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# **Environmental Impact Statement**

## **(Expanded Summary based on ESIA 2017)**

**For Tina River Hydropower Development Project, Solomon Islands**

April 2019

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# 1. EXECUTIVE SUMMARY

## 1.1 The Purpose, Extend, And History Of The Project.

### 1.1.1 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).

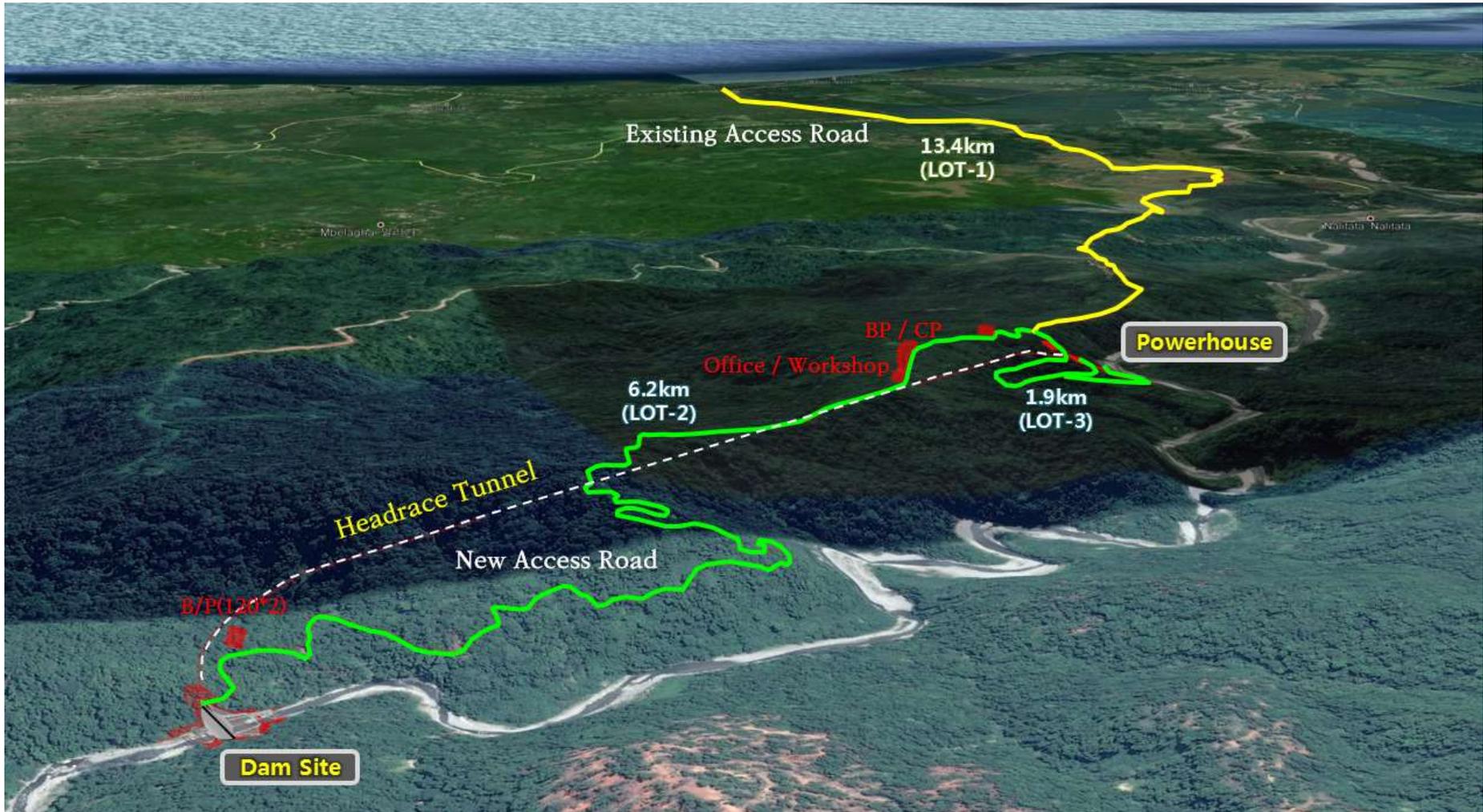
Electricity will be generated by an Independent Power Producer (IPP), Tina Hydropower Limited. The Tina Hydropower Limited (THL) is a Project Company (PC) and duly organised under the law of the Solomon Islands. THL will sell electricity to the Solomon Islands Electricity Authority (SIEA), the state-owned 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](#)) show the Scheme Layout

Figure 1-1 Scheme Layout



Source: Tina Hydropower Limited, 2019

### **1.1.2 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.

### **1.1.3 History of Project**

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.

Since K-water and HEC consortium became a developer that has priority in 2015, the project has been developed with SIG, concessional finance parties including WB and ADB. In 2018, Implementation Agreement (IA) and Power Purchase Agreement (PPA) has been signed up between the developer and SIG. Tina Hydropower Limited (THL) has been set up in December 2018 with its office based in Honiara.

### **1.1.4 Basis for EIS**

To implement the TRHDP, an Environmental Impact Statement (EIS) 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 EIS was prepared for MECDM based on the TRHDP ESIA 2017 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 TRHDP ESIA 2017. In addition, a program of ongoing consultation has been carried out by the TRHDP Office since 2011.

