: ▪ Subsoil spoils - Soil spoils produced by cuts to be reused for fill embankments and unsuitable soil spoils to be transported outside the Project area to a designated disposal site. ▪ Rock spoils - Spoils not utilised in construction to be disposed of in quarries. *Accidental Colonisation by Invasive Species:* Machinery to be checked by designated staff before equipment can enter project area. Wheels, tracks, buckets and other parts of machinery must be clean of mud and soil materials. Washing station will be installed just outside the project area at Veroande (see Section 6.4.2.1 – Invasive and Feral Species). Drainage water from washing stations to be diverted away from water bodies. Importation of soil from outside work areas will be prohibited. Soil deposited in the construction area will never be permanent in order to avoid colonization by invasive species. Soil stockpiles will be covered with geofabric tarps or revegetated with native plants. Soil Management Plan will be prepared by developer to assess the amount of spoils from road cuts, the need for road embankment and future use of excess soil; and to locate stockpiles. Topsoil will be left on site and will be reused as much as possible. Chemical and biological control of invasive plant species is not recommended as the extent of the impacts will be limited spatially. Local population will be sensitized regarding the threat posed by Water Hyacinth and the consequences should it find its way into the area**.** *Terrestrial habitat fragmentation:* To mitigate indirect impacts of the terrestrial habitat fragmentation and the edge effect, the following actions will be implemented: ▪ Construction activities will be favoured in already affected areas (such as along the existing access road) and in disturbed and remnant forests rather than undisturbed primary forests. ▪ Where possible, impact-causing activities will be spatially concentrated to limit any encroachments. ▪		
Implementation Actor:	**Oversight Actor:**	**Costing/Funding Source:**
Developer (Soil Expert) Overseen by Environmental Monitoring Consultant	TRHDP PO	PPA

13.2.1.10 Activities Causing Disturbance to Wildlife

Impacts Addressed:
Workers Affects on Fauna: Construction and operational impacts on fauna (see section 10.5.2.1) *Lighting Disturbance:* Construction impacts on fauna (see section 10.5.2.2.2) *Transmission Line Operation:* Operational impacts on bats, birds and marsupials (section 10.6.2.1) *Harvesting by Workers:* Impacts of over fishing (see section 11.4.3.4) Operational impacts on fauna (see section 10.5.2.2.2)
Measures:
Workers Affects on Fauna: Workers prohibited from harming wildlife. Workers to receive wildlife awareness training informing them of the requirement to request the project's environmental specialist capture and remove animals that are either in danger or are dangerous to construction workers. Workers will be restricted to work areas and shall not enter adjacent natural habitat except where required for Project purposes. Workers to discard all rubbish and food waste in designated areas. *Lighting Distrurbance:* The number of artificial lights during construction period shall be kept to a minimum, while still maintaining a safe working environment. Light intensity will also be limited, where possible, and the lights will be oriented toward the ground to avoid disorienting bats in flight. Regular use of artificial lights during operational period shall be avoided. *Transmission Line Operation:* Metal shields to be installed on wooden power poles in forested areas to prevent Cuscus from climbing poles and becoming electrocuted. *Harvesting by Workers:* Workers will be prohibited from fishing in the Tina River, noting that this restriction will not prevent local villagers who also work on the Project from continuing their existing subsistence fishing activities outside of work hours.

Project's food services / caterers will be prohibited from purchasing fish from local villagers. Vehicle speed limits will be controlled along the access roads, to ensure that drivers are able to prevent running over wildlife that may be lying on, or crossing, the access road.		
Implementation Actor:	**Oversight Actor:**	**Costing/Funding Source:**
Developer Solomon Power (for transmission line)	TRHDP PO	PPA

13.2.2 Measures to Protect the Social Environment

This section consolidates the recommendations made throughout the ESIA on the avoidance, mitigation, and management of the adverse social impacts of the TRHDP. The recommendations draw upon:

- Consultations and findings of local people, communities and stakeholders on the potential social impacts of the project during the ESIA fieldwork, community and stakeholder mitigation workshops;
- Review of related projects and studies; and
- Comments of peer reviewers, World Bank experts, and members of the TRHDP team.

The objectives are to:

- Specify the strategies to mitigate the adverse social impacts identified in the ESIA, and to maximise the benefits, as required under the World Bank Operational Policy 4.10 regarding indigenous peoples;
- Establish the responsibilities for managing the social impacts during the construction and operation phases of the TRHDP, including implementation of specific impact mitigation and avoidance measures;
- Outline a strategy to ensure ongoing community and stakeholder communications, consultation and involvement in project decision-making, including the management of impacts and benefits. Arrangements for including women in decision-making should be explicit;
- Specify issues regarding loss of livelihoods resources and vulnerable people to be addressed in a Resettlement Action Plan or Livelihood Restoration Plan, as required under the World Bank's operational policies;
- Present a plan for ongoing social impacts monitoring and reporting; and
- Present benefits intended for females, children, and vulnerable communities.

13.2.2.1 Siting of Workers Camps

Impacts Addressed:
Local Customs and Way of Life (see section 12.5.6) Health Safety and Wellbeing During Construction (see section 12.5.3)

Measures:		
To avoid unwanted long-term residence of outsiders in the Tina River communities, the construction contractors are required to provide residential accommodation for incoming construction staff and workers outside of the Tina Valley, preferably in Honiara. No workers camps or similar facilities shall be permitted in the project area. The Developer shall explore accommodation options on the east side of Honiara (eg. Panatina) and at Lungga and Henderson, for the workers who live outside of Malango and Bahomea.		
Implementation Actor:	**Oversight Actor:**	**Costing/Funding Source:**
Developer	TRHDP PO	PPA

13.2.2.2 Employment and Recruitment Practices

Impacts Addressed:
Uninvited Job Seekers (see section 12.5.5.3) Increase in Employment Opportunities (see section 12.6.2)
Measures:
The construction contractor shall implement a recruitment policy prioritizing work-seekers from Bahomea and Malango. If additional recruitment is necessary, job applications shall be open to residents of the nearby areas and Honiara. This measure will be a condition of the Implementation Agreement between SIG and the contractor. The construction contractor shall include a quota for women and be able to identify explicit strategies to ensure that women are recruited to work on the TRHDP. It is recommended that the TRHDP PO conduct a survey of local villagers to identify those interested in working on the project construction. The survey should aim to identify preliminary skills and experience. Based on the survey, the Project Office, together with local training providers, shall provide training to youth and other job seekers in the project area, on subjects such as safety and health, money management, driving, plant operation, trades, and other relevant subjects. Funding for this training is proposed to be provided through a JSDF grant. Facilities created for the construction of the Project (e.g., storehouses and offices) shall be made available, if requested, for any future use by the community. This use will be facilitated through the Tina Core Land Company and it is proposed that this measure form part of the lease between TCLC and the Developer.

Implementation Actor:	Oversight Actor:	Costing/Funding Source:
Developer TCLC (Facilities Retention) TRHDP PO (pre-employment training) Training Provider Contractor (pre-employment training)	TRHDP PO	PPA (recruitment policy and quota) Pre-employment training (JSDF Community Benefit Share Fund Grant)

13.2.2.3 Worker Behaviour, and Activities that could Affect Worker Health and Wellbeing

Impacts Addressed:		
Local Customs and Way of Life (see section 12.5.6.1) Moro Movement (see section 12.5.6.2) Health Safety and Wellbeing (see section 12.5.3)		
Measures:		
The Developer is required to implement the workers' code of conduct (see Annex 18 of the Annex Report) covering, for example, working hours and conditions, safety, driving, socially and culturally appropriate behaviour, alcohol and drug use, prohibition on hunting and fishing, driving and use of vehicles, conflict and violence, gender based harassment and cultural heritage protocols. The code of conduct should also set a dress code for workers who interact with local communities. The Developer shall conduct Code of Conduct pre-commencement training with workers. The construction contractor will provide tailored workplace health and safety training for construction workers before the start of the project. A full-time first aid / nursing post will be established on site and arrangements will be made for medical assistance and evacuation facilities. These matters will be covered in the construction contractor's Health and Safety Plan as part of their overall CEMP.		
Implementation Actor:	**Oversight Actor:**	**Costing/Funding Source:**
Developer	TRHDP PO	PPA

13.2.2.4 Activities that could Affect Villagers' Safety, Wellbeing, and Amenities

Impacts Addressed:
Health Safety and Wellbeing – Construction (see section 12.5.3.1) Health Safety and Wellbeing - Operation (see section 12.5.3.2)
Measures:
Road safety concerns related to traffic on Black Post Road will be addressed by: ▶ Installing roadside fencing and speed controls near residential areas; ▶ Creating separate footpaths and safe crossing points and bus stop bays; and ▶ Using best practices for transportation of dangerous goods. The construction contractor will develop a protocol for managing contractor-related road accidents and injuries (including compensation and restitution arrangements). The protocol will also address accidents involving power transmission lines. This plan be included in the construction contractor's health and safety management plan. To avoid traffic-related noise and dust, access roads will be sealed in areas adjacent to villages, community facilities, and food gardens. Educational programs will be organised by the TRHDP PO to reduce the level of fear expressed by communities regarding potential risks of dam failures and catastrophes. Moreover, to reduce any potential opposition to the development of the Project, the TRHDP PO will design and run a village level educational program to present information, at an overview level, on modern-day dam engineering, construction and operation. The program will pay special attention to reaching women and young people. Community briefings from the World Bank's Dam Safety Panel could complement this program. As the time for villages to be electrified gets close, Solomon Power shall carry out educational programs in communities and schools to familiarize residents on electricity and its safe use in homes and communities, including safe behaviour around transmission lines and other power infrastructure components. Specific measures will be implemented to avoid any social threats or mis-conduct. A strict drug and alcohol prohibition for all workers will be implemented by the construction contractor to minimise any threats of antisocial behaviour. The ban also aims to reduce risks of road accidents on the Tina Road and on the project site. Awareness will be conducted on STDs including HIV/AIDS to prevent and mitigate the impacts of social behaviors which will encourage sexual behaviours. Outside parties will be engaged to carry out this awareness program. Condoms will made freely available at the first aid/nursing post to be established on site.

Implementation Actor:	Oversight Actor:	Costing/Funding Source:
Developer Road Design and Construction Contractors Solomon Power TRHDP PO	TRHDP PO	PPA Road Design and Construction Contracts

13.2.2.5 Activities that could Affect Vulnerable Groups and Minorities

Impacts Addressed:		
Minority and Vulnerable Groups (see section 12.5.4.3)		
Measures:		
TRHDP-PO's Social Impacts Monitoring Plan shall include monitoring of impacts of the project's construction and operation phases on squatters and settlers. The developer's Stakeholder Engagement Plan shall assist communities in having their issues dealt with as the project progresses. This should include a grievance / complaint mechanism and nominated community representatives for CLAs. These plans shall include measures directed towards isolated communities, such as Senghe, Choro and Koropa, as these are particularly vulnerable due to changes of flow in the by-passed section of Tina River and due to their remote location.		
Implementation Actor:	**Oversight Actor:**	**Costing/Funding Source:**
TRHDP-PO Developer	TRHDP PO	PPA

13.2.2.6 Activities that could Affect Water Supplies

Impacts Addressed:
Water Quality and Quantity (12.5.7.4.3) For the three-year period of project construction, the water of the Tina/Ngalimbiu River may become, without treatment, unusable for some human domestic purposes. This is likely to continue for several years after the construction has ended. Many of the downstream riverside villages, which represent more than 2,000 people, will be affected. Many villages rely on the river as their main water source, while a number of villages further downstream on the Ngalimbiu have access to water supplies.

Uncertainty exists in the community about the long-term effects of the dam and reservoir on water quality.
Measures:
Downstream Alternative Water Supplies In consultation with local communities, the Developer is to undertake a detailed survey and mapping of community drinking and washing river use downstream of the dam site. The downstream area will include communities using the Tina River as well as the Ngalimbiu. The survey is also to identify communities with existing alternative water supplies. These measures will form part of the Developer's Water Supply Feasibility Study. The Study is to include modelling of predicted impacts on water quality and assess whether these impacts will affect community river use. Access to alternative water supplies shall be provided for all river dependent communities whose use of the river is anticipated to be affected. Appropriate water supply solutions will be site specific. Alternatives may include: ▪ River-based supply with appropriate treatment systems and supply points for each village; ▪ Rainwater collection and storage tanks; ▪ Establishment of alternative supplies from local streams, and; ▪ Borehole / ground water supplies, piped to several villages / hamlets. Transportation and distribution of clean water could also be done by tanker truck on a regular basis. The water will be stored in tanks at the village level. Regardless of the method, it shall not create an additional workload for women. For example, the villages of Valesala and Antioch could obtain water from the Kolohio stream. Therefore, the design of replacement or alternative water supplies should explicitly include the views of women and teenage girls and consider the impacts to them. Alternative water supplies shall be provided to affected communities prior to construction work on the dam, powerstation, river quarries or reservoir. During the impact mitigation workshops, community leaders specifically requested the provision of alternative reliable clean water supplies to affected communities. A list of affected communities along the Tina River and a map showing their locations is provided below. Communities reliant on the Ngalimbiu River shall be mapped as part of the Water Supply Feasibility Study: Table 13-1 Table of Water Supply Affected Communities on the Tina River

Communities & affiliation that rely on Tina River for their domestic use and/or as a drinking water supply	Villages/ hamlets	2013 households (approx.)	2013 population (approx.)
Senge community	Senge	3	16
	Choro	1	4
	Koropa	3	19
Pachuki community	Pachuki	14	65
	Habusi	6	33
Namopila comm.	Namopila	5	27
	Komureo	6	28
	Vatunadi	1	5
	Valekocha	5	26
Antioch community	Antioch	23	110
	Valesala	20	105
	Kolanji	2	10
	Komeo	0	0
Tina community	Tina	23	104
	Valebarik	6	22
	Valebebe	22	104
	Tahurasa	5	15

Communities & affiliation that rely on Tina River for their domestic use and/or as a drinking water supply	Villages/ hamlets	2013 households (approx.)	2013 population (approx.)
	Valemaota	4	12
Vuramali comm.	Vuramali	18	70
	Haimane	26	111
	Horohotu 2	17	84
	Vuvamali	16	77
Horohutu comm.	Horohotu 1	12	60
Verakuji community	Verakuji	11	56
	Managikiki	21	111
Marava community	Marava	28	168
	Ngongoti	1	20
	Vatupaua	5	50
	Rate school	?	?
Vera'ande community	Vera'ande	6	30
	Verakweli	6	24
	New Mahata	2	15
Verakabikabi comm.	Verakabikabi	44	219
Total		**362**	**1800**

Figure 13-3 Map of Tina River dependent affected communities

Water quality monitoring

Management of water quality will need to be investigated, monitored, and managed as part of the overall environmental management of the TRHDP over the long term.

The construction contractor shall commence monitoring water borne diseases in the Tina/Ngalimbiu River catchment just prior to commencement of construction. This should continue as part of the ongoing environmental management and monitoring throughout construction and the initial years of reservoir operation.

During the period of construction and initial years of reservoir operation, when water quality may be impaired, all affected villages will be made aware that water in the Tina River may not be drinkable, and that the use of traditional small “sand point” holes in river gravel will not be sufficient to treat water.

Survey of water supplies near road works

In consultation with local communities, all present and alternative village water supply resources in the vicinity of the access road works will need to be identified, surveyed, mapped, and engineer-assessed, prior to construction work on the access road.

Implementation Actor:	**Oversight Actor:**	**Costing/Funding Source:**
Developer	TRHDP PO	PPA

13.2.2.7 Activities that could Affect Ecotourism Opportunities

Impacts Addressed:		
Ecotourism Opportunities (see Section 12.10.5)		
Measures:		
Senghe village foot track will be disrupted by heavy traffic on the access road to the powerhouse. It is important to relocate the access track prior to the construction of the access road, so that visitors and residents are not affected by traffic.		
Implementation Actor:	**Oversight Actor:**	**Costing/Funding Source:**
Developer	TRHDP PO	PPA

13.2.2.8 Damage to, or Loss of, Core Area Resources

Impacts Addressed:
Natural Capital (see section 12.5.7.4)
Measures:
Use-rights for the storage reservoir and its margins, dam and powerhouse access roads, and other land acquired for the project Core Area shall be defined by the proposed TCLC as the entity responsible for managing the use of the core area resources. The Land Acquisition and Livelihood Restoration Plan shall discuss local householders' use of the land and resources on sites required for the Project, and quantify impacts as a basis for compensation. The LALRP provides an entitlements matrix where local households lose access to livelihoods resource areas because of the project. Where construction activities damage or destroy resources outside of the acquired Direct Impact Area, compensation for these resources should be payable using transparent formulae. Where feasible, the TRHDP PO should contract out the reservoir vegetation clearing work to local community members.

Implementation Actor:	Oversight Actor:	Costing/Funding Source:
Developer	TRHDP PO	PPA

13.2.2.9 Activities that could Affect Cultural heritage

Impacts Addressed:		
Cultural Heritage (see section 12.5.8)		
Measures:		
As part of the Construction ESMP (CESMP), the TRHDP-PO will identify and compensate or relocate cultural heritage sites in accordance with the Cultural Heritage Management Plan. This Cultural Heritage Protocol is presented in Annex 18. Prior to any construction commencing, TRHDP-PO shall carry out a “tambu site compensation follow-up” to identify areas that will require compensation in the designated Core Area and in the communities adjacent to any road building or upgrading and construction. A suitably qualified cultural heritage expert, working closely with knowledgeable elders and the National Museum, should undertake this task. All sites that will be destroyed and compensated will be recorded and photographed for monitoring purposes, but the details and records of the sites shall only be disclosed to affected communities and the construction contractor and the SIG for confidentiality purposes to ensure that the construction contractor does not destroy any sacred (tambu) before compensation for losses are granted to communities. Prior to construction, TRHDP-PO, in conjunction with culturally knowledgeable locals and a botanist, shall survey the project and road construction sites to identify culturally important medicinal and magical plants that may need to be protected or relocated. Fear that the customs and lifestyle of the Gaena’alu followers will be disrespected will be averted by not having a workers camp located within the Tina/Ngalimbiu area, and by the contractor establishing and enforcing a strict code of conduct for its workers with respect to contact with local villagers.		
Implementation Actor:	**Oversight Actor:**	**Costing/Funding Source:**
TRHDP PO	TRHDP PO	PPA Tambu Site Disturbance Compensation – Component of allocated SIG budget for land compensation

13.2.2.10 Decisions Made on the Project

Impacts Addressed:		
Social Impacts (see section 12)		
Measures:		
The Developer will continue consulting directly with the project-affected communities throughout the life of the Project using culturally appropriate, inclusive and proven methods and arrangements. District-level consultations could be done through a representative of the Community Liaison Committee or any similar forum. The Developer will address any issues raised by communities and should report any corrective measures to the communities and to the SIG.		
Implementation Actor:	**Oversight Actor:**	**Costing/Funding Source:**
Developer	TRHDP PO	PPA

13.2.2.11 Dam Failure and Emergency Flow Releases

Impacts Addressed:		
Fear of dam failure (see section 12)		
Measures:		
The Design study shall prepare a disaster/extreme event model showing the submersion wave in case of dam break, covering the management or responses to situations of extreme floods and cyclones in the catchment, emergency water releases, and dam beaching or overtopping. Such plan shall be part of the design report and then integrated in the Emergency Preparedness Plan. Through training and sensitization carried out by the Developer, powerhouse start-up and shut-down procedures must be clearly understood by local communities to avoid any accident with sudden release of water at power station outlet (peak hour releases).		
Implementation Actor:	**Oversight Actor:**	**Costing/Funding Source:**
Developer	TRHDP PO	PPA

13.2.2.12 Daytime Peaking Flow Releases

Impacts Addressed:
Operational Impacts (12.5.3.2)
Measures:
The detailed design study shall include a disaster / extreme event model showing the inundation zone that would result in the event of a dam break, and cover emergency

management or responses to situations of extreme floods and cyclones that may affect the catchment, emergency water releases, and dam beaching or overtopping. This plan shall be part of the design report. The Developer shall install an early warning system when floods will flow over the spillway along the by-passed section of the River. This shall be incorporated into an Emergency Preparedness Plan which shall include: • The need to train local communities on actions to follow in the event of floods, • How to recognise and respond to the powerhouse flow release / flood warning system.

Implementation Actor:	**Oversight Actor:**	**Costing/Funding Source:**
Developer	TRHDP PO	PPA

13.2.2.13 Changes Associated with Diminished River Flows

Impacts Addressed:
Sediment Recruitment: Extraction of Aggregates from the River (section 12.5.7.3) There is potential for reduced or altered stream flow in the Ngalimbiu River on gravel deposition and the sustainability of gravel extraction. However, this effect will only be noticeable over the long term. *Timber Transport and Recovery:* Small scale timber harvesting (section 12.5.7.2)
Measures:
Sediment Recruitment: Monitoring of gravel transport shall be undertaken by a river geomorphologist. This may include: ▪ Identifying key river points ▪ Taking annual transect measurements, including gravel depth ▪ Taking additional transect measurements after 1 in 10 year flood events. Further mitigation measures to be considered where measured changes in gravel distribution affect livelihoods of downstream communities. This measure is in addition to other mitigation measures in this ESMP in relation to sluicing of sediments. *Timber Transport and Recovery:*

An alternative to timber rafting as a mean to transport sawn timber down the Tina River will be proposed by the TRHDP PO, so timber millers can continue to transport and recover their timber around the dam and the bypassed section of Tina River. Arrangements for the transport of timber extracted by local landowners from their lands above the proposed dam site will need to be put in place prior to dam construction and operation. One option to do this is through the creation of a truck pickup point beside the river and future reservoir, connected to the dam access road.

Implementation Actor:	Oversight Actor:	Costing/Funding Source:
TRHDP-PO	TRHDP PO	PPA

13.2.2.14 Activities that could affect fishing effort

Impacts Addressed:
Livelihood Impacts (Chapter 12)
Measures:
Fish monitoring is to be undertaken in accordance with a fish monitoring plan to be prepared by the Developer in accordance with section 13.4.3.3. Monitoring will include fish quantity and species diversity in the Tina River and Ngalimbiu River including the estuary, and in the Toni River as a control site. Monitoring is to include both comprehensive baselines studies and ongoing monitoring throughout the operational period. Where monitoring identifies statistically relevant reductions in fish quantities or species during operations, adaptive management procedures for fish migration are to be implemented. Where construction impacts on water quality have a statistically relevant affect on fish species used as a source of food or income for downstream communities, compensation measures will be implemented for impacted communities. If this measure is triggered, the Developer shall undertake a study of the impacts on fishing efforts, and the compensation payable. A compensation management plan is then to be prepared and approved by SIG.

Implementation Actor:	Oversight Actor:	Costing/Funding Source:
Developer	TRHDP PO	PPA

13.2.2.15 Activities that could Strain Relations with Project-Affected Communities

Impacts Addressed:		
Community Liaison, and Capacity Buiding: Social Impacts (numerous, see section12)		
Measures:		
Community Liaison: This measure is intended to ensure communication between affected communities and the Developer/TRHDP Project Office Community liaison committees (CLC) shall be established for the construction and the operations phases, supported by a small group to oversee monitoring and mitigation measures and provide input to reporting on conditions in the project-affected communities. This monitoring shall include the state of relationships between the different clans as well as the distribution of water to affected communities. Each Community liaison committee will include the existing Community Liaison Assistant (CLA) as well as women and youth. The former role of the CLA will be formalized by the CLC so that grievances are documented in reports and in the Stakeholder Engagement Plan. Each committee shall have a secretary that will be in charge of producing regular reports on community grievances and monitoring of impacts. These reports will aim at communicating with the Developer, the SIG and TRHDP as well as the independent Consultant specialized in environmental and social management. *Capacity Building:* Capacity building is required to CLAs as discussed separately in this ESMP. The Developer with assistance of TRHDP PO shall provide capacity development, training and administrative support to the Community Liaison Assistants and Community Liaison Committees. TRHDP PO's ongoing training with landowning tribes in money management and administrative procedures shall continue throughout the pre-construction and construction stages of the Project. This work includes facilitation of financial benefit sharing among all tribal members. TRHDP PO to facilitate management training for TCLC board members where required. The Benefit Sharing Program facilitated by TRHDP PO shall focus on delivering pre-employment training to members of the Bahomea and Malango areas. To minimise any social disruptions arising from increased amounts of cash in the community, the Developer/TRHDP PO provide budgeting and money management training as part of the induction and training of locally recruited workers.		
Implementation Actor:	**Oversight Actor:**	**Costing/Funding Source:**

Developer TRHDP PO Community Liaison Committees	TRHDP PO	PPA Pre-employment training through JSDF Grant.

13.3 MANAGEMENT PLANS

In preparing the CESMP and OESMP, the constructor/operator shall developer and include a number of detailed management plans. A list of these plans, the timeframes for these and the framework for review and approval is set out in Table 13-2. In case of both THL and EPCC's role in preparation such as influx management plan and security management plan, EPCC and THL will cooperate for preparation of plans.

13.3.1 Table of Management and Monitoring Plans

Table 13-2 Management Plan Timeframes and Approvals

No.	Name	Completion Date	Prepared by	Implemented by	Review/Approval by	Applicable Policy/PS
Dam Safety Plans						
DS-1	Construction and Quality Assurance Plan	Draft Plan (at minimum, TOR and budget for independent consultants preparing plan) to be completed by PPA Effective Date. Final Plan to be completed by the Closing Date (Plan to form part of TOR of Owner's Engineer)	THL (Sponsors)	THL and Owner's Engineer	MMERE/WB	PS4 (OP4.37)

No.	Name	Completion Date	Prepared by	Implemented by	Review/Approval by	Applicable Policy/PS
DS-2	Instrumentation Plan	Draft before completion of Basic Design. Final before completion of Detailed Design	THL (Sponsors)	EPCC	THL/MMERE/ WB	PS4
DS-3	Operation and Maintenance Plan	Draft by completion of Detailed Design; final not less than 6 months before first reservoir impoundment	THL	THL	THL/MMERE/ WB	PS4
DS-4	Emergency Preparedness Plan	Framework as part of Detailed Design stage; final plan no less than 12 months before reservoir impoundment	THL	THL	THL/MMERE/MECDM /WB	PS4
Preparation Phase Plans						
P-1	Construction ESMP (CESMP)	Before contractor mobilization	EPCC	EPCC	THL/MMERE/MECDM /WB/ADB	PS1, SPS 2009(see (a) below)
P-2	Biodiversity Management Plan	Before contractor mobilization	EPCC	EPCC, THL	THL/MMERE/MECDM /WB/ADB	PS6.OP4.04
P-3	Stakeholder Engagement and Communications Plan	Draft before contractor mobilization in country. Final before	THL	THL	MMERE/WB/ADB	PS1.PS4

No.	Name	Completion Date	Prepared by	Implemented by	Review/Approval by	Applicable Policy/PS
		contractor mobilisation on site.				
P-4	Human Resources and Labour Management Plan	Before engagement of contractor employees	PC/EPCC	PC/EPCC	PC/MMERE/WB/ADB	PS2, PS4
P-5	Influx Management Plan	Before contractor mobilization on site	EPCC and THL	EPCC and THL	PC/MMERE/WB/ADB	PS2.PS4
P-6	Grievance Redress Mechanism	Before contractor mobilization in country	EPCC and THL	EPCC and THL	PC/MMERE/WB/ADB	PS1,PS2,PS4
P-7	Security Management Plan	Before contractor mobilization on site	EPCC and THL	EPCC and THL	PC/MMERE/WB/ADB	PS4
P-8	Worker's Health and Safety Plan	Before contractor mobilization on site	EPCC	EPCC	PC/MMERE/WB/ADB	PS2 EHS Guidelines
P-9	Workers Code of Conduct	Before contractor mobilization in country	EPCC and THL	EPCC and THL	PC/MMERE/WB/ADB	PS2.PS4
P-10	Community Health and Disease Vector Management Plan	Before contractor mobilization on site	EPCC and THL	EPCC and THL	PC/MMERE/WB/ADB	PS4
P-11	Traffic Management Plan	Before contractor mobilization on site	EPCC	EPCC	PC/MMERE	PS1, PS4
P-12	Waste Management and Point Source Pollution Plan	Before contractor mobilization on site	EPCC	EPCC	PC/MMERE/WB/ADB	PS3 EHS Guidelines
P-13	Hazardous Materials Management Plan	Before contractor mobilization on site	EPCC	EPCC	PC/MMERE/WB/ADB	PS3 EHS Guidelines
P-14	Spill Prevention and Emergency Response Plan	Before contractor mobilization on site	EPCC/ THL	EPCC/ THL	PC/MMERE	PS1,PS3
P-15	Air Quality Management	Before contractor	EPCC	EPCC	PC/MMERE	PS1,PS4

No.	Name	Completion Date	Prepared by	Implemented by	Review/Approval by	Applicable Policy/PS
	and Dust Control Plan	mobilization on site				
Construction Phase Plans						
C-1	Cultural Heritage Management Plan	Two months before land clearing	MMERE	MMERE, THL and EPCC	PC/ WB/ADB	PS8
C-2	UXO Management Plan	Before land clearing	EPCC	EPCC	PC/MMERE	PS1,PS2
C-3	Forest Clearance Plan	Before land clearing	EPCC	EPCC	PC/MMERE/MECDM/ WB/ADB	PS6,OP4.04, OP4.36
C-4	Post-construction Rehabilitation and Revegetation Plan	Before land clearing	EPCC	EPCC	PC/MMERE/MECDM	PS1,PS6
C-5	Quarry Management Plan	Before construction start	EPCC	EPCC	PC/MMERE/MECDM	PS1,PS2,PS4 EHS Guidelines
C-6	Reservoir Preparation Plan	Before biomass removal	MMERE	MMERE	PC/MMERE/MECDM/ WB/ADB	PS1,PS6
C-7	Water Supply Replacement Plan	Before construction start	EPCC	EPCC	PC/MMERE	PS4
C-8	Watercourse Crossing Management Plan	Before land clearing	EPCC	EPCC	PC/MMERE	PS1
C-9	Spoil and Topsoil Management Plan	Before land clearing	EPCC	EPCC	PC/MMERE	PS1
C-10	Drainage, Erosion and Sediment Control Plan	Before land clearing	EPCC	EPCC	PC/MMERE	PS1
C-11	Drill and Blast Management Plan	Before construction start	EPCC	EPCC	PC/MMERE/MECDM/ WB/ADB	PS2,PS4 EHS Guidelines
C-12	Stormwater Management Plan	Before construction start	EPCC	EPCC	PC/MMERE	PS1
C-13	Noise and Vibration Management Plan	Before construction start	EPCC	EPCC	PC/MMERE/MECDM/ WB/ADB	
C-14	Cumulative Impact Management Strategy	Within one year of mobilization	SIG	various public and private entities	MMERE/WB/ADB	PS1
Operations Phase Plans						

No.	Name	Completion Date	Prepared by	Implemented by	Review/Approval by	Applicable Policy/PS
O-1	Operations ESMP (OESMP)	3 months before reservoir filling	THL	THL	MMERE/MECDM/WB/ ADB	PS1
O-2	Reservoir Operation & Management Plan	3 months before reservoir filling	THL	THL	MMERE/MECDM/WB/ ADB	PS1, PS6
Decommissioning Phase Plans						
D-1	Decommissioning Plan	1 year before station closure	THL (SIG, if it continues to operate after PPA period)	THL	MMERE	PS1, PS2, PS3, PS4, PS6
D-2	Retrenchment Plan	1 year before station closure	THL (SIG, if it continues to operate after PPA period)	THL	MMERE	PS2
Monitoring Plans						
M-1	Suspended Sediment Monitoring Plan	Before land clearing	EPCC and THL	EPCC and THL	PC/MMERE/MECDM/ WB/ADB	PS1,PS
M-2	Water Quality Monitoring Plan	Before land clearing	EPCC and THL	EPCC and THL	PC/MMERE/MECDM/ WB/ADB	PS1
M-3	Fish, Algae, and Macro-Invertebrate Monitoring Plan	Before land clearing	EPCC and THL	EPCC and THL	PC/MMERE/MECDM/ WB/ADB	PS6
M-4	Social Impacts Monitoring Plan	Before contractor mobilisation on site	MMERE	MMERE	MMERE/MECDM/WB/ ADB	PS1,PS7
M-5	Flora and Fauna Monitoring Plan	Before land clearing	THL and EPCC	THL and EPCC	MMERE/MECDM/WB/ ADB	PS1,PS6
M-6	Construction Works Monitoring Plan	Before land clearing	EPCC	EPCC	PC/MMERE/MECDM/ WB/ADB	PS1
M-7	Air Quality and Noise Monitoring Plan	Before land clearing	EPCC	EPCC	PC/MMERE/MECDM/ WB/ADB	PS1,PS3

THL shall report on the implementation of the above plans, and the results of studies executed as part of the plans, to the PO, WB, ADB and MECDM.

13.3.2 Management Plan Frameworks

Frameworks for key plans and sub-plans are provided below. Each plan should contain at least the following:

- Purpose
- Definitions
- Links, as required, with other plans (i.e. grievance redress mechanism (GRM), stakeholder engagement and communication plan, CESMP, health & safety etc)
- Organizational structure and arrangements for implementation of the plan
- Risk assessment (or other) methodology to identify aspects/impacts/risks to focus on for mitigation and management
- Performance indicators or standards to be followed/met plus any additional targets cited in ESMP in ESIA
- Mitigation and management measures
- Site-specific plans for each of the components (maps, drawings, overlays etc),
- Costs and budget
- Monitoring and reporting requirements (to link with monitoring plans)
- Checklists and forms (for recording compliance, registry, monitoring, corrective actions etc).

13.3.2.1 D-1 – D-4 Dam Safety Plans

Management Plans required shall include the following Dam Safety Plans in accordance with World Bank OP 4.37:

- Construction and Quality Assurance Plan
- Operation and Maintenance Plan
- Instrumentation Plan
- Emergency Preparedness Plan

All plans relating to dam safety and response to operations related emergency events will be prepared by the THL and reviewed by the TRHDP's Dam Safety Panel. During operation period, annual maintenance will be performed as well as biannual light overhaul and full overhaul every 6 years accompanied by safety inspectin. Dam safety checkup will be performed half-yearly by operators according to Dam Safety Plans.

13.3.2.2 P-1 Construction ESMP

The CESMP may also comprise a number of sub-plans as per Table 13-3 and will include site-specific plans for the infrastructure components, with the linear elements - access roads and transmission lines - comprising several site-specific plans. Each site-specific plan should be prepared following steps including:

- Define boundaries
- Identify sensitive receptors and environmental values
- Specify construction activities (according to program and schedule)
- Conduct risk assessment
- Assign environmental mitigation and management measures
- Prepare site plans and construction methodologies
- Prepare environmental work plans for when different work activities are required at different times or at different locations. Environmental work plans are similar to work method statements.

The CESMP also needs to identify how the developer will implement the relevant aspects and processes of the GRM.

As a guide to preparation of CESMP an outline of environmental specifications for construction is provided at Appendix O.

13.3.2.3 P-2 Biodiversity Management Plan

The Developer shall be responsible for preparing the Biodiversity Management Plan (BMP). The BMP shall develop an appropriate and detailed methodology and program for managing all key biodiversity issues during the construction and operation of the Project.

Because of its particular importance, the terms of reference for the BMP are included with the ESIA as Appendix P. The BMP, together with the proposal for upper catchment protection in Appendix K, will include measures to achieve no net loss of biodiversity as a result of natural habitat conversion, degradation, or fragmentation in the area of influence, including protected set-asides, restoration of areas temporarily disturbed, and offsets in the form of rehabilitation of modified habitat. It will also contain wildlife management measures to protect fauna that may pass through or reside in the project footprint, including prohibition of hunting and on-call experts to assist in relocations. The requirements for minimum flows that have been established in the ESIA and the provisions in the design to move migrating fish past the dam are also measures that contribute to no net loss of biodiversity in the aquatic ecosystem. The BMP will also include detailed management provisions to mitigate the impacts of invasive species, incorporating as a minimum standard this ESMP's measures, including machinery washing stations.

Impacts the project may cause, if any, on the river upstream of the reservoir are difficult to predict, and the BMP will therefore link to the monitoring plans so that benthic organisms, fish fauna, and water quality are monitored upstream of the reservoir. Findings of adverse impacts will lead to adaptive management measures. The BMP will also include measures to restrict public vehicular access, including commercial logging access, south of the end of the existing road close to Mengakiki.

At a minimum, the BMP shall be structured as follows:

- Executive Summary
- Methodology
- Biodiversity Context
- Priority Biodiversity Features
- Biodiversity Objectives and Targets
- Recommended Management Actions (legal requirements; biodiversity actions; responsible parties; etc.)
- Implementation Mechanism
- Monitoring and Surveillance (including adaptive management process)
- Budgets and Timelines
- Internal and External Reporting
- References
- Appendices (maps; photo documentation; etc.)

13.3.2.4 P-3 Stakeholder Engagement and Communication Plan

The Stakeholder Engagement and Communication Plan (SECP) describes the purpose, method and outputs of the project being implemented by the MMERE, THL, EPCC and the stages and processes for communication. The SEPC covers the requirements of relevant country laws, current practice in respect of communications and consultations and also complies with the development partner requirements.

The purpose of the Stakeholder Engagement and Communication Plan (SECP) is to guide what types of information need to be provided to and obtained from stakeholders, when and how such information is communicated, and how the information is to feed into the different project stages and aspects including feasibility study, detailed design, construction, and operations. It provides an overall mechanism for guiding communications about the project for the THL, other relevant government agency staff, implementation and supervisory consultants, and the primary beneficiaries and other stakeholders (such as civil society organizations). Importantly, the SECP is based on local custom and tradition to ensure it facilitates meaningful consultation.

Not all of the stakeholders need to receive or provide information at all times, therefore a hierarchy of communication can be used ranging from the most intense and frequent communications with the directly affected and beneficiary communities through to releases of more general information to the wider public at specific times within the project.

In terms of processes for communication with different project stakeholders, these can range from meetings (including focus group discussions) and interviews through to releases via radio, electronic or print media.

The main channels of communications will depend on the stakeholders, the information to be provided or received, and the purpose and timing of the communication. Methods include face to face meetings with stakeholders, focus group discussions, community meetings, establishing community liaison committees, preparation and dissemination of posters, information sheets or booklets, and use of media including electronic, radio, newspaper and social media when/where appropriate. Information communication technology such as mobile phones, internet and website can also be utilized by the project to inform stakeholders about the progress of the project.

The SECP is integrally linked with the project's grievance redress mechanism (GRM) that will also be reflected in the CESMP and other plans as required. The GRM (refer plan P-5) sets out the process for resolving concerns or complaints and shows how communities and other stakeholders can lodge any complaints or concerns about the project at different stages/levels.

The SECP will cover:

- Project communications
    - Meaningful consultation principles
    - Overall communication approach
    - Stakeholders and target audiences
    - Key communication outcomes
    - Medium of communications with external stakeholders
    - Key messages
- Project stages and communication outcomes
    - Preparation
    - Construction
    - Operations
    - Decommissioning
    - Monitoring
- Project's GRM and disclosure requirements

13.3.2.5 P-4 Human Resources and Labour Management Plan

The priority recruitment of members the local Benefit Share Community over other workers (as defined in the Community Development Plan), as well as the preferential recruitment of Solomon Islands' nationals over non-nationals is a key mitigation measure of the Project. Further details are provided in the Project's Implementation Agreement.

This plan shall identify hiring processes to implement these recruiting measures, together with a grievance mechanism, and audit, reporting and review process.

In addition, the plan shall specify the HR policies of the THL and EPC Contractror, to meet at a minimum the following objectives:

- To attract and retain a skilled and competent workforce.
- To ensure employees are aware of their rights and entitlements including pay, holiday, sickness and bereavement leave, and rest breaks.
- To deliver a fair and equitable environment that includes mechanisms for responding and resolving employees questions, difficulties or concerns, and to provide a clear process for performance management.

- Ensure compliance with relevant industrial relations legislation, and any applicable requirements of Project donors.
- Ensure employee relations issues are managed justly, and in a coordinated and consistent manner.

13.3.2.6 P-5 Influx Management Plan

Construction projects, especially those comprising large civil works, require labor force and associated goods and services that cannot always be fully supplied locally. A partial component of the labour force may need to be brought in from outside the project area. In many cases, this influx is compounded by an influx of other people ("followers") who follow the incoming workforce with the aim of selling them goods and services, or in pursuit of job or business opportunities.

The purpose of the influx management plan (IMP) is to set out the objectives in relation to management of project-induced in-migration and its impacts and to successfully implement measures to manage the in-migration, and avoid, prevent, and mitigate the direct and indirect adverse impacts associated with project-induced in-migration. All stakeholders have a role to play in managing in-migration.

The IMP will need to:

- Identify project components/requirement for labor and potential for in-migration
- Scale of in-migration and its impacts
- Management of project-induced in-migration into the project area, which includes minimizing in-migration, managing the inflow of in-migrants, and managing the physical and social footprint of in-migration within the project area
- Mitigation of adverse impacts associated with in-migration
- Buy-in and capacity of potential partners to collaborate in the design and implementation of the measures to manage the in-migration
- Resource costs of selected management approaches
- Stakeholder engagement and monitoring and information flows.

The IMP needs to be clearly linked with the SECP and the Human Resources and Labour Management Plan.

13.3.2.7 P-6 Grievance Redress Mechanism

This ESMP shall utilise the following process as the mechanism for addressing grievances between the different project stakeholders. The GRM is designed to facilitate feedback from any project participant or stakeholder regarding project operations, management, use of resources and impacts of activities, intentionally or otherwise, and resolution of the same by the developer. Grievances related to land acquisition will be dealt with separately under the GRM proposed in the LALRP.

Grievance mechanism allows the developer to interact with communities living along the Tina/Naglimbiu Catchment. The document will be reviewed as project development stages progress.

The THL will advertise and inform communities including isolated communities of the grievance mechanism and also ensure that communities are well aware of its structure. In the event that the communities of the Tina/Ngalimbiu Catchment feel that environmental and social complaints have not been adhered to or followed, those stakeholders have the right to raise their concerns and to seek satisfactory acknowledgement and resolution of their grievances. This right is essential to ensure transparency and accountability. Communities will be informed of the Project GRM through community meetings, project documentation and through the local media.

Grievance mechanism structure. Community liaison committees (CLC) will be established for the construction and operation phases of the project supported by a team from the TRHDP PO to oversee the monitoring and implementation of the mitigation measures. The monitoring team will also provide report on any impacts that may be happening in the project affected communities. The CLCs will be the focal points for information dissemination to the project affected communities.

Documenting grievances. The CLC would be responsible for recording the grievance or complaint through regular meetings with members of each community. Raised concerned will be written down in a report and presented to the TRHDP PO and the Developer. The CLC will consult with the developer on all complaints received to respond to any systematic issues or problems.

Responding to grievances. Responses to grievances will be the responsibility of the Developer. If, due to its nature, the grievance requires immediate attention, the developer should commit to address raised issues in an acceptable time frame. The developer shall keep minutes of meetings and other form of records regarding the way they have addressed the issues.

Where grievances cannot be resolved at this level, the aggrieved party or person will have recourse to a review and a decision made by the TRHDP-PO where a grievance relates to a construction impact and to MECDM where a grievance relates to an operational impact. If the CLC cannot resolve the issue, or at any other time, an aggrieved person may have recourse to the Solomon Islands' Courts.

13.3.2.8 P-7 Security Management Plan

The purpose of the security management plan (SMP) is to protect the site, physical assets, workers and information.

The SMP will include:

- Identification of risks, threats and security issues
- Risk mitigation and assurance measures
- Alarm systems
- Lighting and CCTV coverage
- Guards, personnel and schedule
- Site security plans
- Crime prevention

- Visitor control
- Perimeter access control – fences, walls, vehicle and pedestrian barriers
- Other controls.

13.3.2.9 P-8 Worker's Health and Safety Plan

The purpose of the Worker's Health and Safety Plan (WHSP) is to establish and maintain an effective health and safety management system. The WHSP will demonstrate the developer is committed to implementing a structured approach to workplace health and safety in order to achieve a consistently high standard of safety performance. The WHSP applies to all officers and workers and to other persons at risk from work carried out at workplaces.

The WHSP will assist in meeting its obligations in accordance with work health and safety legislation of Solomon Islands and comply with the requirements of the World Bank Group's Environmental Health and Safety Guidelines (EHSG).

The WHSP will cover:

- Health and safety arrangements
    - Responsibilities
    - Communication arrangements (incl. important contact numbers)
    - Risk assessment
    - Risk register
- Inspections, training and reporting
    - Emergency procedures (link to emergency response and evacuation plan)
    - Hazard and injury reporting
    - First aid
    - Training and induction
    - Record keeping (incl. register, documents to be displayed etc)
- Health and safety requirements
    - Behavior (link to code of conduct)
    - Dangerous good and hazardous substances
    - Electrical safety
    - Plant and equipment
    - Incidents (slips, falls, trips)
    - Drugs and alcohol
    - Vehicles
    - Personal protective equipment.

13.3.2.10 P-9 Workers Code of Conduct

The project developer and construction contractors will be expected, in advance of any construction work commencing on the project, to prepare and promulgate a code of conduct for its workers (and related visitors), including locals, other Solomon Islanders, and immigrants/expats. Induction training should include a cultural induction, delivered with the help of local knowledgeable elders.

The project developer and construction contractors will be expected, in advance of any construction work commencing on the project, to promulgate this code of conduct for its workers (and related visitors), including locals, other Solomon Islanders, and immigrants/expats.

Induction training shall include a cultural induction, delivered with the help of local knowledgeable elders.

The following is the code of conduct:

- Prior to entering a village or hamlet for the first time, the Chief, a leader from a church, or the head of a family (usually the father) shall be met for the construction contractor to show their respect.
- All workers must always consult the Chiefs, and community leaders (such as a church pastor or an elder) about any issues that may not be clear in the local culture
- If no male members of the community are present, the outsider/visitor must not enter and talk to women, especially young girls and married women. This will help avoid any unnecessary arguments arising between a man and his wife or parents with their daughters.
- When talking or shaking hands with someone (whether a man or woman) do not look straight at them in the eyes or press their hands strongly because to some it is disrespectful, shameful or could mean something different.
- Custom requires that visitors who enter a village are suitably attired. In particular, all genders should wear clothes that cover thighs.
- Do not criticize someone openly but always call the person aside and talk to him or her separately to avoid any ill feelings. Such incidents may even escalate to a stage where other relatives may become involved.
- Saturdays and Sundays are days when some people in the communities go to Church. The Human Resources and Labour Management Plan shall provide workers the right to take one or both of these days off as required for their religous observance. Death and funerals are also times when work and other activities stop in the community. Always seek advice and clearance from the Chiefs or community leaders in such cases whether work should continue on or temporarily stop.
- No alcohol or any form of drugs shall be consumed in the communities by any project employees. The contractor/developer should have and enforce an alcohol and drug-free policy (in the work place, while driving vehicles, or use of the access roads). The company policy should develop a position on the use of betel nut in the workplace.
- All employees should respect the local custom or culture of the people. For example one must always ask before taking any produce growing in the area, such as bananas, kumara, cassava/root crops, nuts, fruits from trees, and coconuts etc. There is always someone in the community who owns them. Picking something without asking first is regarded as disrespect for the owner, or stealing, and may require payment of compensation to the owner.
- Workers and visitors should not make any disrespectful gestures or use any swearing words to anyone either in the community, or along the access road, especially to women or coworkers in the company workforce. These may lead to demand for compensation fees from communities.
- No unlicensed person shall drive work vehicles. Drivers shall be tested prior to starting work on the project, and have a valid license.
- Construction company vehicles or trucks shall not be permitted to pick up anyone who is not an employee of the Project, except in case of an emergency.

- Heavy machinery shall only be operated by those who have the license and proven skills to use those types of machines. This shall be embedded in the recruitment and other policies of the contractor/s. This will help avoid health and safety problems and the unnecessary destruction of property, resources, and tambu sites.

- Workers and visitors shall drive slowly when passing villages that are very close to the access roadside or a pedestrian walking along the side of the road.

- Drivers and passengers shall watch out for domesticated animals or people crossing the access road.

- Take Prior Consultation, Careful Listening, and Paying Respect (PC-CL-PR) seriously because they are the key to avoiding conflict. Incidents can easily escalate into company/community conflicts.

13.3.2.11 P-10 Community Health and Disease Vector Management Plan

The purpose of the Community Health and Disease Vector Management Plan (CHDVMP) is twofold; firstly, it is to protect the health, safety and well-being of the communities within the project area; and secondly it is to control disease vectors and pests namely mosquitoes and vermin.

The CHDVMP will cover:

- Community health and safety
    - Health and safety impacts
    - Communicable diseases (incl. sexually transmitted infections and HIV/AIDS)
    - In-migration (links with the IMP)
    - Non communicable diseases due to changes to lifestyle leading to chronic conditions
    - Nutrition related diseases
    - Food security
    - Increased pressure on health care services
    - Site access and security (links with the SMP)
    - Management and mitigation measures
    - Approved service providers delivering awareness and prevention
    - Public awareness and prevention (link with SECP)

- Disease vector management
    - Identify vectors, species and diseases
    - Methods to control vectors of disease
    - Identify triggers for treatments and types of treatment options
    - Review methods of vector management
    - Working with Ministry of Health
    - Increasing public awareness (links with SECP)

13.3.2.12 P-11 Traffic Management Plan

The traffic management plan (TMP) describes how the developer proposes to safely manage vehicular and pedestrian traffic during the preparation and construction phases of the project. The safety of road users and the effective management of traffic to and around the site is paramount to the successful day-to-day activities during the construction phase of the project.

The purpose of the TMP is to describe how the developer will implement the work in accordance with the requirements of the contract, specifications and ESMP requirements, in addition to meeting national laws and regulations in respect of traffic safety.

Traffic accidents, minor or major, will have significant consequences and must be managed carefully.

The TMP will cover:

- Key traffic management and safety issues (incl. safety and amenity of road users and on-site)
- Traffic management responsibilities
- Access road upgrading and new site road construction
- Traffic control plans
- Managing construction vehicle movement
- Traffic and road user delay management
- Traffic flow arrangements and control
- Traffic control devices
- Traffic controllers, plant and equipment
- Information and awareness (links with SECP)
- Emergency response, including immediate and culturally appropriate responses to any traffic accidents. The plan should include clear processes for dealing with any accidents and the support to be provided for any impacts on persons or property (links with WHSP and SPERP).

13.3.2.13 P-12 Waste Management Plan and Point Source Pollution

The waste management plan (WMP) will provide guidance on waste management in relation to construction activities and to understand what excess materials are likely to be generated and then focus on how the generation of those excess materials can either be avoided.

The WMP will cover:

- Waste streams - likely to be generated (by type and condition) and estimates of the approximate amounts of material (by type and condition)
- Waste management options with a focus on waste avoidance/reduction
- Management of concrete wash water
- Opportunities to recycle and reuse
- On-site management – segregation of wastes, selection of disposal sites and methods, how the waste management system will work on-site, including bin placement and access
- Off-site management – selection of third-party waste management contractor who will provide services for the waste streams generated and data on waste/recycling generation
- Transportation

- Responsibilities – identification of those involved in relation to construction activities and WMP
- Monitoring and evaluation.

13.3.2.14 P- 13 Hazardous Materials Management Plan

The hazardous materials management plan (HMMP) is to describe the procedures for storing, using, managing, and disposing of hazardous materials in a safe manner. The HMMP will describe the requirements under national laws and standards, EHSG, and international codes for hazardous materials.

The HMMP will cover:

- National laws and regulations and international best practice requirements
- Hazardous materials inventory including:
    - Summary of storage and usage of chemicals and materials
    - Hazard class of chemical and material
    - Volume/amount of each hazard class and the container
    - Maximum allowable quantity (MAQ)
    - How the chemical/materials is to be used and stored (incl. labeling)
- Identification of risk associated with hazardous chemicals and materials
- Facility description and site plan that illustrates all buildings, roads, yards, outdoor chemical storage, sewers, wells, rivers and streams, and adjacent villages
- Facility storage map that shows the location of:
    - All hazardous materials
    - All storage areas
    - Emergency equipment and exits
    - Evacuation points
    - Spot where designated individual will meet emergency personnel
    - All tanks/sumps/ piping
- Accidental exposure measures
- Emergency response (links with WHSP and SPERP)
- Recording and reporting incidents.

13.3.2.15 P-14 Spill Prevention and Emergency Response Plan

The purpose of the spill prevention and emergency response plan (SPERP) is to: (i) develop a proactive hazard identification system so as to prevent (or lower the likelihood) of spill events; (ii) establish the prevention measures and response process and responsibilities for managing these situations; and (iii) establish emergency response procedures.

The SPERP will set out the requirements for management of unplanned spills of dangerous or hazardous materials during the project including spillages of: hydrocarbons (including diesel, petrol, greases, oils and other lubricants); drilling chemicals; hazardous chemicals; and, waste water, including sewage.

The SPERP will cover:

- Spill Prevention and Response
    - National laws and regulations and international best practice requirements
    - Spill response and containment strategies and capabilities
    - Framework for reducing the potential for spills
    - Sources of potential land contamination associated with construction
    - Sources of potential pollution of streams and rivers associated with construction
    - Categorize potential spill hazards
    - Training
    - Measures and process for rapid and efficient response to and manage hazardous material spills
    - Identify and document management measures to prevent, control and mitigate spill events
    - Responsibilities for implementing the management measures
    - Verification and monitoring and reporting measures
    - Monitoring operations to confirm that preventative measures are in place and followed

- Emergency Response
    - Approach to emergency planning
    - Potential threats and emergencies (fire, landslide, tunnel collapse, earthquake, tsunami and medical emergencies)
    - Incidents and emergencies
    - Evacuation procedures (including drills)
    - Communication protocols
    - Emergency control structures
    - Personnel and warden teams
    - Checklists and logs
    - Post-incident review procedures.

13.3.2.16 P-15 Air Quality Management and Dust Control Plan

The purpose of the air quality management and dust control plan (AQMDCP) is to minimize: greenhouse gas (GHG) emissions resulting from construction activities; impacts of dust generated due to the construction works; impacts of dust generated during transport of materials and other traffic; and, complaints from the community in relation to dust generated from construction activities.

The AQMDCP will cover:

- National laws and regulations and international best practice requirements
- Air quality baseline and existing environment
- Location and type of sensitive receptors
- Criteria and performance standards
- Identification of plant and activities that generate emissions
- Identification of plant and activities that generate dust

- Management, mitigation and control measures
- Water spraying schedule
- Monitoring and reporting.

13.3.2.17 C-1 Cultural Heritage Management Plan

This ESIA identifies that cultural heritage sites may be adversely affected by the project, including Tambu Sites. The TRHDP-PO will carry out a detailed assessment of physical cultural resources before construction work commences.

A Cultural Heritage Management Plan (CHMP) will be prepared by the TRHDP. The objective of the plan is to identify cultural heritage sites that may be impacted by projet construction and operation, to protect sites where possible, and to provide culturally appropriate compensation to land owning groups associated with sites where avoidance is not possible. Further information to inform this plan is set out in Annex 18.

The Plan will identify sites that will require preservation, or excavation and relocation where appropriate, and the steps to be taken, timing, and responsibility for carrying out these measures. These activities will be undertaken in conjunction with authorities of the Ministry of Culture, and the National Museum. Additional physical and cultural resources (chance finds) may be encountered during construction. THL/Epc contractor will develop Chance Find Procedures (refer to Annex 18) that identify what measures will be taken to protect these cultural resources. The Plan will also address measures to monitor any physical cultural sites that may be affected by on-going operation of the TRHDP.

The CHMP will be in place two months prior to the commencement of construction works involving land clearing and grubbing, or other land disturbing activities. This includes access roads, and main project site(s).

The Plan will be reviewed by the Ministry of Culture, and the National Museum.

The CHMP will identify measures to be followed for both the construction and operation phases of the Project.

Chance Find Procedure. For unknown Tambu sites, the following procedure specify how the construction contractor will act if a site is discovered. This process shall be subject to consultation with the five identified landowning tribes:

- First work will stop,
- The relevant previous customary land owning tribe (pre SIG land acquisition) to be identified,
- A scientific examination and/or cultural rituals performed and compensation agreement shall take place (in case of destruction),
- Additional actions shall be carried out to protect the rest of the site if the tambu is to be preserved (fencing the site).

Cultural Heritage Management Plan. The following is provided by way of guidance in the preparation of the CHMP by the future TRHDP developer and contractor/s.

i. First, talk with the members of the Landowners Core Group (LCG – the representatives of the landowners of the “core” project area) concerning the need to identify someone among them who has the knowledge of any tambu site(s) and their location(s) in the Project Impacted area(s).
ii. An expert with experience in recording the information associated with the tambu sites should be deployed from within or outside of the LCG to assist the knowledgeable person(s) they have identified and selected.
iii. Such knowledgeable and experience persons must be approved by the representatives from the LCG prior to involving them in this task.
iv. After the known tambu sites within the Project Impacted areas have been identified and the data collected and recorded, it must be stated clearly whether they will be completely or partly destroyed or only disturbed during the construction work on the Project.
v. It is of paramount importance that any tambu sites that are certain to be completely or partly destroyed should be prioritized for documentation while those that may be only disturbed could be clearly marked by using red and white painted posts erected around them to show that they are tambu sites and to be avoided. Where cultural sensitivities exist to the publicizing of a tambu site, alternate ways of bringing the site to the attention of workers will be adopted.
vi. Any tambu sites located within the construction areas that the LCG really feels should not be destroyed should be demarcated with fence and worked around where possible. This will help avoid any disagreements or demands for huge compensation payments which might delay the construction programme.
vii. Any decisions or agreements to move, relocate, or destroy any sacred objects from tambu sites must come either from the LCG or the heritage protection expert. This should be done before the construction work on the Project starts.
viii. For unknown tambu sites, it is important that, prior to construction, a clear understanding is reached and recorded (in the form of an accidental discovery protocol) between the LCG and the contractor. This should specify how a contractor will act if a site is discovered, e.g., work will stop, the nominated LCG representative contacted (if not already on site supervising the work), the site owner identified, a scientific examination and/or cultural rituals performed, and any additional actions carried out to protect the rest of the site if required.
ix. The current compensation rates for disturbance or damage to tambu sites depend on the significance of the site, scale of destruction, and the distances between the sites and where the construction work is being carried out. Logging, and to a lesser extent mining agreement, can provide indicative national rates. An example of such compensation rates is provided in Table 13-3. Rates should be discussed with the National Museum.

Table 13-3 Costs associated with compensation for Tambu site destruction

Destruction or Disturbance of Tambu Sites	**Compensation rates (Solomon Dollars)**
Major Scale	$50,000
Minor Scale	$20,000
Disturbances: 50 meters from Sites 100 meters from Sites	 $10,000 $15,000
Graves in Cemetery (per grave)	$10,000

Note that disturbances are caused when trees fall into nearby tambu sites, and machines or employees pass through these sites during construction work even though they might not cause any physical damage to them.

13.3.2.18 C-2 UXO Management Plan

Regarding unexploded ordnance (UXO) management there is a chance that UXO, which is a historic remnant of WWII, may be found within the project area. A UXO Management Plan (UMP) shall be included as part of the stand-alone CESMP for the Project, the aim of which is to reduce the risk of interaction between workers/communities and UXO and identify the procedures to follow in the event of a "chance" find.

Following finalization of the project layout, and prior to commencement of construction, the EPC contractor will engage a suitably qualified firm to review the project layout, including access roads, temporary and permanent construction sites, and areas where project-related infrastructure is to be provided. The firm will carry out a site survey and, if UXO is encountered, the Royal Solomon Island Police Force Explosives Ordinance Unit (RSIPF EOU) will clear the UXO, following best practices for protecting workers and the surrounding communities.

13.3.2.19 C-3 Forest Clearance Plan

The purpose of the forest clearance plan (FCP) is to clearly identify trees and vegetation to be removed by the project and trees and vegetation to be retained and protected. The FCP will be based on accurate and scaled maps and plans.

The FCP will cover:

- Demarcation of area on the ground (fencing etc)
- Identification of trees (incl. drip-lines) to be protected
- Site plans (showing cleared areas, protected trees, designated storage areas, areas to be cleared manually only etc)
- Methods (machinery and manual clearance)
- Notification to communities (links with SECP)
- Schedule of forest clearance activities (avoiding wet season as much as possible)
- On-going vegetation control measures
- Re-use (mulch) and cut-timber collection by locals
- Storage, transportation and disposal of cut timber
- Sanctions for felling trees beyond footprint
- Coordination with independent environmental expert
- Recording of clearance activities
- Monitoring and reporting.

13.3.2.20 C-4 Post-construction rehabilitation and replanting plan

There will be two stages of rehabilitation, 1) upon the completion of the construction phase; and 2) upon the decommissioning of the hydropower facility. Rehabilitation at decommissioning will be covered by the Decommissioning Plan.

Toward the end of the construction phase, the developer will amend its Post-Construction Rehabilitation Plan. Amendments will detail how the construction contractor intends to carry out the following:

- Remove hazardous materials, hazardous materials storage facilities, and concrete production works;
- Remove other structures that are not required for operation, and which the TCLC does not wish retained on the site (e.g., work areas, work sheds and storage buildings) and which may become safety hazards;
- Test for soil and groundwater contamination at key sites, including fuel and lubricant storage facilities, machine shops and other locations where hazardous materials were stored and/or used;
- Remediation measures that may be required following testing, including removal of contaminated soil and spreading of clean topsoil, and treating contaminated groundwater; and
- Rehabilitate work areas by spreading clean topsoil over former temporary work sites and access roads. As previously noted, based on observations of disturbed sites within the project area, it appears that vegetation regeneration is vigorous in areas where topsoil has been retained. Weeds will likely invade some sites as long if natural regrowth of trees is delayed. According to preliminary assessment, rehabilitation will be necessary in the following areas:
    - Work areas, covering approximately 1.18ha;
    - Construction areas at the entrance to the headrace tunnel covering roughly 2ha; and
    - Temporary quarry access roads (approximately 1.5km long and 15m wide), covering roughly 2.25ha. The project intends to have most of the quarry sites to be within the reservoir and will be inundated by the reservoir.

If one meter of topsoil is spread over these areas, the total amount of topsoil necessary for rehabilitation will be about 54,300m^3. The total amount of topsoil to be stockpiled is estimated to be about 327,900 m^3. Therefore, there will be an excess of soil to deal with. It is recommended that the site of the soil stockpiles be re-contoured using the excess soil and allowed to naturally re-vegetate.

On areas to be rehabilitated, soil should be spread no closer than 100m from any water body and be uniformly distributed to a thickness of 1m and compacted. Sites where soil has recently been spread will be surrounded by deeply-anchored silt fences. Soils will not be spread during the rainy season., Silt fences will be removed after one year by a local contractor that has been contracted by the TRHDP PO.

Site restoration using native plant species will be undertaken in affected areas. Native vegetation species are expected to become quickly established if planted in good quality soils.

Since the two rock quarries are expected to be inundated by the reservoir they will not have to undergo rehabilitation. However, if other quarry sites are used that are outside of the reservoir area, a re-vegetation plan will be required as part of the Quarry Management Plan.

Temporary access roads, including those to the quarries, will be permanently decommissioned once construction of the Project has been completed, to avoid unnecessary human encroachment into the upstream Tina River catchment area. Road decommissioning will involve removing all stream crossings, breaking up the road surface (scarification), spreading topsoil to allow vegetation to regrow, and installing an earth mound at road entrance to prevent vehicle access. Significant cut areas along the road will be refilled with soil.

13.3.2.21 C-5 Quarry Management Plan

The developer shall prepare a Quarry Management Plan incorporating the following measures as appropriate. Some measures, including rehabiltiation, will not be required for quarry sites located within the reservoir area.

- Water quality monitoring to be undertaken, including baseline moniitoring before works commence. Water quality monitoring will be incorporated into the water quality monitoring plan and sediment transport monitoring plan;
- Fish and invertebrate monitoring to be undertaken, including baseline monitoring. This monitoring will be incorporated into the Aquatic Life Monitoring Plan;
- Maintain natural continuity of sediment transport through the river system by implementation of good international industry practice for river mining;
- Minimise impacts on riverbank and channel by maintaining a buffer zone either side of river banks to maintain their integrity. Channel not to be undermined by extracting from or below banks. Protect vulnerable banks and remedy erosion where apparent;
- Ensure trucks and industrial machinery are in proper working condition to minimse avoidable exhaust fumes
- Fuels, lubricants, coolants, waste oil and chemicals must be stored in an approved manner such as in drums or surface tanks with impervious bunds to contain spillage and located away from operating areas, natural or engineered drainage pathways, waterways and areas prone to flooding ;
- Minimise total disturbed area at any one time to reduce erosion potential and transfer of suspended solids to adjacent surface waters ; and
- Minimise areas exposed to vegetation removal (if any), and rehabilitate each disturbed area immediately after use.
- Detail measures to construct and rehabilitate quarry access roads, incorporating access road measures set out in 13.2.1.4.
- Where additional aggregate is purchased from a licenced gravel supplier, the supplier shall show:

- Compliance with approval requirements under the *Environment Act*;
- Compliance with applicable licensing requirements under the *Mines and Minerals Act* ;

The THL and EPC Contractor will be responsible for ensuring that third party suppliers comply with the Quarry Management Plan.

13.3.2.22 C-6 Reservoir Preparation Plan

The Reservoir Preparation Plan will describe the types of vegetation to be cleared, the extent of removal to be achieved, methods of clearing, methods and arrangements for use or disposal of cleared biomass, and arrangements for plan implementation including opportunities for local community members and small businesses to benefit from contracts and timber.

13.3.2.23 C-11 Drill and Blast Management Plan

In addition to addressing technical and worker and community safety issues, the plan will include measures prepared in conjunction with the Noise and Vibration Management Plan to minimize adverse impacts on local fauna. Plan preparation will include modelling of noise levels at various distances from blasting locations and a review of literature to identify noise levels likely to disturb wildlife.

13.3.2.24 O-1 Operations Environmental Social Management Plan

The OESMP will set out the detailed management of all enivornment and social measures during the period of operations. See also section 13.11. The THL, together with the O&M Contractor, shall prepare a framework fo the OESMP to be submitted to the PO for review and approval prior to the preparation of the plan.

13.3.2.25 O-2 Reservoir Operation and Management Plan

This plan will cover the environmental aspects of reservoir management, including options to establish a reservoir fishery (natural development versus stocking), to prevent arrival of invasive species, and to monitor fishery status. It will also address water quality; it will be linked to the Reservoir Preparation Plan and will provide predictions of water quality in the reservoir, identify potential impacts on water quality in the river downstream, describe real-time monitoring techniques to detect deterioration in quality that could result in adverse downstream impacts, and propose remedial actions.

13.3.2.26 D-1 Project Decommissioning Plan

Although it is expected that the TRHDP will operate for many decades, there may come a time when the facility is no longer required. In the run-up to that time, a dam closure plan will be prepared by the operator and submitted to the Ministry of Environment (MECDMM) for approval. A new ESIA will be prepared at that time by the operator. Information that will be required in a decommissioning plan includes:

- Detailed engineering design dealing with:

- Relocation and/or stabilization of nearby structures prior to decommissioning (e.g., access roads, bridges, etc.);
- Site access requirements (e.g., access roads), temporary easements, construction staging and lay down areas;
- Method for dewatering the reservoir and restoring flows to the by-passed section o the river;
- Method for demolishing the dam and removal of concrete and metal debris;
- Material testing for safe disposal and identification of locations for off-site disposal; and
- River channel improvement works, including natural channel design (bio-engineering techniques), especially within the former reservoir reach.

▪ Regulatory permits, including a new ESIA which will focus on the following:

- Environmental impact assessment:
- Fish surveys in the reservoir;
- Invasive plant species survey in the reservoir;
- Identification of impacts from the sudden release of fish and plant species adapted to lentic environment downstream into the river;
- Water quality monitoring, including stages of stratification in the reservoir and downstream impacts of releasing sudden deoxygenated water.
- Bathymetry mapping to assist in determining thickness of accumulated sediments in the reservoir;
- Characterization of accumulated sediments both above and below the dam (granulometry, volume, presence of pollutants);
- Estimation of the duration of natural flushing to achieve a sediment distribution pattern similar to pre-dam conditions.; and
- Assessment of impacts on the Tina River's geomorphology; and
- Mitigation measures for demolition methods based on staged release of sediments; and
- Assessment of impacts on the mouth of the river.

- Socio economic impact assessment:
- Consultation with riparian communities;
- Description of users and uses of the modified Tina River environment (i.e., reservoir, and 5.7km by-passed section of river below the dam);
- Economic impacts of sudden changes in the dam area and economic impacts of sediment releases on downstream communities;
- Description of settlements on the right bank of the Tina River that had become dependent on the by-passed river reach for easy crossing to the left bank; and

- Fate of the Core Area post-project monitoring:
  - Water quality monitoring;
  - Long-term monitoring of sediment distribution patterns and river geomorphology; and
  - Long-term monitoring of socio-economic modifications.

13.4 MONITORING ACTIVITIES

13.4.1 Measures for Ensuring Environmental and Social Monitoring Implementation

Measures will be put in place to ensure that environmental and social mitigation and monitoring is implemented and communicated with stakeholders. Mitigation measures will be monitored by an environmental and social safeguards management specialist engaged by the THL (THL ESS Specialist), and audited by an environmental and social safeguards specialist engaged by the Project Office (PO ESS Specialist).

- Both specialists shall have extensive experience in issues and impacts related to the Project such as aquatic ecology, water quality, etc.
- The THL ESS Specialist will ensure that all general mitigation measures are implemented especially those that apply to the construction contractor and health and safety.
- The following reports/plans shall be prepared by the Developer (with the assistance of the THL ESS Specialist). All reports will be submitted to the PO for review with support of PO ESS Specialist:
  - Recruitment policy(ies) of the Developer (part of the Human Resources and Labour Management Plan)
  - Worker's Health and Safety Plan of the construction contractor as well as data on accident and injuries. Minutes of meeting of various trainings to workers
  - CESMP and OESMP
  - Reports from the Community Liaison Committees
  - Minutes of meetings on the educational programme about modern day dam engineering and other sensitization trainings
  - Reports of STD awareness training
  - Report on protection of sensitive habitats prior to construction
  - Data on water quality, bed load and sediment model, environmental flows in the by-passed section and flows through the powerstation
  - Reports on aquaculture results and any fishery monitoring
  - Report of the soil expert regarding topsoil stripping and stockpiling.
- The PO ESS Specialist will:
  - assess compliance of THL with ESMP and management plans throughout the lifespan of the Project;
  - report to the PO and support the PO and MECDM in ensuring THL compliance; and
  - build MECDM capacity to monitor compliance during operations.
- It is required that the PO ESS Specialist be present 3 times a year to audit measure implementation as well as consult with other actors of the ESMP. During each mission, the specialist will produce a report to the attention of the Developer and its subcontractors to inform them of non-compliances. The PO ESS Specialist will work with the THL ESS Specialist to ensure that corrective measures are implemented. The role of PO ESS Specialist is expected to be undertaken by an independent NGO or firm.
- It is expected that the THL ESS Specialist will be a full-time role during the period of construction.

- The tasks of the Developer ESS Specialist and the PO ESS Specialist are to be described in detail in sub plans.

In addition to these monitoring and auditing roles, it is anticipated that the EPC contractor will appoint a safeguards specliast as part of their key personnel to oversee the implementation of construction mitigation measures.

13.4.2 Monitoring Plans

Environmental monitoring will be undertaken in accordance with the ESMP and supporting Environmental and Social Action Plans (ESAPs), the LALRP, and good international industry practice for preparing and implementing management plans.

The Developer will develop monitoring plans for each key area including:

- Construction Works Monitoring Plan
- Air Quality and Noise Monitoring Plan
- Social Impacts Monitoring Plan
- Sediment Transport Monitoring Plan
- Water Quality Monitoring Plan
- Aquatic Life Monitoring Plan
- Flora and Fauna Monitoring Plan

Each monitoring plan will identify the parameter being monitored, how it will be monitored, how frequently and who will be responsible for monitoring.

Monitoring plan frameworks for a number of plans are set out below.

13.4.3 Monitoring Plan Frameworks

13.4.3.1 M-1 Suspended Sediments Monitoring

Water quality during construction is a central issue for local communities (see social impact) and communication with stakeholders regarding water quality is important. A typical indicator of water quality is TSS, as this parameter is the main element that will change during construction. This section presents how TSS should be monitored.

The Tina/Ngalimbiu River exhibits natural peaks in TSS during heavy rains/fast flood events, with direct impacts on water uses by riparian communities (subsistence fishing by sight, clothes washing, water consumption).

During the planned 3-year construction period, the river is assumed to be exposed to accentuated peaks of TSS, due to sediment-laden run-off from cleared areas and works within the river bed. This extra-load of TSS might represent a significant inconvenience for riparian populations.

It is recommended that TRHDP collect regular TSS data on the natural suspended sediment load and to monitor TSS during construction, Besides being a good indicator of water quality, monitoring TSS at a location immediately upstream of the damsite and reservoir, it will be useful as a means of estimating the rate of siltation of the reservoir. Monitoring TSS downstream of the damsite will provide reliable data about TSS peaks, information that may prove useful if disputes arise with communities over what are natural versus project caused increases in turbidity.

This type of monitoring was undertaken in Tahiti, where construction of new dam and emptying/mucking out operations of existing reservoirs was a source of conflict with downstream populations.

Notwithstanding that TRHDP may undertake regular monitoring of TSS, this should not be used as an excuse to abandon or relax measures to control the release of sediment laden runoff from disturbed areas or worksites

The objective of monitoring TSS is to determine the load of suspended solids in the Tina/Ngalimbiu River over a long period, through regular monitoring of TSS during peak river flows prior to, and during, construction.

Monitoring should begin one month before construction work begins and continue until the work is completed.

The following protocols should be implemented:

- Water samples / measurements should be made at four stations: (i) upstream of the reservoir; (ii) immediately downstream of the toe of the dam; (iii) at Horohutu or Valekotcha, approximately 10km downstream of the dam; and (iv) at Ngalimbiu bridge, approximately 20km downstream of the dam.
- The samples / measurements should be done at least once a week on a fixed day. Additional sampling should be conducted during floods.
- TSS will be analyzed at SIWA laboratory. Turbidity will be measured using a turbidity probe. For each sampling event, a blank sample will be taken to assess the laboratory accuracy.

The results will be treated as follows:

- Correlation between TSS and turbidity.
- Correlation between suspended solids and flow measured at the gauging station.
- Comparison of peaks of suspended solids during construction work with those observed in natural conditions.
- Commented results will be made available to stakeholders (e.g., on the project website) or by mean of regular environmental reports.

Since the Tina River has natural peaks of TSS during flash floods, trigger values should not be used to describe thresholds where specific measures need to be implemented. Rather, a comparison should be made between pre-construction and construction conditions, as an important indicator of the efficiency of sediment control structures, such as silt fences and settling ponds. The efficiency of sediment trapping structures will be monitored throughout construction, to ensure that peaks in TSS do not originate from sediment erosion associated with work being conducted on land.

Monitoring should begin at least one month prior to commencing construction and continue at least two months after reservoir inundation and commencement of dam operation.

Several stakeholders should be involved in putting into practice the monitoring program:

- Local environmental specialist under the direct responsibility of TRHPD - or construction contractor (sampling / measurements)
- SIWA Water quality laboratory (analysis).

13.4.3.2 M-2 Water Quality Monitoring

In addition to applying GIIP, construction environmental management and water quality monitoring will be necessary.

Throughout the 3-year construction period and initial reservoir impoundment a constant concern of TRHPD will be: (i) to ensure implementation of the environmental and social management plan (ESMP), and the associated health, safety and environment (HSE) policies, and environmental management system (EMS), standards and national regulations; and (ii) to follow-up on environmental impacts and to adapt mitigation measures or implement new ones as necessary.

The construction environmental supervision and monitoring activities will be undertaken by an independent environmental monitor.

During construction of the dam, when the risk of water quality alteration is highest, a program of water quality monitoring will be undertaken to assess key parameters.

Water quality monitoring during construction and impoundment will include communication of results to stakeholders in an appropriate form. Besides monitoring of TSS (see Section 13.4.1.1 – Suspended Sediment Monitoring), daily water quality monitoring of the Tina/Ngalimbiu River will be undertaken for key parameters shown in Table 13-4.

During operation, monitoring will be undertaken at the environmental flow outlet of the dam, in the by-passed river reach (i.e., upstream of the powerhouse), and downstream of the powerhouse, for the key pollution indices shown in Table 13-4. Monitoring will be conducted weekly for the first 2 to 3 months following commissioning, then quarterly for the first year, followed by annually when annual testing is conducted of the project electro-mechanical systems. Trigger values (threshold values for health and biodiversity protection) will include:

- ANZECC Water Quality Guidelines for tropical Australia, for upland or lowland rivers for parameters that can affect aquatic life; and
- Australian Drinking Water Guidelines (ADWG), or World Health Organization (WHO) guidelines for potable water, for parameters that can affect domestic use.

Table 13-4 Key water quality parameters

Construction phase water quality parameters	**Operation phase water quality parameters**	**Reference**	**Trigger values (or range of acceptable values)**
Temperature	Temperature	-	-
pH	pH	ADWG	6.5-8.5
		ANZECC	6.4-7.9
Conductivity	Conductivity	ANZECC	20-250 uS/cm

Dissolved oxygen	Dissolved oxygen	ANZECC	> 6 ppm
Oil and grease	Oil and grease		Any detection is a sign of spills
Nutrients NH_4-N	Nutrients NH_4 -N	ANZECC	< 0.006 mg/L
Nutrients $N0_3$-N	Nutrients $N0_3$-N	WHO	< 10mg/L
Nutrient Ptot	Nutrient Ptot	ANZECC	< 0.01mg/L
Fecal contamination: Ecoli		WHO	0 MPN
Fecal contamination: total coliforms		WHO	< 10 MPN

Environmental management and monitoring of the construction works and operation of facilities will facilitate minimal environmental impacts and risks, under a continuous supervision.

Some pollution of the river is anticipated if GIIP are not followed during construction. If monitoring determines that trigger values have been reached, the root cause will be determined (e.g., release of sewage, concrete leachate, fuel / oil, spoils, or other contaminants), and procedures will be refined to prevent future occurrences.

Water quality results will be disclosed to local villagers. The construction contractor will implement an alarm system in case of oil/concrete/dangerous substance spill. This includes alerting local villages along the Tina River., An emergency warning system will be used in the event of a dangerous spill to alert downstream communities in the event of a spill of a hazardous material into the river (e.g., fuel / oil, concrete leachate, or other hazardous substance), without first waiting for laboratory results to confirm the risk posed by the spill.

During construction, regular environmental monitoring and supervision of impacts and activities, with regular assessment reports will be undertaken on a daily basis. Monitoring of nutrient parameters will be carried out on a monthly basis. Regular (weekly) monitoring will be carried out for the first 2 to 3 months after the project has been commissioned and is operational. Quarterly monitoring will be undertaken for the first year of operation and then reduce to annual monitoring to coincide with annual inspections of the dam and powerhouse systems.

Several stakeholders will be involved in the monitoring program as follows:

- Water quality laboratory (water quality analysis reports);
- TRHDP and / or construction contractor environmental management and monitoring staff (self monitoring and auditing); and
- Local environmental authorities (compliance auditing).

Aside from very limited sand and gravel extraction for personal or village use in communities upstream of the Tina and Toni rivers, there is little anthropogenic disturbance (e.g., no gold placer mining, no major sources of TSS, no agriculture activities, or other enterprises) that could presently affect the rivers. Therefore, heavy metals such as mercury, arsenic, cadmium that are associated with industrial mineral processing, or agricultural pesticides, are unlikely to be a pre-project water quality issue. However, it is probable that the downstream reach of the Ngalimbiu River experiences fertilizer and pesticide pollution introduced from waters that drain adjacent oil palm plantations. Therefore, it is strongly recommended to conduct a single sampling of water, sediment and fish flesh to test for these pollutants in the river system prior to construction of TRHDP. National laboratories do not have the capacity to analyse such sources of pollution. Samples could be sent to Brisbane, Australia.

The following potential contaminants will not be generated by the Project. However to ensure proper cover in the event of complaints from downstream communities, these parameters should be analyzed as par of a single monitoring event prior to construction:

- Pesticides such as Glyphosate CT, Basta, 2-4-D Amine, Ally (Metsulfuron Methyl), Kamba 500 Selective herbicide (present as the dimethlyamine salt). Gramoxone Tropical (Paraquat) in the Ngalimbiu River system. These sources of pollution are suspected from oil palm plantations.
- Metals such as Cyanide, Nickel, Aluminium, Copper, Arsenic, Cadmium, Lead, Cobalt, Mercury, Silver, Copper, Lead and Zinc in water and sediment. These are the common sources of pollution from the mining industry.
- Bioaccumulated metals in fish flesh related to mining activities for the following metals: Silver, Arsenic, Cadmium, Cobalt, Copper, Mercury, Lead and Zinc.

The sample site for pesticides should be located downstream in the Ngalimibiu River reach, and the sample site for metals should be located on the Tina River. If any of the metal parameters exceed detection levels on the Tina River, additional samples will be collected and analysed. Pesticides are expected to be found in Ngalimbiu River samples. In addition to these measures, wastewater from the cement plant will not be directed to any water body. Rather, it will be collected and treated.

13.4.3.3 M-3 Fish, Algae and Macro-invertebrate Monitoring

The Tina River is a relatively pristine, low nutrient watercourse originating from bedrock-controlled substrate in the undisturbed montane forests found on the higher elevation slopes of Guadalcanal. Lower trophic level aquatic organisms, such as algae and macro-invertebrate species support many of the fish species found within the Tina River. Species assemblages and populations can be used as an index of aquatic ecological health.

This fish monitoring plan is to frequently monitor the physical changes of the Tina River during and after the construction of the hydro electrical system. This is to conduct a long term water shed health monitoring in the Tina River reaches and its tributaries over time.

Field studies conducted in support of the ESIA involved only limited sampling of aquatic macro-invertebrates, primarily aquatic dependent insect species, mostly in their emergent adult forms. In the interest of monitoring potential impacts of TRHDP construction and operation on the health of the aquatic habitat, TRHDP will implement a program of algae and macro-invertebrate monitoring. Baseline algae and macro-invertebrate data collection will be undertaken pre-construction during a typical low flow period, when it is safe to enter the river to collect samples. Periodic algae and macro-invertebrate sampling will be subsequently carried out to measure potential changes to these lower trophic levels that may result from construction and operation of the Project. At least one station will be located upstream of the reservoir, to be used to determine whether the project is having any impact on the aquatic ecosystem there.

The monitoring plan shall:

1. Review and understand the terrain, river and hydrology of Tina River through the series of respective studies especially the hydrology, fish and fisheries and water quality. gather information from relevant stakeholders and plan for specific indicators for aquatic health. In this area, the expert will do and formulate baseline data of the area and the gaps that may be considered during monitoring.
2. Identify sampling locations. It is proposed to have at least eight consistent sample stations in the Tina, Toni and Ngalimbiu areas. This should include 2 sample stations on the Toni River, 4 sample stations on the Tina River and 2 sample stations on the Ngalimbiu river, including one station in the river mouth to monitor the commercial fishing area. Sample stations are to be homogenous to allow consistent monitoring over time. Sample stations should be reference by either human features (e.g. roads, barriers) or any natural attributes due to changes of stream physical changes. Baseline data should be collected for each sampling station.
3. Identify parameters to be tested and observed
4. Formulate schedules of tests/sampling dates
5. Data collection tools
    - Field data sheets
    - Hand-held GPS
    - Waders
    - Digital camera
6. Reporting framework and policy in the case of emergency declarations

Stakeholders are to be involved in the process with proper awareness of the results analysed during the monitoring.

13.4.3.4 M-5 Flora and Fauna Monitoring Plan

The flora and fauna plan will include monitoring of invasive plant and animal species, e.g., Water Hyacinth to assess its presence in the reservoir and to ensure quick response in case it becomes established. This monitoring will be done twice each year and will include surveys of the entire reservoir. In the event that Water Hyacinth does become established in the reservoir, immediate removal of the plant and its roots will be carried out to limit the ability for it to propagate further.

13.5 PROTECTION OF THE TINA RIVER UPPER CATCHMENT

The protection of the upper Tina River catchment has the potential to create one of the largest terrestrial protected areas in Solomon Islands, providing conservation support to a key portion of the cloud forests of Guadalcanal identified as habitat Key Biodiversity Area by the IUCN and Bird Life International. Protection could bring potential benefits to the ecosystem, the landowners and the wider community.

As customary land owned by a number of indigenous tribes, the protection of the catchment depends upon the leadership and support of the indigenous landowners. Appendix K provides an outline of (a) the legal process for according protected status to customary land – a process that is landowner driven; (b) actions that have already been taken by the Project to promote the protection of the area, including the support of the University of South Pacific's 'Islands in the Sky' biodiversity expedition; and (c) a framework of the stages needed to promote and facilitate protection.

As a component of project financing SIG will fund an NGO within a year of receipt of funds to consult with landowners and communities and to conduct studies towards the creation and management of a protected area. Also as a component of the first stage of establishing a protected area, SIG will work with the Developer to monitor and report on changes in forest cover using satellite imagery, and to monitor trends in logging truck traffic into and out of the catchment through existing logging roads.

The Biodiversity Management Plan will also incorporate measures for the Project Company and Tina Core Land Company (TCLC) to restrict vehicular access to the catchment through the Project's access road.

13.6 Community Benefit Share

TRHDP Office have prepared a benefits sharing package for the host communities of Malango and Bahomea.

The Community Benefit Share is proposed as two components, a construction period pilot scheme and an ongoing sustainable

13.6.1 Construction period Community Benefit Share Pilot

To prepare the community for the benefit share arrangement, the TRHDP and the World Bank propose to pilot a project with financing from the Japanese Social Development Fund (JSDF). MMERE through the TRHDP PO, is in the process of applying for US$ 2.8 million (approximately SB$22.6 million) to "*establish the institutional arrangements and capacity for affected communities to effectively manage benefit sharing revenues from the Tina River Hydropower Development Project and improve their basic services and economic opportunities*".

The fund is proposed to provide pre-operation community infrastructures such as water supply and electricity access, as well as training for jobs during construction. The JSDF is intended to provide community benefits from the project before the power scheme becomes operational.

This pilot stage will design and establish the detailed operational arrangements and build capacity for the ongoing community benefit share fund (post operation). It will also facilitate the following three sub-projects:

- Electricity distribution to identified communities in the Bahomea and Malango Area;
- Provision of pre-employment training to members of the Bahomea and Malango Area; and

- Water supplies for identified communities.

13.6.2 Operational Period Community Benefit Share Fund

The internal management of the benefit sharing fund, and its formal objective, will be designed in partnership with the community under the Community Benefit Share Pilot project. The fund is intended to focus on community benefits and services and is not intended to incorporate cash payments. Early consultations suggest that some key objectives of the fund may include: Based on IA, benefit sharing consists of benefit share from THL which include fixed and variable amounts, and energy royalty which is 1.5% of capacity payment.

- Permanent provision of reliable clean water supplies;
- Provision of sanitation and drainage facilities with improved water supplies;
- Provision of better quality, more accessible education for the young people of this community;
- Implementation of in-village and residential training for local youth in technical skills;
- Improvement of access to health services, especially for women and children;
- Skills based training for women and utilisation of women's centres; and
- Development of ecotourism opportunities in the Central Guadalcanal area, involving people of Malango ward.

13.7 Land Acquisition and Livelihood Restoration Plan (LALRP)

13.7.1 Rationale for Preparing a LALRP

The land required for the TRHPD was identified at the end of the feasibility Study. It was an objective of Solomon Islands Government (SIG) to ensure that only the minimum amount of land reasonably necessary to enable the project to proceed would be acquired from the indigenous owners. It was also an objective of the SIG that there be "No Loss". That is, that none of the indigenous peoples affected by the Project would be worse off as a result of its construction and operation.

World Bank Environmental and Social Safeguard Policies require that where a project undertaken by a Client of the Bank involves World Bank funding, the Operating Procedures (OP) must be followed. In the case of the acquisition of the project land, OP 4.10 (Involuntary Resettlement) and OP4.12 (Indigenous Peoples) were identified as relevant Safeguards against which the Project needed to comply.

A usual consequence of these two safeguards would be the preparation of Resettlement Action Plan and an Indigenous Peoples Plan. For the TRHDP, it became clear after Option 7C was ultimately identified as the preferred option, that the project area was sufficiently far upstream and sufficiently small that no residential buildings or households would need to be relocated.

Therefore, to provide clarity to all stakeholders, the nomenclature was changed to Land Acquisition and Livelihoods Restoration Plan to reflect that land was being acquired, and that the consequent impacts on livelihoods and livelihood assets were assessed and mitigated in accordance with the Safeguards.

As currently proposed, the transmission line component of the project will be constructed along the road corridor acquired for the project area to a point where it travels West to the Lunnga Power Station. The transmission line will be constructed using IDA funding, by Solomon Power, a commercial enterprise owned by the SIG. Therefore, its impacts will be addressed under the World Bank Performance Standards in accordance with OP4.03 (Performance Standards for Private Sector Activities). The route of the line to Lunnga has not yet been finalised by Solomon Power. The LALRP provides a framework for a separate ESIA to be prepared by Solomon Power and TRHDO PO.

The related Indigenous Peoples Plan is incorporated into this ESIA and the associated ESMP and LALRP.

13.7.2 Summary of the LALRP

13.7.2.1 Land Acquisition

The LALRP identifies the actions that will be taken to avoid, minimise, mitigate, and otherwise manage the adverse livelihoods impacts of the land acquisition and restrictions on land use arising from the Project, by achieving an equitable and socially and economically sustainable situation for the people and whose land has been acquired. This includes ensuring those affected by the hydro development are engaged in its planning and have opportunities to participate in devising and implementing livelihoods mitigations and enhancements where offered.

The construction and operation of Tina Hydro Option 7C requires the acquisition of 428 ha of land - referred to as the "Core Land". The Core Land is described in the acquisition 'Process Agreement' with the customary landowners as the area required "*to provide all things necessary for the construction and operation of the scheme, including a concrete dam, reservoir, 3.5 km water tunnel, power station, access road, surge shaft, substation… transmission lines, telemetry, and helicopter landing pads*". It will also contain temporary sites and structures required for construction, such as quarries, materials borrow pits, a concrete batching plant, set down and storage areas, office and workshop buildings, generator sheds and so on.

The Core Land is in the customary ownership of five local tribal groupings or lineages, as determined by the Commissioner of Lands.

In 2011, to facilitate site investigations and other fieldwork for the Tina Hydro Project, the SIG entered into a land access agreement with the 27 land owning tribes of the Ngalimbiu-Tina River area. In the agreement, the customary landowners guaranteed to provide physical access to their lands for 18 months to enable investigative drilling, environmental and social impact studies to be carried out. In return the SIG gave each tribe a "goodwill payment" SB$100,000, i.e., a total of $2.7 million, paid into a "*special account held on behalf of the landowners, and under control of the [then] Landowner Council*".

In February 2013, following a programme of community consultations involving more than 500 members of the affected communities, the landowners agreed to extend the access agreement for a further 18 months to enable finalisation of the technical studies.

While the process used was a ‘compulsory’ process under the Land Titles Act, the acquisition of the Core Land was contingent on first obtaining the consent of all identified landowning tribes. This consent was obtained through the negotiation of a written ‘process agreement’. The land acquisition process is consistent with the requirements of the World Bank’s OP 4.12 and 4.10, and the IFC’s PS5 and PS7 where there must be free prior and informed consent by the landowners and communities. Community support for the overall project was evident in the community SIA workshops held in 2013 and 2014.

Through the Process Agreement the Core Land Tribes consented to the compulsory acquisition of the land by the SIG under the LTA, and unimpeded access to the Core Land for the constructor, and developer / operator. In exchange, the SIG agreed to: a 50% ownership in the acquired land after the acquisition through the creation of the Tina Core Land Company (TCLC); assistance to the Core Land and Reservoir Land tribes for each to establish a corporation to receive and invest or distribute the royalty payments, dividends from the TCLC, and the compulsory acquisition compensation; a revenue share (royalty) of 1.5% of the price paid by SIEA to the developer each year; a consent fee for each tribe and signatory; financial, management and investment training for tribal members; a guaranteed minimum payment per hectare for the acquired land; and other benefits.

The LALRP sets out a series of measures undertaken by the TRHDO PO to ensure an equal sharing of benefits to tribal members and to support opportunities for the tribes to invest in businesses.

The land required for the project infrastructure corridor (for the road and power transmission lines) included customary land compulsorily acquired for the infrastructure corridor, plus an additional four parcels of registered land at the northern end of the corridor. One parcel is owned by the Commissioner of Lands, for which acquisition is not required. Consultation with the interest holders on the remaining registered land required for the infrastructure corridor has occurred on multiple occasions over the last 2 years, and negotiations for its purchase are continuing.

13.7.2.2 Livelihoods Restoration Plan

Livelihood restoration is not required under Solomon Islands law but is required by the World Bank. The aim is to ensure that the livelihoods of people affected by the land acquisition for the TRHDP are maintained at the same level, and preferably, improved – both in terms of sustainability and standard.

The consideration of livelihoods restoration measures and entitlements has been guided by the findings of the social studies and consultations carried out as part of the project planning, along with the documented socio-economic and cultural circumstances of those likely to be affected by the project land acquisition.

The LALRP proposes a range of mechanisms and actions to protect and maintain the livelihoods of those potentially affected by the acquisition of the land for the Tina Hydro project. The entitlements provided for are intended to protect, restore, and where possible improve the livelihoods of all persons and households affected by the acquisition of land for the construction and operation of the project. The main agent for the implementation of the livelihoods restoration plan will be the TRHDP PO. It is proposed that it establish sufficient in-house capacity to undertake the day-to-day implementation of the LRP early in the project design phase.

Other participants in the plan include the BOOT Contractor, various government departments including the Ministry of Agriculture and Livestock, the Ministry of Forests (and/or forestry consultants) and an independent external specialist.

While not strictly part of the livelihoods restoration programme, people belonging to tribes that are part of the Bahomea or Malango Houses of Chiefs will be included in benefit share arrangement made possible by the Tina Hydro project, even if their land or assets are not being acquired for the project.

The details of the proposed community benefit share are still being developed by the Project Office in consultation with the beneficiaries communities. It is anticipated that the design of the benefits programme and its implementation will involve a high level of community involvement and that the various benefits programme activities will result in livelihoods improvements and increased wellbeing for local people.

The IFC and World Bank require that the SIG as the client *“establish procedures to monitor and evaluate the implementation of a Livelihood Restoration Plan and take corrective action as necessary”.* The extent of monitoring activities should be *“commensurate with the project’s risks and impacts”.*

The principal purpose of any monitoring will therefore be to assess whether the livelihoods of those affected by the acquisition of the land for the project have been sustained or improved. Internal monitoring will be undertaken by the TRHDP PO to confirm the delivery of the livelihoods restoration entitlements to the affected persons, and their outcomes. External monitoring and evaluation will be carried out by an independent consultant to: assess the overall performance of the LRP and its goal of sustaining the livelihoods of affected persons; verify that the particular livelihoods restoration activities have been undertaken, and the compensation funds appropriately delivered; review the community engagement and awareness activities of the TRHDP PO; review the overall performance of the grievance resolution mechanisms; and assess the adequacy of measures put in place to protect vulnerable groups and households.

A grievance mechanism is provided. Grievances relating to land acquisition, livelihoods restoration, compensation and related matters will be separated from grievances relating to the impacts of the project on local communities that arise from the construction and operation of the hydro power facility.

13.8 INSTITUTIONAL RESPONSIBILTIES FOR ESMP IMPLEMENTATION

A full description of Government, NGOs and Stakeholders, and their roles with respect to this ESIA, is set out in Section 3.1 – Institutional Framework. This section describes the roles and responsibilities of key actors with respect to the implementation and oversight of the ESMP.

13.8.1 Construction and Operation Contractor (Developer)

13.8.1.1 Role

The Developer plays the key role in the implementation of the mitigation and monitoring measures relating to the construction and operation of the Project. The "Developer" encompasses both the Tina Hydropower Limted (THL) (proposed to be jointly ownedby Korea Water Resources Corporation), and its Engineering, Procurement and Construction (EPC) contractor, proposed as Hyundai Engineering Company.

The Developer is not responsible for mitigation measures relating to the construction of the Transmission Lines which are intended to lie with Solomon Power.

THL's compliance with the ESIA and environment and social management plans forms part of the contractual arrangements signed for the Project including the Power Purchase Agreement (PPA) between Solomon Power and THL and the Implementation Agreement between SIG and the THL.

The Developer will assign specific responsibilities to key personnel in the stand alone Construction Environmental and Social Management Plan and Operation Environmental and Social Management Plan and accompanying action plans.

In terms of organization, the THL will assign an experienced, senior environment, social, health and safety manager. A lesson learned from the Star Hydropower Project supported by IFC in Pakistan is that early, continuous, and authoritative presence of this manager is essential for satisfactory performance of the company, its contractors, and its consultants. The manager will supervise a team of local staff in a unit which will hold responsibility for Environmental/Social Impact Mitigation, Health/Safety Management, Stakeholder Engagement/Government Agency Liaison, and Monitoring/Data Management/ Reporting.

It is likely that the EPC contract between the THL and HEC will allocate responsibility for the preparation of the CESMP and the construction management plans to the HEC. The HEC is expected to engage environment and social specialists to lead and oversee the implementation of the ESMP construction measures. It is possible that some of the EMU functions during construction will be contracted to the Owner's Engineer. The THL will retain the responsibility for environmental, social, health and safety compliance with ESMPs, the project's Environmental and Social Action Plan (ESAP), the Performance Standards, and applicable SIG regulations. The THL will ensure that the HEC, and Owner's Engineer where appropriate, are contractually obligated to provide the necessary number of qualified personnel and will monitor to ensure they perform according to the contract.

The THL and its contractors will ensure that all staff, as appropriate with their job profile, understand the environmental and social policies, procedures and mitigations. Contractors will be required to provide sufficient resources to manage the E&S aspects of their work. They will be required and responsible for the training and awareness of their staff on the project environmental and social setting, potential environmental and social impacts of their work activities, management and mitigation measures, and the existence of, and importance of complying with, the TRHDP CESMP and OESMP, including relevant interfacing with contractor's management systems.

The Developer's final stand alone ESMPs are intended to form part of the conditions of the Development Consent issued by the Ministry of Environment, Climate Change, Disaster Management and Meteorology (MECDMM) under the Solomon Islands' *Environment Act*. The THL will apply for and hold the Development Consent and will be responsible for compliance under the Act.

13.8.1.2 Capacity

It is anticipated that the Developer shall engage personnel with the relevant skills and experience to implement the mitigation and monitoring measures of this ESMP. As such, no capacity building is considered to be required.

13.8.2 TRHDP PO

13.8.2.1 Role

The Project Office will have a key oversight role for ESMP compliance during the construction period. The Project Office will appoint an Environmental and Social Safeguards Expert to facilitate this role.

As part of this role the Project Office shall:

- Review and approve the final ESIA and stand alone ESMPs prior to submission by the Developer to MECDMM for development consent approval (under the *Environment Act*);
- Review and approve Developer's management action plans in accordance with Table 13-2;
- Undertake audits in accordance with the schedule set out in 13.9.1; and
- Facilitate expert training for PO staff and MECDMM staff on monitoring skills specific to the Project and specified safeguards.

These Project Office roles will be incorporated in the Implementation Agreement between SIG and the Developer.

13.8.2.2 Capacity

The Project Office and its local contractors have capacity to oversee some mitigation measures, with particular strengths in social monitoring and water quality monitoring but will require further support and training in other areas. World Bank and DFAT propose significant funding to the Project Office to be used for training Project Office staff and responsible agencies, including MECDMM, to conduct environment and social audit and oversight roles.

13.8.3 Environment and Conservation Division of MECDMM

13.8.3.1 Role

The Environment and Conservation Division (ECD) will play an important role under the *Environment Act* in evaluating and issuing the development consent for the Project and in monitoring the environmental impacts of the Project.

ECD will be responsible for reviewing and assessing the developer's final environmental impact statement and stand-alone CESMP and OESMP under the *Environment Act*. In undertaking this review the Director of the Environment and Conservation Division will confirm that the documents meet the requirements of the Act and Regulations. The Director will run a public consultation process and ultimately determine whether or not to issue a development consent and with what conditions.

ECD staff will have ultimate responsibility for ensuring that the Developer complies with the Development Consent and its conditions, breaches of which constitute an offence under the Act.

13.8.3.2 Capacity

The increasing number of large-scale developments in the country has put pressure on the division, which has limited capacity in terms of staff and technical ability to assess and monitor environmental and social impacts.

ECD has developed some recent experience addressing the social and environmental issues facing the neighbouring Gold Ridge Mine, however, it has had little involvement in ongoing management of other major projects and no experience with a large hydro dam.

ECD would benefit from technical inputs and analysis of water quality and other parameters by third parties. For this reason, the Project Office will engage an environmental and social safeguards specialist and other personnel as relevant to provide assistance and training to the ECD in undertaking its approval, statutory monitoring and compliance roles.

13.8.4 Solomon Power

13.8.4.1 Role

Solomon Power (the trading name of Solomon Islands Electricity Authority) will have the central responsibility for all mitigation measures relating to the construction and operation of the transmission line corridor from the Solomon Power owned Lunnga power station to the Project's power station.

In addition to this role, Solomon Power shall oversee the developer's ESMP compliance during the operational stage of the Project. Solomon Power will work closely with MECDMM in undertaking this role.

13.8.4.2 Capacity

The organisation is currently going through an institutional reform with support from the World Bank to increase its revenue collection capacity and improve its services. If capacity shortcomings are identified before the operational stage commences, the World Bank shall arrange monitoring and compliance training for Solomon Power.

13.8.5 Road Design and Road Construction Contractors

13.8.5.1 Role

The Access Road upgrade and construction from the Black Post turn off to the dam site shall be designed and constructed by EPC contractor (HEC)

The road design contractors shall incorporate access road design measures, including culverts and drainage measures, into the final road design..

13.8.5.2 Capacity

Contractors are anticipated to have sufficient skills and experience to implement the mitigation measures.

13.8.6 Ministry of Infrastructure Development

13.8.6.1 Role

The Ministry of Infrastructure Development (MID) plays a role in maintaining the access road from the Black Post turnoff to Mengakiki once the Project is commissioned.

13.8.6.2 Capacity

Current indications are that the capacity of the MID is sufficient to respond to the post construction maintenance requirements with the support of the TRHDP PO and donor agencies.

13.9 IMPLEMENTATION SCHEDULE AND BUDGET

13.9.1 Schedule

The schedule for implementing the ESMP is presented in Table 13-5. Detailed schedule will be updated based on the progress of survey and design by EPC contractor.

Table 13-5 Proposed schedule for implementing environmental and social management program

Phase	Activity	Constructor/operator (Manage and Monitor)	TRHDP PO (Auditor)

Detailed design	Prepare detailed construction ESMP; Provide environmental inputs to design	Detailed design will be prepared 1 year from the closing date Monthly review meetings during design process until developer submits detailed design	Review and sign-off "No Objection" "No Objection"- PO to ensure that environmental inputs are captured in developer's final design
Construction	Implement Construction ESMP;	prior to EPC contractor mobillization through completion of construction	Schedule of reporting and monitoring to be included in final CESMP forming conditions of the Development Consent under the *Environment Act*. PO to oversee developer's monitoring programme and arrange regular audits –quarterly in first year and then at least semi-annually until commissioning
Project commissioning	Prepare draft Operations ESMP Implement Operations ESMP for commissioning	Prepare 3 months prior to reservoir filling Weekly Monitoring of environmental and social compliance during commissioning period.	PO to review and provide No Objection. The OESMP and schedule of monitoring, reporting and audit will be prepared. Director of Environment and Conservation Division of MECDM to review and approve OESMP Weekly Monitoring during Commissioning and PO and developer agree on the Schedule of

			Monitoring and audit which will be fed into the operations ESMP.
Operation and maintenance	Implement operations ESMP	Monitoring will be carried out on a quarterly basis on the first year and decisions on how often this is required (e.g. semi annually or annually) can be confirmed in this first year	Initially, audits of environmental and social performance will occur on a quarterly basis. PO and Developer in consultation with Ministry of Environment will agree a frequency of subsequent monitoring based on their experience of the first year.

13.9.2 Budget

THL signed the PPA with Solomon Power in December 2018. HEC will be primarily responsible for the EPC development; THL will be responsible for the Operation and Maintenance contract during the BOOT period. The BOOT concession period is expected to be for a period of 30 years from commissioning, approximately 35 years from mobilisation. Unless otherwise stated, costs of ESMP implementation are incorporated into the EPC contract for the construction period and through the ongoing budgets for the THL for the life of the PPA. Compliance monitoring by PO and MECDM during construction will be a component of the project financing managed by SIG. Compliance monitoring during operations will be continued by the relevant ministries, in particular MECDM.

13.9.3 Contractual Arrangements

The environment and social safeguard measures will be accommodated and enforced through contractual and approval arrangements between institutional actors. Table 13-6 sets out the key project agreements and actors. Figure 13-5,

Figure 13-4 demonstrate these arrangements for the hydropower, transmission line and access road project components respectively.

Table 13-6 – Contractual Arrangements

Agreement/Approval	**Safeguard Responsibility**	**Safeguard Oversight**
Implementation Agreement (IA)	THL	SIG
Power Purchase Agreement (PPA)	THL	Solomon Power
Engineering Procurement Construction Contract (EPC Contract)	HEC	THL
Financial Agreements	SIG (Ministry of Finance)	Financiers
On-Lending Agreement	THL	Financiers
Project Agreements	THL	Financiers
Development Consent	THL	MECDM
Subsidiary Finance Agreement	Solomon Power	SIG
Project Agreement (Transmisison Line)	Solomon Power	Financiers

Figure 13-4 Hydropower Project Contractual Arrangements

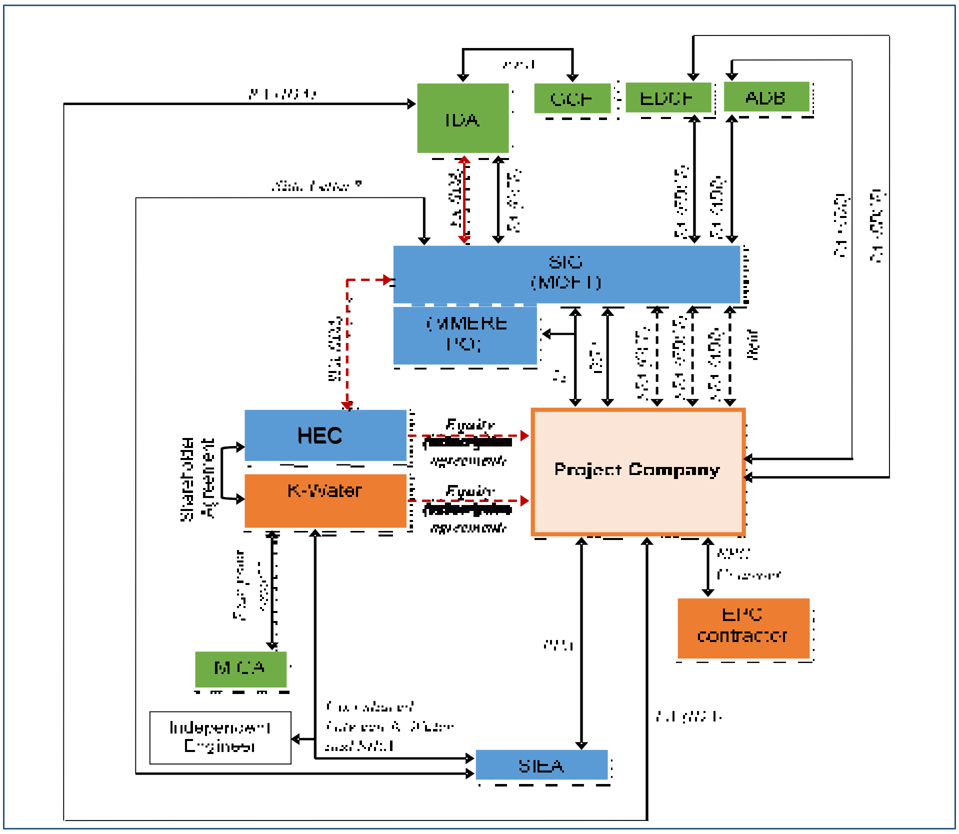
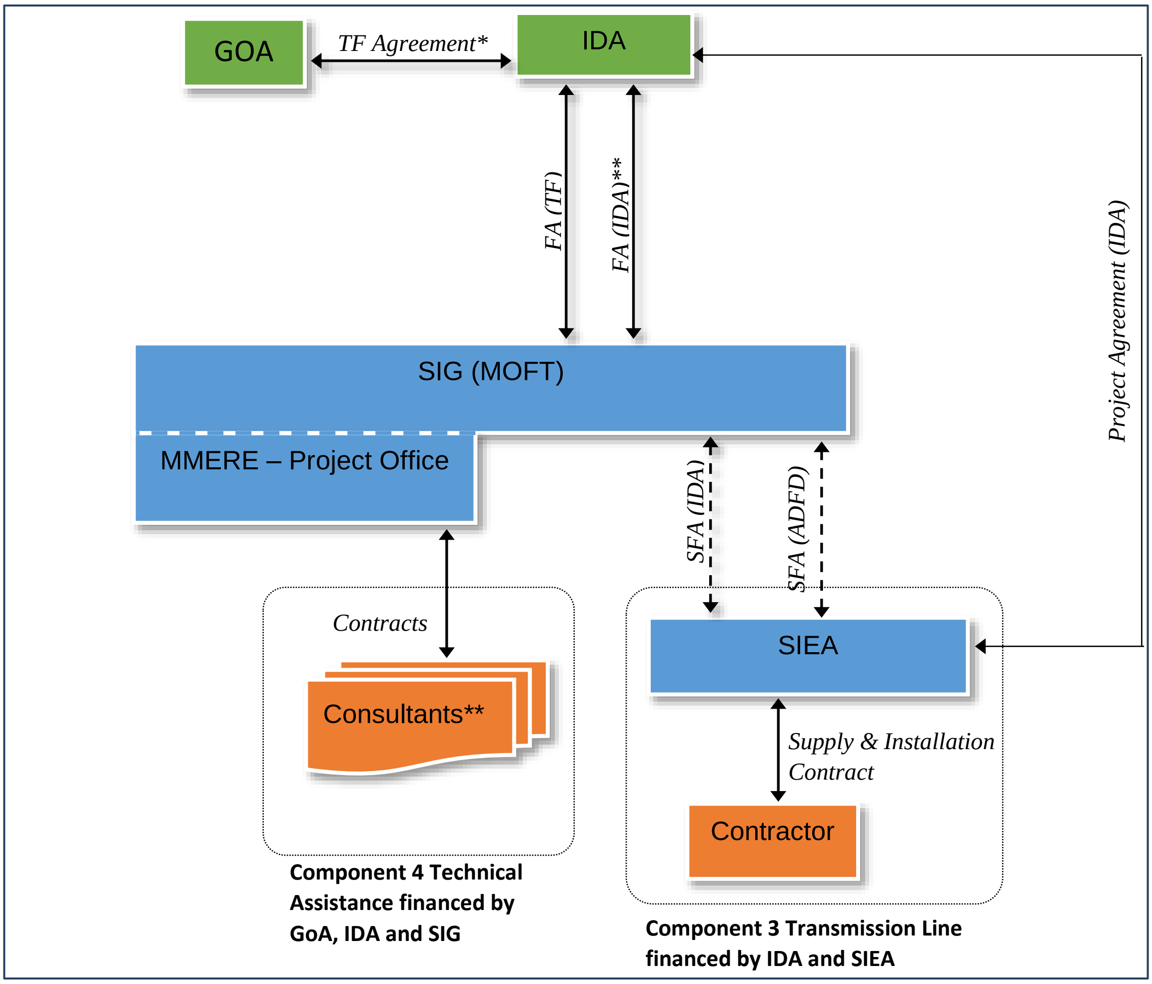


Figure 13-5 Transmission Line and Access Road Contractual Arrangements



13.9.4 Integration of ESMP in Project Management

As the TRHDP will be designed, constructed and operated under a build-own-operate-transfer project delivery model, the construction contractor and the operator will be one and the same (i.e., constructor/operator). The constructor/operator will be responsible for establishing an environmental management office that employs environmental and social specialists to provide their input during detailed design, construction and operation of the TRHDP. The constructor/operator's environmental and social management team will be required to function autonomously, from the constructor/operator, to ensure the contractor complies with GIIP, and they will be given "stop work" authority to halt specific project-related actions or activities that are deemed by the monitors to be immediately threatening valued environmental or social components.

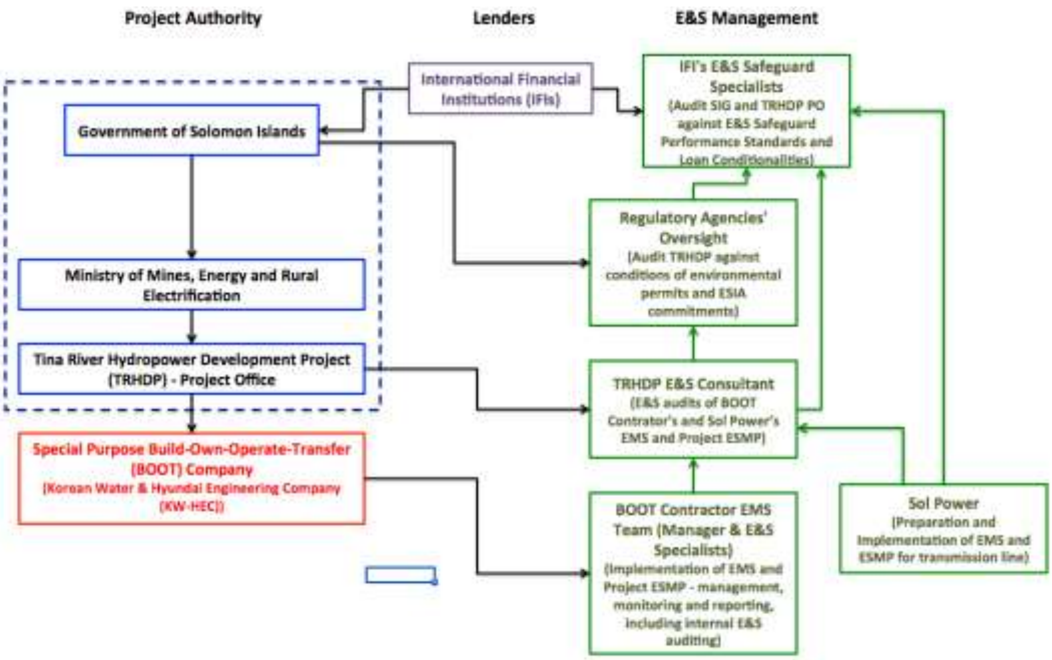
During construction and operation, the TRHDP PO will engage an environmental and social expert to audit the performance of the constructor/operator's environmental management, monitoring and actions.

A Dam Safety Advisory Panel (DSAP) has been engaged to ensure that the design for the dam complies to international accepted dam safety standards. The PPA will also ensure that the project complies with the applicable environmental, social and labour Legal Requirements. Some of these requirements include WB performance standards, the World Bank Group / IFC Environmental, Health and Safety Guidelines.

Figure 13-6 illustrates the reporting structure for developing and implementing the main Environmental Management System and Environmental Management Plan components into the TRHDP.

Table 13-7 provides a summary matrix of the Environmental and Social Management Plan, including project activities / actions, effects, mitigation measures implementation and monitoring and reporting roles and responsibilities, project phase timing and budget.

Figure 13-6 EMS and ESMP reporting structure



13.10 SUMMARY ESMP MATRIX

Table 13-7 Summary ESMP matrix

#	Project Activity / Action and Its Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility / Timing	Monitoring & Reporting Activity	Responsibility / Timing	
Measures to Protect the Natural Environment During, or as a Result of:						
1	*Reservoir Preparation, Filling, and Operation*					
	GHG emissions; suspended solids on aquatic life; river pollution on aquatic life; temporary diminished water quality; reservoir water quality	• Prepare Reservoir Preparation Plan • Clear trees >10cm dbh and strip loose soil and rocks from reservoir area during dry season prior to inundation; • Use of herbicides will not be permitted • (see also Vegetation Management Plan) • (see also Sediment and Erosion Management Plan)	• BOOT Contractor to prepare plan / pre-construction; • BOOT Contractor to implement with support from local Community labourers in last dry season of construction phase; and operation phase	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report on pre-construction completion of plans, and construction phase implementation	• Included in BOOT Contractor's USD2.0M ESMP budget

#	Project Activity / Action and Its Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility / Timing	Monitoring & Reporting Activity	Responsibility / Timing	
Measures to Protect the Natural Environment During, or as a Result of:						
	Surface hydrology; reduced flows on aquatic life; water users	• Maintain minimum E-flow of $1.0m^3/s$ in bypassed section of river at all times	• BOOT Contractor / late construction phase; and operations phase	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report / operations phase	
	Reduced overnight flows on surface hydrology, aquatic life, and water users	• Maintain minimum of $3.4m^3/s$ flow downstream of powerhouse	• BOOT Contractor / operations phase	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report / late construction phase; and operations phase	
	Reduced sediment transport, with changes to aquatic life; reduced gravel extraction; reservoir	• Periodic flushing of sediments from reservoir, or drawing down of reservoir to excavate/dredge sediments	• BOOT Contractor / operations phase	• Monitor and report on implementation of mitigation	• TRHDP PO to Audit BOOT Contractor; BOOT Contractor E&S Subconsultant to monitor and report in	

#	Project Activity / Action and Its Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility / Timing	Monitoring & Reporting Activity	Responsibility / Timing	
Measures to Protect the Natural Environment During, or as a Result of:						
	sedimentation			measures	construction phase implementation	
2	*Hydro Facility Operation*					
	Reduced flows between dam and power station; indirect impacts on fauna; direct impacts on aquatic fauna; water users	• Prepare Environmental Flows Management Plan • Maintain minimum E-flow of 1.0 m^3/s in bypassed section of river	• BOOT Contractor to prepare plan / pre-construction • BOOT Contractor to implement in operation phase	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report on pre-construction completion of plans, and construction phase implementation	• Included in BOOT Contractor's USD2.0M ESMP budget
3	*Barrier to Fish Passage and Fish Entrainment*					
	Dam as barrier to upstream fish migration	• Prepare Fish Passage Plan • Implement trap and haul fish passage system	• BOOT Contractor to prepare plan / pre-construction • BOOT Contractor to implement onwards from commissioning stage of late construction phase	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report on pre-construction completion of plans, and construction	• Included in BOOT Contractor's USD2.0M ESMP budget

#	Project Activity / Action and Its Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility / Timing	Monitoring & Reporting Activity	Responsibility / Timing	
Measures to Protect the Natural Environment During, or as a Result of:						
	Dam as barrier to downstream fish migration; entrainment of fish into power intakes	• Spill water over spillway early wet season; install fish exclusion screens	• BOOT Contractor / operations phase	• Monitor and report on implementation of mitigation measures	phase implementation • TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report / operations phase	
4	*Access Road Location, Design, Construction and Operation*					
	Slope stability; erosion; human encroachment into upper watershed	• Locate roads away from sloping terrain where possible; • Engineer for road stability and drainage; • Roads to quarries to remain unsealed to facilitate decommissioning; • No spoils within 100m of	• Ministry of Mines, Energy and Rural Electrification; • BOOT design and construction contractors / design phase and construction phase	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report / design phase and construction phase	• Included in BOOT Contractor's USD2.0M ESMP budget

#	Project Activity / Action and Its Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility / Timing	Monitoring & Reporting Activity	Responsibility / Timing	
Measures to Protect the Natural Environment During, or as a Result of:						
		watercourses • Restrict vehicular use of the access road to project staff. Commercial logging vehicles prohibited.				
	1.1.1.1.1 Installation of drainage and stream crossing works - operation effects on fauna; hydrological changes on flora; soil erosion; suspended solids and siltation on aquatic life; river pollution on aquatic life; diminished water quality on aquatic environment; disturbance to aquatic habitats and aquatic life	• Prepare Watercourse Crossing Management Plan • Geo-reference watercourses in vicinity of access road for proper sizing of crossing; • Protect tributary streams with fencing; • Exclude proposed stream crossings initial forest clearing as they will be selectively cleared; • Construct road crossing perpendicular to stream; • Culverts to be equipped with headwalls to ensure bank stability; • Fauna friendly underpasses to be installed in culverts; • Construct crossings using excavators, not bulldozers to	• BOOT Contractor to prepare plan / pre-construction • BOOT Contractor to implement / construction phase	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; BOOT Contractor E&S Subconsultant to monitor and report on pre-construction completion of plans, and construction phase implementation	

#	Project Activity / Action and Its Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility / Timing	Monitoring & Reporting Activity	Responsibility / Timing	
Measures to Protect the Natural Environment During, or as a Result of:						
		minimise excessive soil disturbance; • Size culverts to facilitate dry passage of terrestrial animals, and wet passage for amphibians and fish, including provision of suitable cover; • Size crossings to pass design flood flows; • Install upstream trash racks; • (see also Drainage Management Plan) • (see also Erosion and Sediment Control Plan)				
	Vegetation clearance on environmentally and culturally sensitive areas	• Prepare Vegetation Management Plan • Botanist to walk access road / TLine alignments to geo-reference, and fence environmentally and culturally sensitive areas using orange plastic fencing, and map for	• BOOT Contractor to prepare plan / pre-construction • BOOT Contractor to implement / construction phase	• Monitor and report on implementation of mitigation measures		

#	Project Activity / Action and Its Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility / Timing	Monitoring & Reporting Activity	Responsibility / Timing	
Measures to Protect the Natural Environment During, or as a Result of:						
		presentation to clearing committee of resident engineer, BOOT sub-contractors and independent environmental expert • (see also Physical Cultural Heritage Management Plan)				
	Road Access Restrictions - Operations effects on flora	• Black post road to remain private access between Mangakiki to dam site; • Access restricted to local populations. Vehicular access restricted to TRHDP operator; • No occupation of Core Area lands except for necessary Project housing (eg.security staff or on call engineers); • No workers camp on Core Area lands; BMP to be developed, implemented and enforced to restrict access through Core Area to prevent establishment of new settlements in areas beyond	• TCLC to assist BOOT Contractor in preparing settlement policy within the Biodiversity Management Plan	• Monitor and report on implementation of mitigation measures / operation phase	• TRHDP PO to Audit BOOT Contractor; BOOT Contractor E&S Subconsultant to monitor and report / operation phase	
5	*Vegetation and Forest Clearance*					

#	Project Activity / Action and Its Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility / Timing	Monitoring & Reporting Activity	Responsibility / Timing	
Measures to Protect the Natural Environment During, or as a Result of:						
	Soil compaction and erosion; suspended solids and water pollution on aquatic life;	• Prepare Erosion and Sediment Control Plan • Minimise spatial and temporal extent that soils are exposed to water erosion; • Stabilise sites and install / maintain erosion controls in wet season	• BOOT Contractor to prepare plan / pre-construction • BOOT Contractor to implement construction phase	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report on pre-construction completion of plans, and construction phase implementation	• Included in BOOT Contractor's USD2.0M ESMP budget
	Burning on air quality; disturbance to aquatic habitats and biota; grassland dependent birds; river dependent birds; loss of terrestrial natural habitat and associated biodiversity	• Prepare Vegetation Management Plan • Minimise clearing footprint; • Strict contract language to be applied to BOOT logging contractor; • Clearing to be monitored by independent expert; • Incorporate in the Biodiversity Action Plan an offset for conversion of natural forest habitat in the Core Area	• BOOT Contractor to prepare plan with input from Solomon Power (for TLine) / pre-construction • BOOT Contractor to implement / construction phase	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report on pre-construction completion of plans, and construction phase implementation, and operation phase implementation for	

#	Project Activity / Action and Its Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility / Timing	Monitoring & Reporting Activity	Responsibility / Timing	
Measures to Protect the Natural Environment During, or as a Result of:						
		• No storing / dumping cleared vegetation into streams; • No use of herbicides; • Vegetation control during dry seasons; • Avoid where possible vegetation clearing on erodible / steep slopes; • Revegetation / mulch progressively; • No draining TLine wetlands unless threatening access roads; • Avoid using machinery on stable areas or close to streams; • Train workers in EHS; • Notify communities to avoid active clearing works; • No burning of non-merchantable vegetation. Vegetation to be shredded. • Minimise removal of large canopy trees; • TLine vegetation control during operation by trained persons. • (see also Sediment and Erosion Management Plan)			TLine	

#	Project Activity / Action and Its Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility / Timing	Monitoring & Reporting Activity	Responsibility / Timing	
Measures to Protect the Natural Environment During, or as a Result of:						
6	*Drilling and Blasting*					
	Physical impacts from noise and vibration; disturbance to fauna	• Prepare Drilling and Blasting Plan • Select methods to reduce noise and vibration; • Hydraulic instead of pneumatic drills; equipment to be equipped with engine exhaust silencers / mufflers; • Use blasting mats to reduce noise, fly rock and dust. • (See also Wildlife Protection Plan)	• BOOT Blasting contractor to prepare plan / pre-construction • BOOT Contractor to implement construction phase	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report on pre-construction completion of plans, and construction phase implementation	• Included in BOOT Contractor's USD2.0M ESMP budget
7	*Accidental Release of Sewage and Other Wastewater*					
	Point source pollution on flora; river pollution on aquatic life; disturbance to aquatic habitat and aquatic life; diminished water	• Prepare Wastewater Management Plan – mandatory installation of toilets for workers; transport wastewater offsite for treatment	• BOOT Contractor to prepare plan / pre-construction • BOOT Contractor to implement / construction phase	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; BOOT Contractor E&S Subconsultant to monitor and report on pre-construction	• Included in BOOT Contractor's USD2.0M ESMP budget

#	Project Activity / Action and Its Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility / Timing	Monitoring & Reporting Activity	Responsibility / Timing	
Measures to Protect the Natural Environment During, or as a Result of:						
	quality and quantity				completion of plans, and construction phase implementation	
8	*Hazardous Materials, Explosives and Concrete Works Handling*					
	Point source pollution on flora; increased suspended solids and siltation on aquatic life; disturbance to aquatic habitats and aquatic life; diminished water quality and quantity on aquatic environment	• Prepare Hazardous Materials Management Plan (which includes Hydrocarbon [fuel, oil, lubricants] Management Plan – Resident Engineer to approve hazardous materials storage, including explosives storage bunker; secondary containment required for hydrocarbon storage; no hydrocarbons to be stored closer than 100m from any water body or wetland; hydrocarbon storage systems must be sound; fuel dispensing areas to be located on concrete hard stand, with drains to oil/water separators, from which product will be removed and transported by tanker truck to Honiara; concrete wash waters	• BOOT contractor(s) / plans prepared pre-construction; BOOT Contractor to implement before construction commences, then throughout construction phase	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; BOOT Contractor E&S Subconsultant to monitor and report on pre-construction completion of plans, and construction phase implementation	• Included in BOOT Contractor's USD2.0M ESMP budget

#	Project Activity / Action and Its Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility / Timing	Monitoring & Reporting Activity	Responsibility / Timing	
Measures to Protect the Natural Environment During, or as a Result of:						
		must not be released to water bodies or wetlands; concrete washwater control system will be constructed in the form of settling ponds • Prepare Emergency Response Plan - • (see also Drainage Management Plan) • (see also Sediment and Erosion Control Plan) • (see also Solid Wastes Management Plan)				
9	*Excavation and Movement of Soils*					

#	Project Activity / Action and Its Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility / Timing	Monitoring & Reporting Activity	Responsibility / Timing	
Measures to Protect the Natural Environment During, or as a Result of:						
	Loss of flora; increased suspended sediment and siltation on aquatic life; river pollution on aquatic life; diminished water quality and quantity on aquatic environment; disturbance to aquatic habitats and aquatic life	• Prepare Soils Management Plan – • Under supervision of soil expert, collect soil cores to determine depth of organic soils and strip organic soils along access roads; stockpile soils for later use for revegetation; store soils in remnant forest habitat to minimise clearing, and locate away from water bodies on flat terrain; compact or cover to prevent re-colonisation; surround stockpiles with sediment control works including settling ponds • (see also Sediment and Erosion Control Plan) • (see also Biodiversity Management Plan)	• BOOT Contractor to prepare plan / pre-construction • BOOT Contractor to implement / construction phase	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; BOOT Contractor E&S Subconsultant to monitor and report on pre-construction completion of plans, and construction phase implementation	• Included in BOOT Contractor's USD2.0M ESMP budget
	Accidental colonisation by invasive flora and fauna	• Prepare invasive species measures as a component of the Biodiversity Management Plan • Machinery to be washed by designated staff before entering	• BOOT Contractor to prepare plan / pre-construction • BOOT Contractor to implement /	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; BOOT Contractor E&S Subconsultant to monitor and report on	

#	Project Activity / Action and Its Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility / Timing	Monitoring & Reporting Activity	Responsibility / Timing	
Measures to Protect the Natural Environment During, or as a Result of:						
		site; • Mud and soil to be removed at designated wash station; • No importation of soils from outside work areas • Control of waste food to avoid attracting feral animals	construction phase		pre-construction completion of plans, and construction phase implementation	
10	*Activities Causing Disturbance to Wildlife*					
	Workers effects on fauna	• Prepare Wildlife Protection Plan • Workers prohibited from harming wildlife; • Workers to receive wildlife awareness training • (see also Environmental Awareness Training Plan)	• BOOT Contractor to prepare plan / pre-construction • BOOT Contractor to implement / construction and operation phases	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; BOOT Contractor E&S Subconsultant to monitor and report on pre-construction completion of plans, and construction and operation phase implementation	• Included in BOOT Contractor's USD2.0M ESMP budget

#	Project Activity / Action and Its Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility / Timing	Monitoring & Reporting Activity	Responsibility / Timing	
Measures to Protect the Natural Environment During, or as a Result of:						
	Lighting disturbance to fauna, especially bats	• Prepare Wildlife Protection Plan • Use only enough artificial lighting to maintain safe work conditions; • Minimise light intensity and orient to ground, where possible; • Avoid use of artificial light during operation	• BOOT Contractor to prepare plan / pre-construction • BOOT Contractor to implement / construction and operation phases	• Monitor and report on implementation of mitigation measures		
	Electrocution of Cuscus during T-Line operation Harvesting by workers	• Install metal shields on wooden poles prior to operation to prevent climbing • Prepare Environmental Awareness Training Plan • Prohibit workers from fishing in	• BOOT contractor(s) / construction • BOOT Contractor to prepare plan / pre-construction	• Monitor and report on implementation of mitigation measures • Monitor and report on implementation	• TRHDP PO to Audit BOOT Contractor; BOOT Contractor E&S Subconsultant to monitor and report / construction phase • TRHDP PO to Audit BOOT Contractor; • BOOT Contractor	

#	Project Activity / Action and Its Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility / Timing	Monitoring & Reporting Activity	Responsibility / Timing	
Measures to Protect the Natural Environment During, or as a Result of:						
		Tina River; • Prohibit food services from purchasing fish from local villagers; limit vehicle speeds on access roads • (see also Wildlife Protection Plan) • (see also Traffic Management Plan)	• BOOT Contractor to implement / construction and operation phases	of mitigation measures	E&S Subconsultant to monitor and report on pre-construction completion of plans, and construction and operation phase implementation	

#	Project Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility & Timing	Monitoring & Reporting Activity	Responsibility & Timing	
Measures to Protect the Social Environment During, or as a Result of:						
1	*Siting of Worker Camps*					
	Disruption to local customs and way of life; concerns for health, safety and wellbeing of community during construction	• Accommodation for incoming workers and workers from outside Tina area to be located outside project area; • No workers camps in project area; • Accommodation to be planned well in advance	• BOOT Contractor to establish accommodation / pre-construction	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report on pre-construction completion of worker accommodation	• Included in BOOT Contractor's USD2.0M ESMP budget
2	*Employment and Recruitment Practices*					
	Uninvited job seekers from outside the region; increased employment for local inhabitants	• Recruitment policy to favour those seeking work from Bahomea, Malango, and landowning clans; • Expand recruitment further afield if necessary; • Include quota for women; • Conduct job-seeker survey of local villages; • Provide training to local job-seekers;	• BOOT Contractor to implement TRHDP PO's recruitment policy / pre-construction, construction and operation phases; • TRHDP PO to provide pre-employment training through contracted training	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report on pre-construction completion of worker accommodation	• Included in BOOT Contractor's USD2.0M ESMP budget; • Funding for training to come from JSDF grant

#	Project Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility & Timing	Monitoring & Reporting Activity	Responsibility & Timing	
Measures to Protect the Social Environment During, or as a Result of:						
		• Future access to post-construction buildings to be provided to community	provider / pre-construction, construction and operation phases; • TCLC to manage buildings / post-construction			
3	*Worker Behaviour, and Activities that could Affect Worker Health and Wellbeing*					
	Affects on local customs and way of life; Moro movement; health, health safety and well being of workers	• Implement the Workers' Code of Conduct • Conduct Code of Conduct training; • Provide tailored workplace health and safety training before workers commence work on the project; • Establish a full-time first aide / nursing post on site, and arrange for medical assistance and evacuation facilities • (see also Health and Safety Plan)	• BOOT Contractor to implement / prior to worker mobilising to work on project	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report on pre-commencement worker health and safety training	• Included in BOOT Contractor's USD2.0M ESMP budget
4	*Activities that could Affect Villagers' Safety, Wellbeing, and Amenities*					
	Threats to health, safety and wellbeing due to	• Address potential road safety concerns;	• BOOT Contractor, Subcontractors,	• Monitor and report on	• TRHDP PO to Audit BOOT Contractor;	• Included in BOOT

#	Project Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility & Timing	Monitoring & Reporting Activity	Responsibility & Timing	
Measures to Protect the Social Environment During, or as a Result of:						
	project construction and operation activities	• Develop protocol for managing contractor-related road accidents / injuries; • Roads to have sealed surfaces through villages to control noise and dust; • Provide information sessions to local communities to explain dam safety measures; • Educate local communities on the use of electricity before villages electrified; • Implement strict measures to avoid worker misconduct toward locals; • Zero drug and alcohol tolerance for workers on site; • STD awareness training; • Free condoms to be available at first aid/nursing post to be established on site • (see also Traffic Management Plan) • (see also Health and Safety Plan)	Solomon Power and TRHDP PO / construction and operation phase	implementation of mitigation measures	• BOOT Contractor E&S Subconsultant to monitor and report / construction and operation phases	Contractor's USD2.0M ESMP budget • Included in TRHDP PO Budget

#	Project Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility & Timing	Monitoring & Reporting Activity	Responsibility & Timing	
Measures to Protect the Social Environment During, or as a Result of:						
5	***1.1.1.1.2*** *Activities that could Affect Vulnerable Groups and Minorities*					
	Threats to wellbeing of vulnerable groups and minorities due to construction and operation activities	• Prepare a Social Impacts Monitoring Plan; • Monitor impact of squatters and settlers on vulnerable and minority people; • Establish grievance mechanism and nominate community representatives; • Ensure coverage of isolated communities	• BOOT Contractor to implement / construction and operation phases	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report / construction and operation phases	• Included in BOOT Contractor's USD2.0M ESMP budget
6	*Activities that could Affect Water Supplies*					
	Diminished water quality and quantity due to project construction activities for construction and commissioning period	• Identify, survey, map and engineer assess village water supplies pre-construction; • Establish alternate water supplies that are reliable and clean, where required; • Conduct water quality monitoring, including for water borne pathogens;	• BOOT Contractor to implement / construction and early operation phases	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report / construction and early operation phases	• Included in BOOT Contractor's USD2.0M ESMP budget

#	Project Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility & Timing	Monitoring & Reporting Activity	Responsibility & Timing	
Measures to Protect the Social Environment During, or as a Result of:						
		• Establish village water committee(s); • Notify communities of risks of using river and sand-point water sources				
7	*Activities that could Affect Ecotourism Opportunities*					
	Disruption to Senghe Village foot track due to heavy access road traffic; loss of ecosystem opportunities	• Relocate access track prior to construction; • Monitor effects on ecotourism	• BOOT Contractor to relocate foot track / pre-construction	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report on pre-construction completion of foot track relocation, and construction phase ecotourism	• Included in BOOT Contractor's USD2.0M ESMP budget
8	*Damage to, or Loss of, Core Area Resources*					

#	Project Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility & Timing	Monitoring & Reporting Activity	Responsibility & Timing	
Measures to Protect the Social Environment During, or as a Result of:						
	Damage to and/or reduced access to natural capital due to construction related site disturbance	• Prepare Land Acquisition and Livelihood Restoration Plan; • Define use rights for Core Area lands; • Compensate for lost resources or diminished access to resources; • Rehabilitate modified habitat of at least 9.5ha in the Core Area and protect remaining natural habitat within the Core Area • Contract local community members for reservoir clearing where feasible	• BOOT Contractor to prepare plan / pre-construction • BOOT Contractor to implement / construction phase	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report on pre-construction completion of plan, and construction and operation phase implementation	• Included in BOOT Contractor's USD2.0M ESMP budget
9	*Activities that could Affect Cultural Heritage*					
	Adverse affects on cultural heritage from site disturbance during construction	• Prepare protocol for managing cultural heritage, including arrangements for relocation and compensation; identify Tambu Site compensation follow-up; survey project and road construction sites to identify medicinal and magical plants for protection or relocation;	• BOOT Contractor to prepare plan and conduct Tambu Site assessment / pre-construction • BOOT Contractor to implement / construction phase	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report on pre-construction completion of plans and Tambu Site assessment, and construction and	• Included in BOOT Contractor's USD2.0M ESMP budget; • Tambu Site Disturbance Compensati on (paid out

#	Project Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility & Timing	Monitoring & Reporting Activity	Responsibility & Timing	
Measures to Protect the Social Environment During, or as a Result of:						
		• Workers to reside outside Tina/Ngalimbiu area; enforce strict code of worker conduct			operation phase implementation	of SIG land compensation budget)
10	*Decisions Made on the Project*					
	Concern that local communities will be left out of project management decisions that may affect them	• Continue to consult with project-affected communities using culturally appropriate, inclusive, proven methods; • Address issues raised through grievance mechanism process	• BOOT Contractor to implement / all project phases	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report / all project phases	• Included in BOOT Contractor's USD2.0M ESMP budget

#	Project Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility & Timing	Monitoring & Reporting Activity	Responsibility & Timing	
Measures to Protect the Social Environment During, or as a Result of:						
11	*Dam Failure and Emergency Flow Releases*					
	Concern of local communities of risks posed by potential dam failure and emergency releases	• Prepare Dam Safety Plan; • Prepare Emergency Preparedness Plan; • Model extreme events and prepare inundation zone maps; • Install early warning system to warn of flood / emergency spillway releases • Deliver information sessions to local communities on dam design, operation and maintenance	• BOOT Contractor to implement / commissioning and operation phases	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report / commissioning and operation phases	• Included in BOOT Contractor's USD2.0M ESMP budget
12	*Daytime Peaking Flow Releases*					

#	Project Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility & Timing	Monitoring & Reporting Activity	Responsibility & Timing	
Measures to Protect the Social Environment During, or as a Result of:						
	Operational flow release effects on community safety under during daylight peaking and non-peaking	• Provide ramping flow releases to enable local inhabitants that may be within the river bet to safely remove themselves as water levels rise during peaking generation; • Deliver notification sessions to local communities on expected daily flow releases and water levels are specific locations along the river	• BOOT Contractor to implement / commissioning and operation phases	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report / commissioning and operation phases	• Included in BOOT Contractor's USD2.0M ESMP budget
13	*Changes Associated with Diminished River Flows*					
	Diminished sediment recruitment from upper watershed; reduced supply of riverbed construction aggregates only noticeable in long term	• River geomorphologist to monitor gravel transport; • Develop mitigation measures, including potential sluicing sediments from reservoir, where changes in gravel distribution affecting livelihoods	• BOOT Contractor to implement / operation phase	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report / operation phases	• Included in BOOT Contractor's USD2.0M ESMP budget

#	Project Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility & Timing	Monitoring & Reporting Activity	Responsibility & Timing	
Measures to Protect the Social Environment During, or as a Result of:						
	Affects on ability of small-scale timer harvesters to mill, transport and recover timber when river flows are curtailed	• Develop alternative method to rafting timber down the river to enable timber to be recovered from upstream of dam, and in dewatered sections of the river	• TRHDP PO to develop alternative / pre-construction phase; • BOOT Contractor to facilitate alternative timber transport system / construction and operation phases	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report / construction and operation phases	
14	*Activities that could Strain Relations with Project-affected Communities*					
	Potential for relations to be strained between community, BOOT Contractor and TRHDP PO	• Establish community liaison committees (CLCs) for monitoring and mitigation input; • Each CLC to include existing Community Liaison Assistant (CLA), as well as women and youth representation; • Each CLC to be supported by a secretary and report on community	• BOOT Contractor with support from TRHDP PO to implement CLC and CLA training, including budget / construction and operation phase; • TRHDP PO to continue training of	• Monitor and report on implementation of mitigation measures	• TRHDP PO to Audit BOOT Contractor; • BOOT Contractor E&S Subconsultant to monitor and report / construction and operation phases	• Included in BOOT Contractor's USD2.0M ESMP budget; • Included in TRHDP PO's E&S budget

#	Project Effect(s)	Mitigation		Monitoring & Reporting		Budget
		Mitigation Measure(s)	Responsibility & Timing	Monitoring & Reporting Activity	Responsibility & Timing	
Measures to Protect the Social Environment During, or as a Result of:						
		grievances and monitoring of impacts; • Provide capacity building through training and administrative support for CLCs, CLAs, and landowner tribes; • Deliver pre-employment training to Bahomea and Malango areas; • Provide budget and money management training to locally recruited workers; • (see also Stakeholder Engagement Plan)	landowner tribes in money management and administrative procedures, and facilitate management training of TCLC board members as required; • BOOT Contractor with support from TRHDP PO to implement money management training for local workers			

13.11 PROCESS FOR PREPARATION OF CESMP AND OESMP

As noted above, this ESMP focuses on design and construction of the Project, and is intended to be a guide for the constructor/operator(THL). The constructor/operator will be required to further refine this ESMP to turn it into its own detailed construction ESMP (or CESMP), which takes into consideration the specific construction timing, location and work methods. The CESMP will be prepared by THL and EPC contractor (HEC) by EPC contractor mobilization, and reviewed for adequacy by the TRHDP PO and financial parties.

As project construction nears completion, and before the Project is commissioned, the constructor/operator will be required to prepare a detailed stand-alone operation ESMP (or OESMP). The OESMP will be reviewed for adequacy by the TRHDP PO's environmental and social expert and financial parties.

The stand-alone CESMP and OESMP shall include the following information:

- Parties responsible for implementing the ESMP and ESAPs and capacity assessment;
- Regulatory agencies;
- Permitting procedures and IFC Performance Standards requirements;
- Mitigation measures;
- Action plans that identify roles and responsibilities, rudimentary levels of effort and schedules, management and monitoring actions as set out in section 1.1; and
- Cost estimates and sources of budget.

All OESMP and CESMP mitigation measures should be designed, discussed and implemented with the participation of the relevant affected persons, regardless of their affiliation. Mitigation targeted at specific groups should be designed in partnership with those groups.

Mitigation programs should be available to all project-affected communities including Bahomea landowner communities, settler communities, Ghaobata communities, and squatters who were already living in the area on the cut-off date of 23 August 2014, which is the date of the publication of the Gazette notice for the taking of the land.

Where possible, works associated with mitigating impacts should employ local people as a priority.

As part of the overall ESMP, community liaison committees should be established during project construction and operation phases of the TRHDP. These committees should be supported by a small group to monitor, and provide input on, the conditions in the project-affected communities.

14. CUMULATIVE IMPACT ASSESSMENT

14.1 INTRODUCTION

This section provides a cumulative impact assessment (CIA) for the TRHDP.

14.1.1 Objective of the CIA

The overall objective of the CIA is to identify environmental and social impacts associated with the TRHDP, that when combined with potential impacts of existing, planned and reasonably foreseeable developments or activities, may generate cumulative impacts that could jeopardise the sustainability of the TRHDP.

14.1.2 Scope and Methodology of the CIA

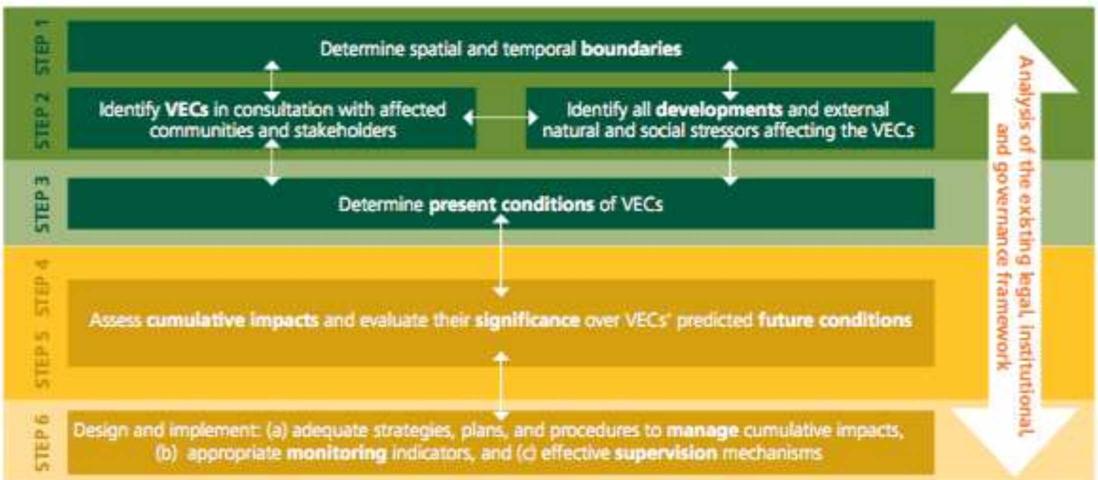
The CIA for the TRHDP examines the cumulative impacts of the Project against past, present and reasonably foreseeable projects and activities within the Tina/Ngalimbiu River catchment.

The approach follows the six steps recommended by the *Good Practice Handbook on Cumulative Impact Assessment and Management for the Private Sector in Emerging Markets* (IFC, 2013).

The CIA focuses on the environmental and social attributes of the Tina/Ngalimbiu River catchment that are considered to be most important to community and government stakeholders. These attributes are referred to as Valued Environmental and Social Components or VECs.

The six-step process used to undertake the CIA is illustrated in Figure 14-1.

Figure 14-1 Six-step process for conducting a CIA



Source: Good Practice Handbook on Cumulative Impact Assessment and Management for the Private Sector in Emerging Markets (IFC, 2013)

Steps 1 and 2 – CIA Scoping - VECs for the TRHDP, and their respective spatial and temporal boundaries, were identified through consultations with local communities and SIG during the course of preparing the ESIA. Information on other past, present and reasonably foreseeable future developments was obtained through review of existing documents, direct observations in the field, and discussions with various SIG resource agencies.

Step 3 – Present VEC Conditions - Baseline conditions of the VECs were also identified as part of the baseline physical environment, biological environment and socio-economic / socio-community environment studies undertaken for the ESIA.

Steps 4 and 5 – Assess CIA and Evaluate Significance – A VEC centred approach was followed, whereby, direct and indirect impacts to VECs arising from proposed TRHDP-related actions were evaluated against impacts on the same VECs arising from other past, present and reasonably foreseeable future projects and activities.

Step 6 – Prepare Management Framework - Wherever significant cumulative impacts were identified, control measures to mitigate these impacts were recommended. These will be carried over to the ESMP.

14.2 ENVIRONMENTAL AND SOCIAL CONTEXT

14.2.1 Regional Context

14.2.1.1 Introduction

The proposed TRHDP will be located in the Tina/Ngalimbiu River basin on the North side of Guadalcanal Island, Solomon Islands. The Tina River emerges from the higher elevation mountains and flows North to the sea. The total catchment covers an area of 150km^2. Elevation of the catchment progressively decreases in a downstream direction toward Tenaru Bay. For the purposes of this assessment, the river was divided into three main reaches: upper, middle and lower. The main features of each of these areas are described in the following sub-sections.

14.2.1.2 Upper Tina River Catchment

The upper catchment area is defined as the area upstream of the proposed TRHDP dam. It covers an area of 125km^2, and represents 83% of the total Tina/Ngalimbiu catchment area. The Tina River upper catchment is characterized by mountainous terrain, with peaks ranging from 800masl to 2300masl. Approximately 60% of the catchment is higher than 800masl.

The Tina River headwaters (270masl), which are comprised of the junction of two main rivers: Vohara River (1) and Mbeambea River (2) and a minor tributary: Njarimbisu River (3). Becho River (4), a tributary of the Vohara is located further upstream.

At its headwaters, the Tina River flows through a very narrow, steeply sided and incised, limestone gorge. The Tina River upper catchment area is comprised of undisturbed montane forests and aquatic ecosystems. The river itself is characterized by sequences of pools and rapids and sharp meanders. Major boulders, some greater than 3 m diameter, have accumulated along the channel bars. These large boulders indicate that intense floods occasionally occur within this reach.

This reach of the Tina River flows along a north-south orientated thrust fault (GeoRisk Solutions, 2012).

14.2.1.3 Middle Tina River Catchment

For the purposes of this assessment, the middle Tina River is defined as the stretch of river from immediately downstream of the dam to the Tina/Toni river confluence, and includes the 5.7km section of by-passed river. The upper half of this reach is dominated by the steep-sided Tina River gorge. Moving down the river toward the Tina/Toni river confluence, the slopes gradually become less steep and are dotted with a few human settlements and gardens.

14.2.1.4 Lower Tina River/Ngalimbiu River

The Tina River joins the Toni River 17km downstream from the Tina River's headwaters. The Toni River is a much smaller river with a catchment area of roughly 45km^2 and flows that are 1/3 that of the Tina River. From the confluence of the Tina/Toni river, the river becomes the Ngalimbiu River, which flows through a coastal plain before discharging into Tenaru Bay in Iron Bottom Sound, on Guadalcanal's North coast.

The Toni River, which flows from a hilly area of elevation 600 masl to 200 masl, meets the Tina River at 40 masl, which marks the beginning of the Ngalimbiu River plain.

The Ngalimbiu River flows across an area characterized by denser human settlement, and other anthropogenic human activities, such as gravel extraction. Drainage from agricultural lands, such as oil palm plantations, enters the river. A small delta has formed at the mouth of the Ngalimbiu River where it enters the Solomon Sea at Lasa Point (close to Tenaru Bay).

14.2.2 Environmental Conditions

Historic rainfall records for Tina River do not exist. However, based on modelling it is estimated that annual rainfall at the dam site exceeds 2500mm. The same model predicts in excess of 3500mm of total annual rainfall in the headwater reaches of the Tina River. Average daily temperatures in Guadalcanal range from 22°C to 31°C throughout the year, with a yearly average of 26.6°C in Honiara.

From the flora survey, a total of 159 plant species were identified. Among the species identified, 5 are listed as vulnerable, and 19 are listed as threatened. A total of 66 species of trees, fern trees and palm trees were identified. They are classified in the "tree stratum". Many species are regrowth and secondary trees species and are, therefore, good indicators of past disturbances, whether from natural events (e.g., cyclones; landslides) or anthropogenic activities (e.g., timber harvest). At least 23 identified tree species are of commercial timber value. A total of 36 shrubs and vines, and a total of 57 herbaceous plants were identified.

The upstream area is dominated by highly valued, undisturbed lowland forests, whereas, the downstream area near Choro, is dominated by disturbed forests. This is mainly the result of anthropogenic activities (e.g., logging, settlements, garden, trails, etc.). However, even though the forests are disturbed, they still show rich plant diversity, which is a factor of rapid vegetation regeneration due to a tropical humid climate and fertile soils.

Wildlife observed within the project included: 9 amphibian species out a total of 13 potential species[86] from 4 families; 5 reptile species out a total of 23 potential species representing 5 families; 41 bird species, representing 28 families, out of a total of 67 potential species previously recorded; and 5 mammals were observed out of a total of 14 potential species from 4 families.

14.2.3 Socio-economic / socio-community Conditions

The TRHDP study area consists of over 30 villages and hamlets of mainly indigenous people originating from the central Guadalcanal mountain lands, and several official "settler" villages made up of people originating from South Guadalcanal/Weather Coast. Settlements range in size from two-house hamlets with one extended family, up to villages with dozens of houses and over a hundred residents.

Most hamlets in the study area are connected together by walking tracks and in some cases by dirt roads, which are prone to becoming impassable during wet weather. In recent years, settlements have been established along the main Bahomea access road and logging track that run up the ridge that marks the left side of the Tina Valley.

At present, the mountainous area of the upper catchment is essentially unpopulated, apart from periodic expeditions by the traditional owners for hunting and camping, and to reconnect with customary 'homelands".

Previous local estimates put the population of the TRHDP area at approximately 2000, with half of these having "direct access" to the Tina/Ngalimbu River (Entura, 2012:32). The counts made during the ESIA fieldwork put the Bahomea/Tina population at about 1800, divided among approximately 362 households.

The villages of the project area have an average population of approximately 56 people, and an average of 11 households. Settlement sizes vary from 4 persons for Choro (the isolated occupation site in the upper Tina River), to 219 for the settler community of Verakabikabi. Nearly half the surveyed settlements had 5 households or less, and only 11 of the 32 villages had 20 households or more. The largest indigenous villages (with 100 people or more) are Tina, Antioch, Valebebe, Haimane, Mangakiki, and Marava. The average household size in the TRHDP area is 5 persons

[86] The term 'potential species' is defined as species that were found in the vicinity by previous studies and have a likelihood of being present, even if they were not observed in the course of this study.

The main livelihood activities of communities and households of the project area appear to be daily food security, and protection of the family from risks of climate and loss of resources. With a paucity of financial capital, local people use a range of strategies, including: a mix of traditional garden cultivation and gathering of staple foods for subsistence needs, combined with occasional hunting; cash-earning activities (e.g., cash crops, small-scale timber milling; day labouring; fishing; small home-based businesses; full or part-time employment for government and private sector companies).

14.3 SCOPE FOR CIA

This section identifies the VECs, their spatial and temporal boundaries, and the past, present and reasonably foreseeable projects and activities that could contribute to cumulative impacts on VECs.

14.3.1 Identification of VECs

As previously noted, VECs were defined for the ESIA baseline and assessment studies based on the following:

- Consultation with project-affected communities;
- Consultation with SIG resource management agencies; and
- Review of existing documents.

The VECs, the rationale for their selection and their spatial and temporal boundaries are presented in Table 14-1.

Table 14-1 VEC selection, rationale and boundaries for CIA

VECs	Rationale for Selection	Area of Influence Boundaries	
		Spatial	Temporal
Slope Stability, Soil Erosion and Water Quality	Potential impacts from an expanded Gold Ridge Mine, timber harvesting soil damage, GPPOL oil palm plantation chemicals in drainage, gravel extraction turbidity	Tina River/ Ngalimbiu River – from upper catchment to ocean, and Toni River catchment	TRHDP construction operation period
Terrestrial and Aquatic Habitat and Biodiversity Loss	Potential impacts from timber harvesting, and gravel extraction	TRHDP Core Area, access road and transmission lines, and upper catchment	TRHDP construction operation period

VECs	Rationale for Selection	Area of Influence Boundaries	
		Spatial	**Temporal**
Employment	Potential conflicts between locals and expatriates for jobs; competition with other key projects	Villages in vicinity of TRHDP Core Area	TRHDP construction period
Food Security	Potential resource depletion owing to food supplied to the key projects	THRDP Core Area and surrounding communities that grow and sell food	Primarily TRHDP construction period
Challenges to Cultural and Traditional Practices	Potential conflicts arising from presence of workers from outside Core Area	TRHDP Core Area and surrounding communities from which workers may be drawn	Primarily TRHDP construction period
Substance Abuse, Domestic Violence and other Increased Crime	Potential conflicts arising due to increased cash economy.	TRHDP Core Area and surrounding communities from which workers may be drawn	Primarily TRHDP construction period
Visual Intrusion	Potential reduction in visual amenity due to large man-made structures and intrusive lighting at night	TRHDP damsite and powerhouse, GPPOL and Goldridge facilities	Primarily during operation period
Natural Resources Availability	Pressure on natural resources due to increased population	TRHDP Core Area and upstream and downstream catchments	TRHDP construction and operation periods
Natural Hazards and Dam Safety	Potential for catastrophic dam failure primarily from natural hazards	TRHDP damsite and upstream catchment	Primarily TRHDP operation period

14.3.2 Projects or Activities Considered for CIA

Only those projects or activities whose impacts on the selected VECs potentially overlap (spatially and temporally) with the impacts of the same VECs for past, present or reasonably foreseen projects or activities, were considered for CIA.

There are four key projects or activities whose impacts could potentially overlap with the impacts generated by the TRHDP to create cumulative impacts. These include:

- Potential expansion of mining on the Gold Ridge tenement;

- GPPOL's Oil Palm production;
- Artisanal and commercial harvesting of timber; and
- Gravel extraction on the Ngalimbiu River.

14.3.2.1 Mining Activities

14.3.2.1.1 Past and Present Mining Activities

As stated in the Gold Ridge Mining Agreement, dated 14 September 1995, Gold Ridge's prospecting license (SPL194 – Vanusa Tenement) extends over a rectangular portion of the Bahomea area and covers 130 km^2 (see Figure 14-2). The lease overlaps with the middle section of the Toni River watershed, and overlays much of the Tina/Ngalimbiu River watershed near the Tina/Toni river confluence. However, at present, none of the pits, mineral processing or tailings facilities affect the Toni/Ngalimbiu river system.

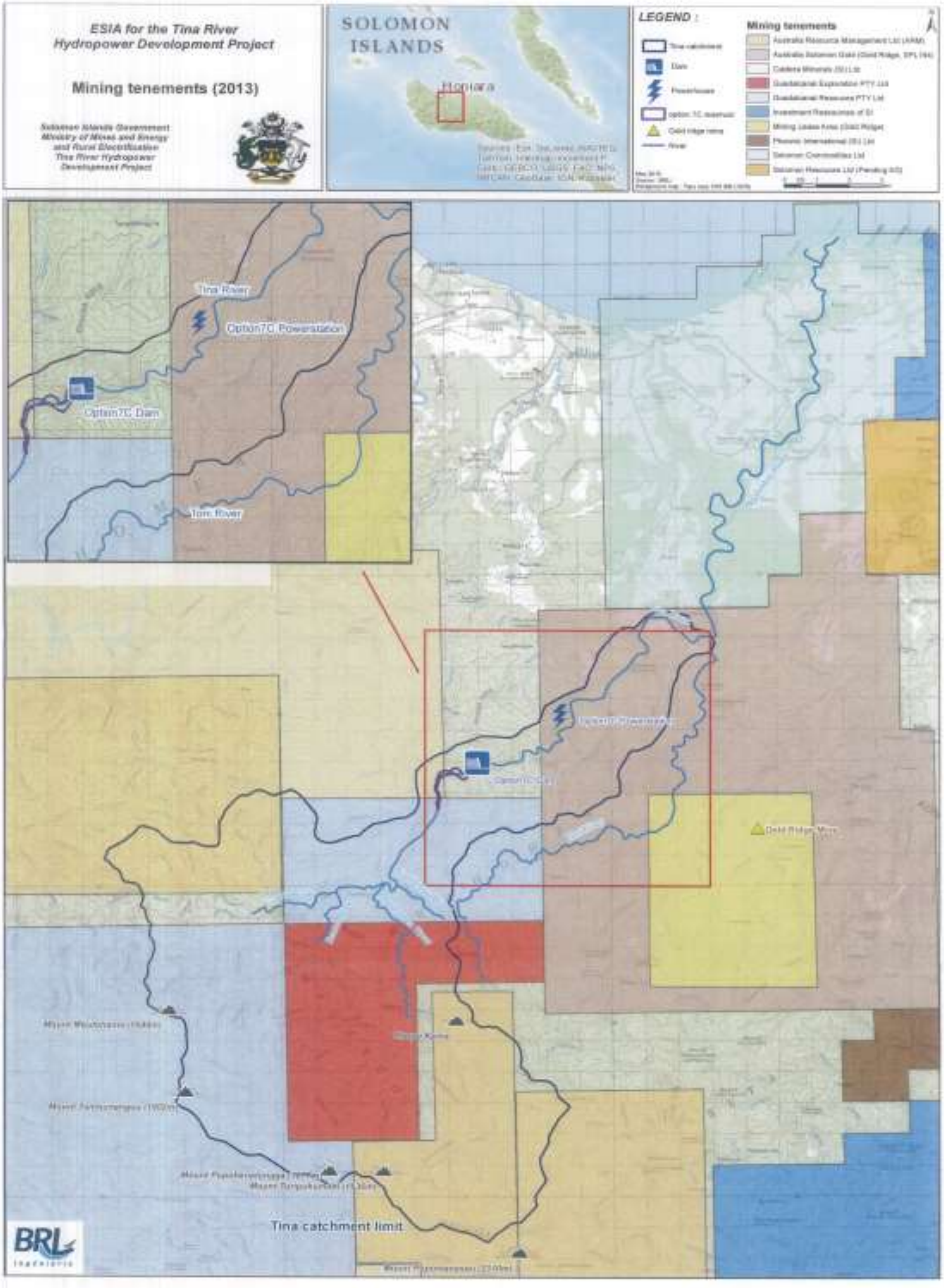
Gold Ridge Mining's facilities, including its Tailings Storage Facility, are presently located on the upper Tinahulu River, which is part of the larger Matepono River catchment. The tailings facility is located approximately 10.5km to the east, and outside of, the Toni River watershed. The tailings dam contains turbid water with high concentrations of cyanide, arsenic, copper, zinc and nickel, particularly in the sediments, which is not supposed to be released into the Tinahulu River. A water quality monitoring program is in place for the Matepono catchment, to confirm whether mine related contamination is occurring, or not. Arsenic, Mercury, Cadmium and other metals were found in sediments of the Chovohoi and Matepono Rivers, many of which exceeded ANZECC guideline values. However, aluminium, copper, arsenic, cadmium, lead, cobalt and mercury levels also exceeded the ANZECC guidelines at some surface water sampling sites that were unaffected by the Project. Some heavy metal concentrations in groundwater samples also exceeded ANZECC guidelines. Highly turbid surface water is also common. Other activities carried out within this river catchment include artisanal placer gold mining, and logging (Golder Associates, 2009).

Fish sampled from the Tinahulu River showed high concentrations of bio-accumulated metals (silver, arsenic, cadmium, cobalt, copper, mercury, lead and zinc), relative to reference samples. It was determined that these high concentrations were attributable to mining activities. Some metal concentrations were potentially detrimental to human and animal health (Golder Associates, 2009).

As part of mine decommissioning, tailings water is to be treated before being released into the river. The substrata of the tailings dam is made of impermeable clay which prevents groundwater pollution. (Ross Mining NL, 1996).

The mine was recently closed and all shares in the holding company sold to a special vehicle corporation established for the purpose, owned primarily by landowners in the Central Guadalcanal area. To reduce the tailings dam level, water from the dam is currently being treated and released in accordance with the terms of the sale.

Figure 14-2 Map of mining tenements (2013) relative to the project area



14.3.2.1.2 Reasonably Foreseeable Mining Activities

Before the closure of the mine, some discussions were underway with landowners regarding possible future extension of mining activities.

A Western extension of the Gold Bridge mine was planned, with new ore pits potentially opening in the upper Toni River watershed. However, with the mine closed and infrastructure and facilities largely destroyed, any mine expansion project is indefinitely on hold unless and until a new investor is found. The current owner of the mine, Goldridge Community Investment Limited, paid a purchase price of $100 and does not have the resources to develop and re-open the mine without investor support. If new mine pits are established, the excavated ore will probably be processed at existing process facilities, once restored, located within the Tinahulu watershed, rather than within the Toni River watershed.

14.3.2.2 Oil Palm Plantation Activities

14.3.2.2.1 Past and Present Oil Palm Activities

The existing oil palm industry, operated by GPPOL, is located on the coastal plain in the lower Tina River catchment. The industry is currently affecting the aquatic ecosystem of the Ngalimbiu River through the use of herbicides, such as Glyphosate CT, Basta (Glufosinate), 2-4-D Amine, Ally (Metsulfuron Methyl), Kamba 500 Selective herbicide (dimethlyamine salt), which are manually applied to keep vegetation under control. Use of other herbicides, such as Gramoxone Tropical (Paraquat), has been discontinued (New Britain Palm Oil Limited, 2011).

Water quality in the Ngalimbiu River has also been affected by GPPOL's use of soil nutrients, including nitrogen-based fertilisers, Keiserite (magnesium), Muriate of Potash (potassium) and boron.

According to Sol-Law Lawyers, monthly water quality sampling of discharges from ponds and watercourses that drain the plantations, is done for BOD, pH, TSS, and Oil and Grease. However, the Ngalimbiu River is not being monitored for pesticides or fertilizers. Also, water quality results are not publicly available.

14.3.2.2.2 Reasonably Foreseeable Oil Palm Activities

There is no indication that the existing oil palm industry plans to expand further up the Tina/Ngalimbiu River, beyond the current coastal plain. Given the hilly topography of the upstream area and the issues of land ownership, it is doubtful that expansion would occur in this direction.

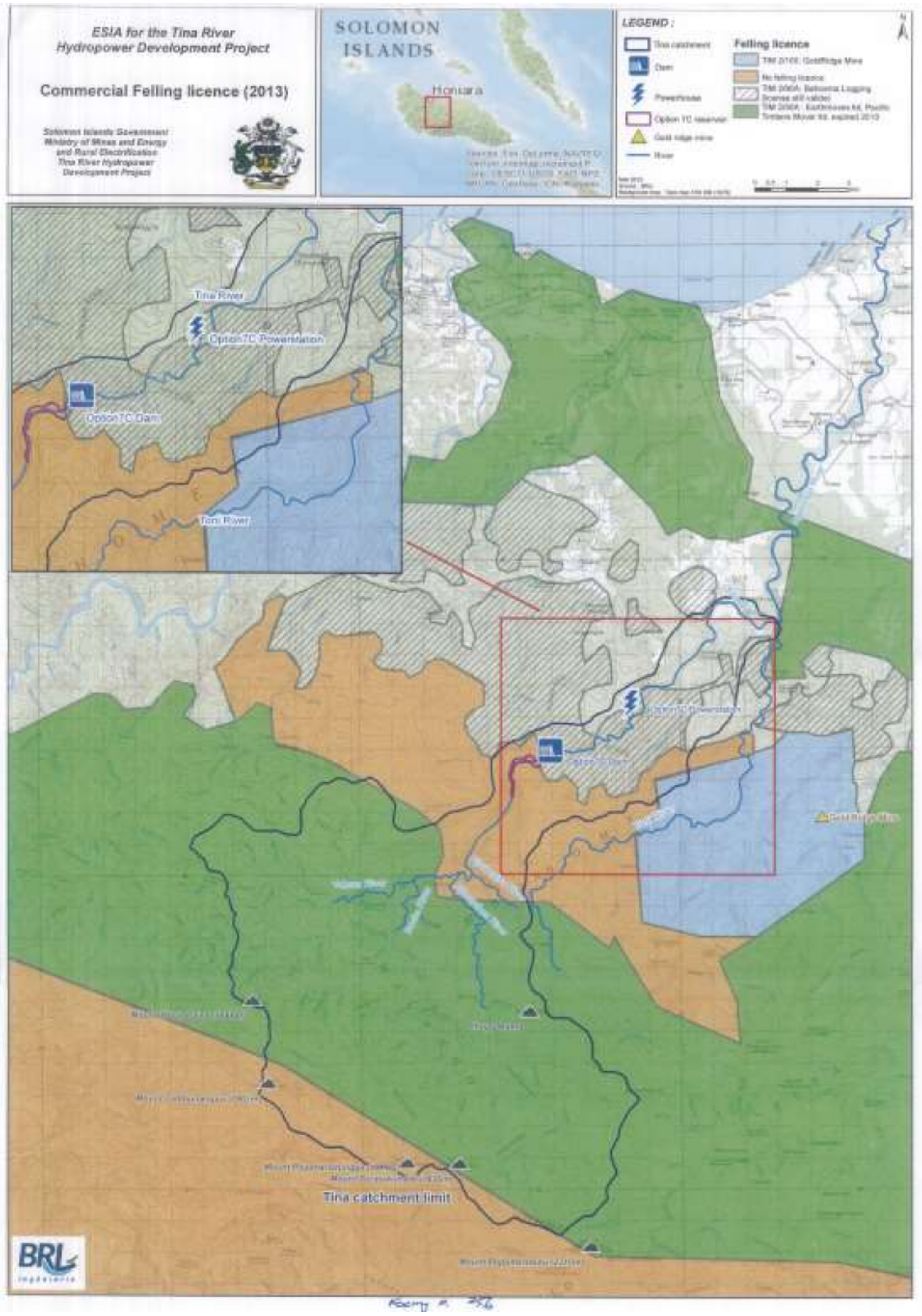
14.3.2.3 Timber Harvesting Activities

14.3.2.3.1 Past and Present Timber Harvesting Activities

As mentioned previously, timber in Tina River catchment is either commercially exploited, when a customary landowner sells the timber rights, or is selectively harvested by local communities. Either way, timber harvesting is poorly documented.

No information appears to be available regarding the type or volume of timber harvested, or the royalties being paid by timber companies to customary landowners. A single timber harvesting license (TIM 2/90A), which is held by the Bahomea Logging Company, is the only license in the Tina River catchment (see Figure 14-3). Since logging is a poorly documented activity, the full extent of both social and environmental impacts is difficult to assess.

Figure 14-3 Map of timber harvesting licenses relative to the project area



Based on field observations, impacts from selective logging are currently minimal along the banks of the Tina River catchment. Whereas, many areas along the Ngalimbiu River are prone to landslides, either as a result of naturally unstable slopes, or because of past forest clear-cutting or other human activities. The photographs in Figure 14-4 provide examples of landslide features along the Ngalimbiu River, downstream of the confluence of the Tina/Toni rivers in an area that appears to have been recently clear-cut.

Figure 14-4 Landslides on Ngalimbiu near confluence of Tina and Toni rivers

14.3.2.3.2 Reasonably Foreseeable Timber Harvesting Activities

It is reasonable to predict that communities will continue to practice selective timber harvesting in the Project area, which will be made easier with the new access road. However, it is not possible to predict whether legal or illegal commercial logging will occur, as this is largely dependent on whether customary landowners will (or will not) sell the rights to their timber.

Commercial timber harvesting will not be permitted within the area of land acquired for the TRHDP.

14.3.2.4 Gravel Extraction in the Ngalimbiu River

14.3.2.4.1 Past and Present Gravel Extraction Activities

Current gravel extraction in the Ngalimbiu River removes bed material (primarily sand and gravel) to be used as aggregate material in construction activities.

As it is the case with logging activities, there are no official records regarding the amount of gravel extracted, and whether the rate of extraction is faster than the rate of natural replenishment. The latter may be the case, as the activity currently contributes to erosion of river-banks. In the long term, the industry is probably not sustainable. As an industry, it is not monitored by the SIG, and does not pay royalties to government. Instead, royalties are paid to customary landowners (SOPAC Secretariat, 2006).

14.3.2.4.2 Reasonably Foreseeable Gravel Extraction Activities

Given that the TRHDP will act as a barrier to recruitment of sand and gravel to the downstream Ngalimbiu reach, it is unlikely that new gravel extraction enterprises will develop within the river in future.

14.3.2.5 Other Past, Present or Reasonably Foreseeable Projects

No other projects or activities, past, present or reasonably foreseeable, were identified by local community or SIG stakeholders that would have a spatial or temporal overlap with the TRHDP, such that they would contribute to cumulative impacts.

14.3.3 Assessment of Cumulative Impacts

14.3.3.1 Slope Stability, Soil Erosion and Water Quality

The downstream communities are important stakeholders for any development on the Guadalcanal plains. The GPPOL and Gold Ridge experience have shown that not taking downstream communities seriously will result in operations being frequently sabotaged. Gold Ridge, in particular, has had to deal with a disgruntled downstream community that blames many issues relating to the river system and water quality on the mining operations located upstream. The downstream communities are related to those upstream and, generally, when they take matters into their own hands the upstream communities usually do not interfere. Gold Ridge is faced with all the risks of disturbance to their operation. This risk will probably be no different for the TRHDP.

The cumulative impacts are in part based on the fact that the hydropower, oil palm and mining activities all overlap temporally, and have a degree of spatial overlap as well (see Table 13-4). The oil palm industry is located downstream of the TRHDP partly within the Ngalimbiu River catchment, and partly within the Matepono River catchment, while the Gold Ridge mine is located on the Tinahula / Chovohoi River catchment, with both rivers joining into the Matepono River. SPL194 Mining Tenement is located on both the Tina River and Toni River catchments (see Figure X-Y), and the actual Gold Ridge mining lease is located partly on the Toni River, although no activity has taken place in the Toni River catchment.

Water quality for many of the major rivers on Guadalcanal has been a source of concern. The communities along the Matepono River, downstream of the Gold Ridge operation, are in frequent conflict with the company. They claim that the river was contaminated by mining operations, resulting in the loss of livelihoods that are dependent on the river. Changes in water quality during rainy seasons are also blamed on the mining operation. The construction of the hydropower dam for the TRHDP will be a source of concern for downstream communities, due to changes to flow levels and perceived pollution levels.

An important aspect is the pollution from the use of chemicals during the construction phase of the dam, in particular, the use of large quantities of concrete. In terms of pollution, the Gold Ridge tailings dam is a potential threat for downstream communities along the Matepono River. In addition, GPPOL uses herbicides. Table 14-2 summarizes the threat to water quality caused by various projects or activities.

Table 14-2 River reaches potentially affected by cumulative impacts

Activities	**River systems concerned**					
	Tinahulu River (headwater tributary of the Matepono River)	**Chovohoi River (headwater tributary of the Matepono River)**	**Matepono River**	**Tina River (headwater tributary of the Ngalimbiu River)**	**Toni River (headwater tributary of the Ngalimbiu River)**	**Ngalimbiu River**
Actual Gold Ridge Mining Limited activities	X	X	X			
Actual mining lease of Gold Ridge Mining Limited	X	X			X	X
Foreseen activities of Gold Ridge Mining Limited (SPL 194, Vunusa Tenement)	X	X	X	X	X	X
Actual Oil Palm activities			X			X
Tina River Hydropower Development Project				X		X

There is a present risk of cumulative impacts on water quality and aquatic habitats due to the interaction of the TRDHP and GPPOL projects, and a potential interaction of these two projects with the Gold Ridge project if the Gold Ridge project expands westward into the Tina River catchment, such that there is spatial overlap between all three. The previous Gold Ridge mine activities did not spatially overlap with the TRHDP or GPPOL projects and any expansion of the Gold Ridge mine is now less likely following the closure of the mine. Therefore, at present there are no cumulative impacts foreseen arising from the TRHDP and Gold Ridge's mining activities on water quality; previous mining activities, including drainage from existing tailings outlets, do not connect to the Toni River, i.e., there is no spatial overlap with the TRHDP's area of influence. Therefore, the cumulative impact is presently not significant.

If any Gold Ridge's mining activities expand to involve tailings works, mine access roads, or overburden spoils dumps within the Toni River catchment during the period when the TRHDP is being constructed, cumulative impacts on water quality and suspended sediment loading could occur downstream of the Tina/Toni river confluence. Additional indirect cumulative impacts would then accrue to aquatic habitats, aquatic organisms, and to water uses. However, at present, there is no indication that the mine will actually be reactivated or, if it is, whether mine development would expand into the Toni River drainage. Therefore, the cumulative impact continues to be not significant.

The TRHDP and oil palm industry overlap both spatially and temporally, insofar as potential releases of sediment-laden runoff and contaminants into the Tina and Ngalimbiu rivers during construction of the TRHDP, and herbicide and nutrient containing runoff releases from oil palm plantations into the Ngalimbiu River, coincide. However, until sampling data on contaminant levels in oil palm plantation drainage waters released into the Ngalimbiu River are available, it is difficult to assess the magnitude of cumulative impacts to water quality in the lower Ngalimbiu River. Notwithstanding, it is anticipated that surface water and sediments in the river will contain traces of the chemicals used on the plantations. During TRHDP construction, water will become turbid due to sediment-laden runoff draining the earthworks. This impact will combine with the impacts from oil palm fields, and will be more significant on days with high rainfall, when drainage water from the field will discharge pollutants into the Ngalimbiu River.

Construction and operation of the TRHDP, when combined with logging activities, will generate cumulative impacts. These will be brought about because:

- The presence of a new access road into the forest could make it easier for timber companies to access areas of standing timber than it is with the logging roads that presently exist; and
- Construction of the access road will further degrade the state of disturbed forest in the area, as it will be easier to remove remaining trees.

Selective logging has less impact on topsoil erosion than forest clear-cutting. Regardless of the type of logging activity, the threat to water quality from current logging or past logging activities along Tina River is a reality, particularly at stream and river crossings.

With the creation of the access road, logging activities could intensify if no formal protection of the Tina River catchment is implemented. Increased logging could contribute to erosion or slope failure, and increased suspended sediment loading of the river. If this occurred upstream of the reservoir, it would speed up reservoir sedimentation, and impact aquatic life both in the reservoir and in the river downstream. As documented in the Gold Ridge ESIA, an increase of logging activities occurred as a result of improving road access around Gold Ridge mine.

Gravel extraction is likely to be the most important cause of current turbidity level in the Ngalimbiu River. Therefore, during construction of the TRHDP dam, there will be cumulative impacts on water quality. Operation of the dam will, however, release clear water, thereby eliminating the cumulative impacts.

14.3.3.2 Terrestrial and Aquatic Habitat and Biodiversity Loss

Cumulative impacts of habitat and biodiversity loss will also be significant between the TRHDP (hydropower) and GPPOL (oil palm) projects. However, unless the Gold Ridge (mining) project expands westward into the Toni River catchment area, there is no spatial overlap and, therefore, no cumulative impact with mining. A portion of forest will be removed and a portion of the river system will be impounded to create the reservoir behind the dam. This is in addition to the significant habitat loss that occurred when the GPPOL operation expanded its production to new “out-growers” who supply oil palm kernels from new satellite plantations, and Gold Ridge prospected onto new sites in central Guadalcanal. This will result in a net loss of habitats and biodiversity.

How the combination of the TRHDP and chemical contaminants discharged from the oil palm plantations into the Ngalimbiu River will affect fish and other aquatic life is difficult to assess, since most studies on herbicide toxicity are carried out using organisms that are not present in Solomon Islands (see Canadian Water Quality Guidelines for the Protection of Aquatic Life, 2012; Dinehart *et al*., 2008; USDA, Forest Service, 2006; and USDA, Forest Service, 2004).

The presence of the TRHDP dam will act as a barrier to sediment coming from upstream. Without mitigation in the form of periodic replenishment of downstream bed load, there will eventually be a net deficit in recruitment of sand and gravel into the Ngalimbiu River. Such deficit may eventually lead to river-bank erosion and may impact fish communities that rely on gravel for spawning. However, there is sufficient material present as bed-load and on river terraces in the middle and lower reaches of the Tina River to provide for downstream sediment recruitment for many decades to come. Any dewatering and excavation or dredging of accumulated bed load sediments from the reservoir will further ameliorate any cumulative impacts over this time period.

14.3.3.3 Land Acquisition and Tenure

A major cumulative environmental impact will be the land tenure change from customary land tenure to alienated land in the Core Area in addition to the land already alienated to GPPOL for the oil palm plantations, and to Gold Ridge Ltd., for mine development.

The process of land tenure alienation sometimes leads to land disputes, although the process followed for TRHDP has averted any serious disagreements. This situation remains prevalent on Guadalcanal with, for example, recent disputes at Gold Ridge. Many of the landowners of the TRHDP area are also landowners of the Gold Ridge mining sites. The disagreements over land ranges from land boundaries, to royalty payments, access rights, tambu sites and even access to developed lands.

Tensions for land acquisition could flair as families, tribes and villages attempt to reconcile the customary land ownership with the government's requirement for landowners to be legally registered, so that the developer can gain land access rights. In the process of acquiring land, identifying the lawful landowners is usually difficult, sometimes leading to more conflict in the community, and ongoing tensions amongst tribes and families. Some disputes of land boundaries are many years old, and have not been resolved sometimes due to a delay in process.

Disputes over royalty payments for land access, is the most common cause of disagreements. Where no clear guidelines and transparency of process is defined, it amounts to continuous tension and disruption of the development activities. This is the experience of both Gold Ridge and GPPOL.

Reclamation of alienated land is among the most challenging land issues, the background of which was the recent civil-conflict which in part involved a request for alienated land on Guadalcanal to be returned to indigenous landowners. At Gold Ridge, after the civil-conflict, some 400 relocated villagers returned to the mine area. Among them, 100 do not have recognizable claims to the land.

14.3.3.4 Employment

Employment is among the most important benefits that all projects have brought to communities and landowners on the Guadalcanal plains and the broader Solomon Islands. The development of the TRHDP would mean a new employment opportunity for communities in the project area.

Post-conflict Guadalcanal has also been resistant to allowing workers from other provinces to work on development projects within their province. This is a challenge that GPPOL and Gold Ridge have had to address, in particular, when skilled workers were needed.

Employment of non-local workers for jobs that could be done by locals could be a threat to the stability of activities. Gold Ridge's experience with the employment of Fijian security officers exacerbated tensions and resulted in resentment by the communities within the project area. GPPOL, on the other hand recently employed local contractors to provide security for its operation, which resulted in significant improvement of the company's operations.

14.3.3.5 Food Security

The combination of three large-scale developments (hydro, oil palm and mining) could further increase the pressure on food security for many communities around the project site. Many of these communities are already supplying local produce to the GPPOL and Gold Ridge work forces, and TRHDP will be an additional one. The increasing dependence on the cash economy will mean that most farmers could produce more to meet market demands, which could mean more pressure on food security of the communities.

14.3.3.6 Challenges to Cultural and Traditional Practices

The added pressure on traditional norms and cultural practices due to the presence of three large-scale developments will result in potential tensions and conflicts within the project area.

Existing internal issues and tensions between communities, tribes and individuals created by existing activities nearby could spill over to affect TRHDP. Also, issues relating to Gold Ridge or GPPOL could spill over to affect the TRHDP, due to relationships of kinship and land shared among the people and communities.

The pressures on traditional norms and cultures from the influence of “western” and modern ways, will increase significantly as communities interact with those participating in the development activities. These interactions could be beneficial in terms of cross-cultural interaction but, at other times, will result in strains on project-affected communities. It could be argued that Gold Ridge is gone, and GPPOL is an example of good practice that TRHDP is following, so the cumulative impact if any is likely to be positive.

14.3.3.7 Substance Abuse and Increased Crime

Substance abuse and alcohol related abuse are frequent among men working at both GPPOL and Gold Ridge. This issue was frequently raised during the Project social surveys, as well as during the February 2014 Mitigation Workshops. The main reason is that some men are unused to regularly receiving a cash salary and do not have the necessary experience to manage their money. Consulted communities fear that the TRHDP will be no exception. This is a challenge that the TRHDP will need to take seriously, to develop appropriate prevention measures. Alcohol and drug abuse result in domestic disputes and issues that threaten peace and harmony within the communities. The experience is that many of the disputes are often started with alcohol and drug abuse. The relatively sudden availability of cash can also result in inappropriate and illegal social behaviour, ranging from petty crimes to criminal related activities.

14.3.3.8 Visual Intrusion

The Guadalcanal Plains already have a very distinct visual impact due to the presence of oil palm. The GPPOL plantations and Gold Ridge are highly visible from a distance. The TRHDP access road and the by-passed river reach would create a significant additional visual intrusion to the area, reducing the natural visual amenity of the whole area. The development of the dam and hydropower station will also be distinct features, although they will only be visible to nearby observers, owing to the steep topography. Already at night the GPPOL oil palm and Gold Ridge mine projects emit light that can be seen at a distance, and TRHDP will be an additional light source. To mitigate this impact, it is recommended not to light the dam at night during operation, or to use only low flux lighting if security lighting is required.

14.3.3.9 Natural Resources Availability

The three major projects - TRHDP, Gold Ridge mines and GPPOL oil palm – have allowed, and will continue to allow, local communities to significantly improve their livelihoods. Although social challenges, such as land tenure issues and disruption of traditional ways of life, are still present, these projects contribute to positive changes to local communities. These projects also have a downside, insofar as improved livelihoods contribute to increased population, new human settlements and demand for land. The projects will, therefore, contribute to increased pressure on natural resources such as wildlife, fish, and forest products. Increased population will lead to degraded water quality, primarily as measured by turbidity and coliform. There is also a risk that squatters will arrive on site and initiate land disputes with local villagers. Human settlement expanding into previously forested areas could bring domestic animals that can become feral, and could open the path for invasive species.

14.3.3.10 Natural Hazards and Dam Safety

Community consultations indicated a concern for dam safety, particularly catastrophic dam failure that could send a wave surging down the Tina River valley, destroying homes and taking lives as it inundated villages. The primary activity that would combine with the TRHDP to create a cumulative impact is timber harvesting in the upper catchment area of the Tina River. The concern is related to commercial clear-cutting, as opposed to select harvesting as it is currently carried out. Clear-cutting on steep slopes could expose fragile soils, destabilise slopes, and result in flooding, landslides and debris flows that could endanger the dam and reservoir. If commercial timber harvesting were prohibited in the catchment upstream of the dam, the potential cumulative impact would be mitigated and not significant. Commercial timber felling of sloped land above 400m is currently not permitted under the relevant law (*Forest Resources and Timber Utilisation Act*). Where this law is enforced it will prevent commercial logging over the vast majority of the upper catchment area.

14.4 MEASURES FOR ADDRESSING CUMULATIVE IMPACTS

Many cumulative impacts are related to land tenure issues, water quality issues, loss of biodiversity and economic growth in the area, the latter of which is a positive impact. Most measures presented in this ESIA already address TRHDP's contribution to cumulative impacts. However, this section focuses specifically on additional means of addressing cumulative impacts.

Addressing cumulative impacts requires measures that encompass a larger area of influence than that for the TRHDP on its own, to reflect the spatial overlap of the projects and activities discussed above. Since cumulative impacts are the result of projects or activities that are beyond the jurisdiction of any one project developer or operator, they must by necessity involve the SIG along with the project staff. Three measures are proposed to address cumulative impacts. These include:

1. The Solomon Islands Government (SIG) could create an inter-community environmental and social action committee comprised of representatives of the government, affected communities and local industries.

- The committee would need to include representatives of all communities in a defined area. It would meet on a regular basis to discuss the activities of the various industries whose impacts on VECs overlap spatially and temporally. Subjects of discussion would include water quality and environmental monitoring results, health and wellbeing of communities, safety issues, and other relevant topics. The committee would base its discussions on Stakeholder Engagement Plans of the various activities in the area.
- A constraint to the efficiency of such a committee is that the focus of discussions could be drawn into land ownership and royalty payment issues.
- Another constraint is that each community has its own interests regarding industries. The oil palm industry mainly benefits downstream communities, while TRHDP will likely benefit upstream communities. Discussions may be counter-productive and may be hindered by community rivalry.
- The committee would, therefore, require a facilitator/mediator to ensure that discussions were focused on the common issues related to managing cumulative impacts and directing individual grievances from communities to specific industries, landowners and the government, to be dealt with outside the committee process.

2. The Solomon Islands Government (SIG) could develop a Local Spatial Development Plan for alienated and customary lands, to ensure good management of the rapid land development in the area:
   - Many of the lands that will be utilized for both construction and operation of the TRHDP will be alienated from customary ownership. In addition, many lands in the area are still under indigenous ownership. A Local Spatial Development Plan for the project area would guide and manage the growth of peri-urban (i.e., rural-urban transition) areas, and set goals for good governance of land. The plan would aim at defining long-term developments and a vision for the desired spatial form and structure of the area, to ensure that land use demands are well managed both socially and environmentally.
   - Such a plan would define strategies aimed at safeguarding environmental quality, improving health and education, and peoples' livelihoods. For example, it would define biodiversity networks and assess ecosystem values and services.
   - Such a plan would define area zoning, and restrict some land use in highly valued areas.
   - Such a plan would spatially coordinate and align public investment, and provide policy guidance for decision-making processes.
   - A challenge to such a plan would be that there are both alienated lands and customary lands. Currently planning legislation does not extend national jurisdiction to planning controls on customary land. The SIG would, therefore, need to fully involve communities in spatial planning procedures, and be adaptable and flexible. However, given the difficulty in reaching agreement for land development in the area, and given indigenous land tenure conflicts (i.e., Indigenous land identification process is lengthy), and the limited capacity of the SIG, implementing such a plan may not be realistic.
3. All industries in the area would cooperate to implement common actions:
   - Local industries could create a fund to implement common actions for the benefit of communities, or could join to create a global community communication plan.

- A major constraint to such a measure is that some activities in the area are unorganized and, therefore, have no communication system.. This includes the timber harvesting and gravel extraction industries, neither of which are transparent, have a Stakeholder Engagement Plan, or a formal means of communicating with communities.

In conclusion, many constraints limit the implementation of global actions to mitigate cumulative impacts, particularly the lack of capacity of the SIG, the mixed-land tenure system in the area, and the lack of transparency of some local industries. Since TRHDP will be located in the upstream area of the Tina River system, mitigation measures designed for the Project will also address some of the cumulative impact issues.

14.5 LIMITATIONS

The primary limitation in conducting the CIA was the lack of available information on other reasonably foreseeable projects or activities that may have either a spatial or temporal overlap with the TRHDP. A second phase of the CIA is anticipated during project implementation, to focus in greater depth on the most pertinent VECs and explore possible management responses in more detail.

14.6 CONCLUSIONS ON CUMULATIVE IMPACTS

A summary of the CIA analysis is presented in Table 14-3.

Table 14-3 CIA summary

<table>
<tr><th>Impacts of TRHDP</th><th>Timber Harvesting</th><th>GPPOL Oil Palm</th><th>Gold Ridge Mine</th><th>Gravel Extraction</th></tr>
<tr><td>Decrease in slope stability, leading to increased soil erosion, and decreased water quality during construction</td><td rowspan="2">Low risk of cumulative impacts as long as no clear cutting are allowed nearby Tina River

High risk of cumulative impacts if, in the future, clear cutting is practiced nearby Tina River</td><td></td><td rowspan="2">If new gold mines are exploited in the SPL 194, there is a high risk of cumulative impacts in the Tina/Ngalimbiu River Catchment</td><td rowspan="2">Cumulative impacts along the Ngalimbiu River</td></tr>
<tr><td>Disturbance to aquatic habitats and aquatic life during construction</td><td>Aquatic habitat disturbance from drainage of the palm fields in the Ngalimbiu River Catchment</td></tr>
</table>

Impacts of TRHDP	Timber Harvesting	GPPOL Oil Palm	Gold Ridge Mine	Gravel Extraction
Disturbance of water uses during construction				
Colonization by invasive species	Risk of cumulative impacts if additional logging activities take place in the upstream area thanks to improved access	Oil Palm has opened the way for plant and wildlife invasive species		
Habitat fragmentation				
Direct habitat and biodiversity loss		Oil Palm has transformed some downstream areas in monoculture fields		
Land Related Issues	Land dispute	Land tenure alienation and land dispute	Land tenure alienation and land dispute	Land dispute
Employment	Creation of non-qualified employment	Creation of non-qualified and qualified employment	Creation of non-qualified and qualified employment	Creation of non-qualified employment
Food security pressure		Increased pressure on food security	Increased pressure on food security	
Challenges to cultural and traditional practices		Added pressure on traditional norms and cultural practices	Added pressure on traditional norms and cultural practices	

Impacts of TRHDP	Timber Harvesting	GPPOL Oil Palm	Gold Ridge Mine	Gravel Extraction
Substance abuse and increased criminal activities	Substance abuse and alcohol related abuse among men	Substance abuse and alcohol related abuse among men	Substance abuse and alcohol related abuse among men	
Visual intrusion	Degradation of landscape quality	Degradation of landscape quality	Degradation of landscape quality	Degradation of landscape quality
Degraded water quality	Suspended solids release due to logging	Herbicides and fertilizers pollution in both water and sediment in Ngalimbiu River	Turbidity, metal and heavy metal pollution in both water and sediment in Matepono River and in the Tina/Ngalimbiu River Catchment if SPL 194 is developed	Major increase of turbidity in the Tina/Ngalimbiu River Catchment
Pressures on natural resources availability	Improved livelihoods – leads to increased population and related increased pressures on land and availability of natural resources	Improved livelihoods – leads to increased population and related increased pressures on land and availability of natural resources	Improved livelihoods – leads to increased population and related increased pressures on land and availability of natural resources	
Natural hazards and dam safety	Removal of forest upstream of dam, leading to floods, landslides and debris flows that could threaten the dam			

15. EFFECTS OF THE ENVIRONMENT ON THE PROJECT

People in most riverside communities, especially women, expressed concern about potential failure of the dam and the devastating consequences that would result from a sudden release of water stored in the reservoir. This concern is related to the effects that cyclones, earthquakes and/or landslides could have on the Project. Some members of the community suggested that to avoid such risks, all riverside villages should be relocated to higher ground. However, the TRHDP PO does not believe that this is a required course of action, given that the project will be designed to withstand the various impacts of the environment on the Project, as discussed below.

15.1 IMPACTS OF SEISMIC EVENTS

As noted in Section 5.5.2, the damsite is located in an area of significant seismicity (GeoRisk Solutions, 2012), and large earthquakes are common. Fourteen earthquakes having a magnitude of greater than 7.5 have been recorded in the South Solomon trench since 1900 including a 7.8 magnitude earthquake in December 2016.

A series of reports have been undertaken to assess seismicity risks and incorporate these into design. The Seismology Research Centre undertook a Seismic Hazard Assessment of the Project in December 2014. This assessment included an examination of historical seismological data, and identified peak ground acceleration (PGA) and horizontal and vertical seismic co-efficients.

A severe earthquake can have a direct impact on a dam by causing it to fail. To mitigate this potentially significant environmental affect on the Project, the dam, headrace tunnel, powerhouse and associated power generation equipment will be designed to sustain an Operating Base Earthquake (OBE) (Annual Return Period 1 in 500 years) and to withstand a Maximum Design Earthquake MDE (Annual Return Period 1 in 10,000 years). An MDE means that the dam can suffer significant damage and movements but will not collapse and cause an uncontrolled release of the reservoir water. These design stipulations are incorporated into the earthquake design requirements of the Minimum Functional Specifications, forming an annexure to the PPA between the Developer and Solomon Power.

Table 15-1 – Peak Ground Acceleration and Seismic Co-efficients, Dam Safety Advisory Panel Report, March 2016

Return Period	***PGA (g)***	***Horizontal Seismic Coefficient (kh)***	***Vertical Seismic Coefficient (Kv)***
145 (OBE)	0.179	0.12	0.08
475 (DBE)	0.286	0.19	0.13
10,000 (MDE)	0.678	0.45	0.30

The Developer has compiled a Geotechnical Design Review Report which sets out the geotechnical conditions and design criteria that they intend to use for the Project's outline design. This document, together with the Geotechnical Baseline Report for Construction (GBR-C), stipulate the design measures proposed to meet the OBE and MDE seismic risk requirements.

The Dam Safety Advisory Panel, engaged in accordance with World Bank OP 4.37, has reviewed the relevant reports, including the Seismic Hazard Assessment, Geotechnical Design Review Report and GBR-C and has prepared recommendations to be incorporated into final design in the Dam Safety Panel Advisory Report, March 2016. The design requirements include:

- foundation excavations for diversion conduit to take place on the left bank where the bedding dip of the sandstone/conglomerate is into the abutment; and
- RCC concrete compressive strength to be not less than 10-15MPa to prevent cracking during an OBE.

The Dam Safety Advisory Panel will continue to review design iterations, and final design, in accordance with the dam safety management plans under WB OP 4.37, discussed further in the Environment and Social Management Plan – Chapter 13.In the event of an earthquake occurring, a post quake assessment would be undertaken of all components of the project to ensure they are structurally and functionally sound. In the unlikelihood that quake damage occurred to the dam, the reservoir would be lowered to ensure no additional strain was placed on the structure and a full assessment would be carried out to identify measures required to remedy any engineering concerns.

A severe earthquake could also adversely affect power generation, by causing switches to be automatically thrown in the switchyard, and transmission line pylons to fall over. Whilst this would be a significant inconvenience to Guadalcanal for the period of time it would take to affect repairs, it would not present a threat to the safety of villagers residing in the downstream communities.

Indirect impacts associated with an earthquake event include triggering landslides or mass wasting. This is discussed in Section 15.2. An earthquake could also cause trees to topple over and block the access road, or knock out the transmission line.

15.2 LANDSLIDES AND DEBRIS FLOWS

Landslides and debris flows triggered by earthquakes, floods undermining toe of slopes, wind thrown trees losing root cohesion and exposing soils to water-logging

As noted in Section 5.5.1, a significant number of landslides occur within the Tina River catchment, particularly on the steeper slopes. However, they remain relatively small (100m^3 to 200m^3), and are primarily associated with rockslides along bedding planes. Other slope failures are located in the upstream end of the proposed reservoir, in Suta Volcanics. Debris flows are also a feature of the upper watershed, and are caused when boulders and logs that are trapped in steep gullies or streams are suddenly mobilised due to a flash flood or small headwall landslide being released in the upper reach of the stream during a major rainfall event.

According to Entura (2014), large landslides can have a detrimental effect on the dam and its reservoir if they occur near the dam, or if the landslide causes wave propagation that could overtop the dam, which is a particular concern for earthfill dams. The TRHDP dam will be an RCC dam with an open spillway. Therefore, the risk of overtopping is not an issue, due to the solid concrete construction and the open spillway design that would pass a landslide propagated wave, should a landslide of significant mass enter the reservoir.

Likewise, debris flows that enter the Tina River upstream of the dam as a result of cyclone generated rainfall deluge, are unlikely to affect the dam or the downstream powerhouse, providing that the fish screens are in place over the power intake, to prevent entrainment of floating woody debris entering the reservoir from debris flows, into the headrace tunnel, as this material could damage the turbine runner blades.

Notwithstanding the above, Entura (2014) has suggested that design of the dam and construction planning should assess the risk of remobilizing existing landslides during construction work. They note that large-scale landslides are unlikely to directly affect the dam.

15.3 Impacts of Severe Weather or Climate Related Events

Depending on how global climate change is manifested in the Solomon Islands, it is possible that one of three effects will be felt: 1) no significant change to the pattern and volume of rainfall within the region (status quo); 2) increasing frequency of severe tropical cyclones and rainfall events; and 3) reduced frequency and magnitude of rainfall patterns that by present standards would be considered “drought” conditions.

15.3.1 Status Quo Weather and Climate Conditions

As noted in Section 5.6, the Tina River is a single channel meandering river. It has a torrential behavior with regular flash floods. High rainfall events generate periodic flash floods, and debris flows. These events are unlikely to have any direct impact on the dam or associated power generation facilities. The open spillway will pass floodwaters, and the fish screens on the power intake will prevent debris from entering the headrace tunnel and turbines.

15.3.2 Cyclones, Severe Rainfall Events and Floods

As noted in Section 5.4, the project area is subject to periodic cyclone events. In May 1986, cyclone Namu contributed 1200mm of rainfall over a period of a few days, causing rivers to overflow their banks. Water depth at the project site was said to be 7m. The floods and mudflows precipitated by Cyclone Namu reshaped the course of the Tina River.

The primarly affect of a cyclone on the Project is the extremely high rainfall that would fall within the catchment area, generating flash floods, debris torrents and, potentially, landslide events. The RCC dam will incorporate an open spillway feature which will be capable of passing a 1:10,000 year flood event without any threat to the dam or its facilities. As the spillway does not have gates or stoplogs, floodwaters will pass over the lip of the spillway unimpeded.

Significant flooding would have the potential to cut off immediate access to the dam due to the likelihood that roads would be flooded or washed out. Due to the small size of the reservoir, it would not have any flood attenuation capacity to mitigate floods generated by high rainfall patterns that accompany a cyclone.

A severe rainfall event can also cause indirect impacts to the Project by saturating soils on steep slopes making them less stable and prone to mass wasting. Where this happens along the access road, the road could be buried in debris or washed out.

15.3.3 Droughts

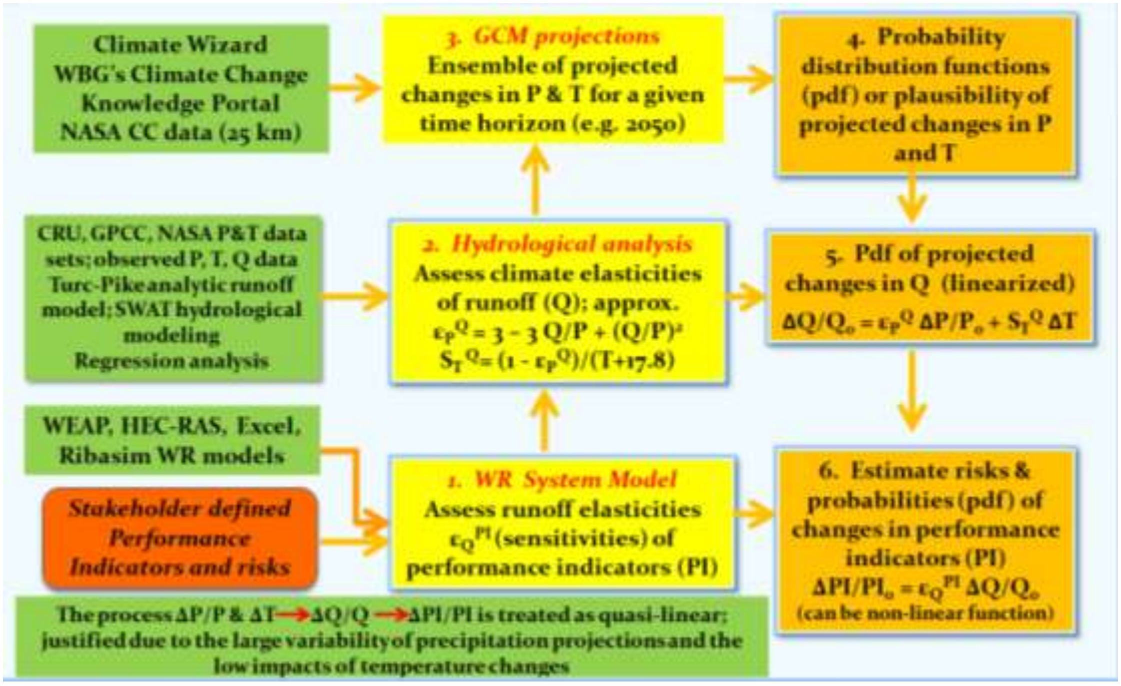
Owing to the reduced flows in the Tina River during the dry season, the TRHDP has been designed to operate as a peaking facility. Power will be generated during the peak load periods during the day, with water released to the river from the powerhouse tailrace. During the night, less power will be generated, and a minimum flow of 3.4m^3/s will be released to the river below the powerstation (2.4 m^3/s from one turbine plus 1 m^3/s environmental flow plus tributary inflows), as the reservoir is refilled for the next cycle of power generation.

If climate change results in reduced average daily dry season flows in the Tina River, then power generation will be affected either by shortening the periods of peak generation during the daytime hours, or reducing the number of turbine/generator sets in operation at a given time. The net effect would be the same – reduced power output for a given volume of water available.

15.3.4 Climate Risk Assessment

With the support of the World Bank, the Solomon Islands Government prepared a *Climate Risk Assessment* (CRA) of TRHP (the Project) by engaging an independent expert. The assessment was completed in June 2016. The objective of the CRA is to assess the impact of climate change on the Project, particularly on the hydrology which affects the economics of the Project. The bottom-up CRA methodology adopted is summarized in the schematic diagram below.

Figure 15-1- Climate Risk Assessment Process



In view of the perceived economic life time of the Project, the CRA focused on the projected climate and runoff changes for the project area by 2050 and their impacts on the hydro-energy generated by the project. Conclusions are as follows:

- Changes in precipitation explain most of the inter-annual and long-term variability in stream flow. Precipitation changes projected by CMIP5 climate models are distributed fairly uniformly over the year; by 2050 projected changes range between a decrease with 15% and an increase with 15%, on average no significant change. Temperatures are projected to increase uniformly over the year, by 2050 mostly between 0.5 ^{0}C and 2 ^{0}C, on average with 1.3 ^{0}C.

- Based on an analysis of multiple ensembles of CMIP5 and CMIP3 climate projections, it is concluded that by 2050 the average basin runoff can vary between 80% (-20%) and 120% (+20%) of the present runoff due to the combined impacts of a 1.3 ^{0}C increase in temperature and potential shifts in precipitation between 85% (-15%) and 115% (+15%) of the present regime; by 2090 the range would likely be between 70% and 130% of the present runoff. On average no significant decrease in runoff is expected but – as indicated here above - the spread between projections of individual climate models is moderate to significant, with an ensemble standard deviation of about 10% by 2050 and 15% by 2090. The analysis shows that only 3 out of 23 combinations of CMIP3 global circulation models and emission scenarios project reductions in river discharge exceeding 10%.
- Generated annual energy could vary most likely between -20% and +10% of the energy generated under the baseline hydrological conditions. This range of annual energy generation is reflected in the economic analysis.
- It is recommended to review at the detailed design stage the preliminary design capacity of the plant's spillway (assessed in 2011), since this estimate was indeed declared to be tentative and also since on a global scale tropical cyclones are projected to be more intense in the future. Climate models agree in general that globally there will be an increase in rainfall rates of the order of 20% within 100 km of the cyclone centre, which could cause for the Tina River basin an increase in extreme flows with 25% to 30%. The operation manual, dam break analysis and emergency preparation plans should also take the possibility of extremely high flash flood flows during tropical cyclone conditions into account.
- Few floods have been accurately measured in the Pacific and there is limited measured flood data to support flood related community risk initiatives, flood mitigation, or water related infrastructure design. Therefore, a concerted effort should be made to monitor rainfall at multiple locations across the upper Tina catchment and monitor river flows at or near the Tina Hydropower dam site. This will allow over time a better assessment of the hydro-meteorological baseline conditions, as well as permit the detection of positive or negative trends in precipitation and runoff caused by climate change.

A new stream gauging station was installed in December 2016 on the Tina River. The contractor is expected to be responsible for monitoring the river water level during construction. The contractor will also update the design of temporary and permanent structures based on these updated hydrological data and in line with the recommendations being made by the Dam Safety Advisory Panel which will be retained by the Solomon Islands Government throughout the construction period and the initial years of operation.

15.4 DAM SAFETY

The World Bank's operational policy 4.37 (see Section 3) requires that the TRHDP prepare and implement a Dam Safety Plan, and that qualified professionals be enlisted to design and operate the project, and prepare the various safety plans. The TRHDP has contracted world class hydropower engineers, who have examined the various environmental risks to the Project. The final layout and design will take into consideration the various effects of the environment on the Project that are discussed above, and produce the requisite safety and operations plans. In addition, the TRHDP PO has engaged a panel of engineering, geotechnical, environmental and social experts to evaluate the Project to ensure that all risks are addressed.

As noted in Chapter 13 Environmental and Social Management Plan, all plans relating to dam safety and response to operations related emergency events will be prepared by the TRHDP's Dam Safety Consultant. The Construction and Quality Assuranace Plan, and Operations and Maintenance Plan, are being developed by the TRHDP, and will be submitted for review and approval prior to Bank Appraisal. An Instrumentation and Emergency Response Plan will be developed by the TRHDP during the project design phase, and will be submitted for review and approval prior to project commissioning.

15.5 CONCLUSIONS

The Project will be designed and operated to withstand the various environmental calamities identified above, to ensure the structural integrity of all its components, especially the dam.

16. CONCLUSION

The Tina River Hydropower Development Project (TRHDP) Project Office (PO) is proposing to construct a peaking hydropower facility on the Tina River in northern Guadalcanal Province, Solomon Islands. The Project would be comprised of a 53m high RCC dam, 3.3km headrace tunnel and penstocks, and 3x5MW powerhouse. The Project would provide clean, reliable, renewable power for 80 to 100 years.

The environmental and social impact assessment of the Project was undertaken in accordance with the Solomon Islands' *Environment Act 1998,* World Bank Performance Standards and guidelines, and relevant World Bank operational policies for safeguards. The ESIA demonstrates: 1) that a comprehensive assessment has been completed for the project, 2) the project-affected communities have been provided a clear understanding of the Project and have been properly consulted regarding their issues and concerns; 3) the guidelines for free, prior and informed consent (FPIC) have been followed and the Project satisfies the FPIC requirements; and 4) the TRHDP PO has engaged with customary land owners / Indigenous peoples since early in the planning process, to receive their input.

Based on the results of this environmental and social impact assessment, the TRHDP PO concludes the Tina River Hydropower Development Project is not likely to cause significant adverse environmental, socio economic / socio-community (including to Indigenous peoples) or other effects, taking into account the implementation of appropriate mitigation, management and monitoring measures, as identified in the assessment and mitigation chapters and the Environmental and Social Management Plan (Chapter 13) of this ESIA.

The most significant potential impact is the barrier presented by the 53m high dam to upstream and downstream migrating fish species. However, through a combination of mitigation measures that involve environmental flow (EF) releases, a trap-and-haul system to move upstream migrating juvenile fish past the dam, spillway flow releases to effect adult downstream eel migration, fish screens to prevent entrainment into the power intake and turbines, and an adaptive environmental management program to assess the success of these measures and adjust them accordingly, the potential significant impacts to migrating fish can be reduced to acceptable levels.

The Tina River is a clean and renewable resource for energy generation. Only 115.49ha of forested land will be cleared, of which only 9.5ha is undisturbed forest. Much of this area is within the relatively small footprint of the reservoir area. The developer's Biodiversity Action Plan will provide for an offset to achieve no net loss of biodiversity as a result of the conversion of natural habitat. It will include the protection of the remaining natural habitat in the Core Area,rehabilitation of at least 9.5 Ha of modified habitat in the Core Area, and measures to protect the upper catchment including forest monitoring and restrictions on access through the Core Area. No net loss of biodiversity will also be sought through support for the creation of a protected area in the upper Tina River catchment.

Most of the vegetation from within the reservoir will be removed. This will ensure that the volume of organic material to be inundated contributes very little GHG production as it decomposes. Other areas no longer required for construction will be revegetated with native plant species at the end of the construction period. Overall, the TRHDP will deliver electricity with very low GHG emissions per kWh of energy generated.

Greenhouse gas emissions from Solomon Islands are approximately 618,000 tCO2e/year. The estimated net GHG emissions abated attributable to the operation of the TRHDP represents an average of 49,000 tCO_2-equivalent. Emissions abated significantly exceed SIG's INDC commitments to reduce GHG by 18,800 tons of carbon dioxide equivalent (tCO_2eq) per year by 2025 and by 31,125 tCO_2eq per year by 2030 with appropriate international assistance per year.

The effects of the Project, as discussed in this ESIA, have been examined using assessment methods and analytical tools that reflect current good international industry practice of environmental and socio-economic practitioners. After consideration of the potential residual effects, and taking into account the site selection, engineering design, and identified mitigation measures, the THL believes that the Project can be constructed, operated, and decommissioned without significant adverse effects.

Further, it is the conclusion of this assessment that the Project will bring substantial net positive benefits, both locally to the communities within the Tina/Ngalimbiu River catchment, and to Guadalcanal in general. The Project will assist in reducing the current cost of electricity, reinforce and expand the electrical system of Guadalcanal, provide direct economic benefits to customary land owners, and provide a “green” source of electrical generation.

Based on these conclusions, THL requests that the Project be approved.