The EIS 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) framework is included in the document. Under the Solomon Islands' *Environment Act*, the developer of a project must submit the project EIS to the Ministry of Environment, Climate Change, Disaster Management and Meteorology.

### **1.1.5 Objectives of the EIS**

The objectives of the EIS 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.

### **1.1.6 EIS Study Methodology**

Preparation of the EIS 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.

## **1.2 A SUMMARY OF EIS STUDY ACTIVITIES**

### **1.2.1 Identification of Baseline Conditions**

The first stage of the EIS 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.

### 1.2.2 Literature Review

In preparing the EIS 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-feasibility 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 Earth);
- Local newspaper articles;
- Information available from various websites (e.g., annual reports for mining companies).

### 1.2.3 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 1.6.1). Table 1-1 identifies mitigation workshop dates, venues, participant groups and number of participants.

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 reside physically outside of it.	60 persons
06 Feb 2014	Mataruka	Landowners who have customary rights in the impacted area but reside 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

#### 1.2.4 Environmental Impact Analysis

Impacts on the following valued physical and natural environmental attributes or 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.

### 1.2.5 Social Impact Analysis

Impacts on the following valued social attributes or 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.

## 1.3 ALTERNATIVES

This section outlines the main alternatives that were studied to provide justification for the selected project.

### 1.3.1 Alternative Energy Sources

The EIS 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.

### 1.3.2 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 feasibility studies, receipt of recommendations from the TRHDP-PO's Dam Safety Panel based on geotechnical conditions, and preparation of the EIS, seven different possibilities 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 53m (river bed-crest), 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.

## 1.4 DESCRIPTION OF THE ENVIRONMENT AFFECTED BY THE PROJECT

### 1.4.1 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** – 397Ha 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. 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 EIS.
  - **Infrastructure Corridor** – Encompassing a 50-metre corridor from Managikiki 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 communities that may be impacted by noise, dust, traffic or electricity safety concerns.

#### 1.4.2 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 Belaha 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 1-2:

- **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<sup>2</sup>. 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 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.



## **1.5 DESCRIPTION OF SIGNIFICANT ENVIRONMENTAL AND SOCIAL IMPACT.**

### **1.5.1 Impacts on Physical Environment**

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.

The Project will have a net GHG reduction potential of 49,500 tCO<sub>2</sub>eq 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<sub>2</sub>eq.

### **1.5.2 Impacts on Flora**

Construction activities will necessitate clearing approximately 115.49 hectares (ha) of natural vegetation in the Core Area, approximately 50ha of which is disturbed forest and 9.5ha of which is undisturbed forest, to create an access road and to prepare the reservoir area. Approximately 15ha each of riparian and cliff vegetation will also be cleared.

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.

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.

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.

### **1.5.3 Impacts on 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 be 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 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.

#### **1.5.4 Impacts on 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.

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.

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.

#### **1.5.5 Social Impacts**

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 24m<sup>3</sup>/s, and;
- opportunities for improved quality-of-life, through the provision of replacement services and facilities.

## **1.6 THE PUBLIC CONSULTATION AND FEEDBACK**

### **1.6.1 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.

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. Table 1-2 and 1-3 provides a summary of the community feedback and its incorporation in ESIA revision.

Table 1-2 Stakeholder Consultations for Revised EIS

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
1 November 2016	GPPOL community building, Ghaobata	Lower Downstream affected communities

Table 1-3 Resolution of Community Concerns - EIS 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. 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.
	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 added to ESMP. Project Finance to include funding for TRHDP-PO and MMERE to provide oversight of THL 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.
	Could the dam be used to provide a water supply for communities and Honiara	Not a component of the current hydropower project.

Community	Consultation Feedback	Project Outcome
	Village water supplies to be built before construction starts	ESMP 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. 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 small floods and make use of spillway.
	Electrification for villages	Electrification for priority infrastructure became a component of the Japanese Social Development Fund (JSDF) Community Benefit Share Pilot
	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 THL.
	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.

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

### 1.6.2 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.

## **1.7 THE ECONOMIC ASSESSMENT OF THE ENVIRONMENTAL AND SOCIAL IMPACTS AND THEIR MANAGEMENT**

### **1.7.1 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.

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.

### **1.7.2 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 River Valley

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.

### **1.7.3 Local Customs and Livelihood**

#### **1.7.3.1 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.

#### **1.7.3.2 Livelihoods**

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.

#### **1.7.3.3 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.

#### **1.7.3.4 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.

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.

#### **1.7.3.5 Extraction of Aggregates from the River**

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 communities in the area.

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 downstream of the dam should be carried out to confirm whether any impacts on downstream gravel users are likely to occur.

#### **1.7.3.1 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.

## **1.8 THE RECOMMENDATIONS FROM THE EIS.**

Based on the results of this environmental and social impact assessment, 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 of this EIS.

The most significant potential impact is the barrier presented by the 53 m high dam (riverbed-crest) 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, fish screens to prevent entrainment into the power intake and turbines, and an adaptive

environmental management program, the potential significant impacts to migrating fish can be reduced to acceptable levels.

## **2. DETAILS OF THE PRESCRIBED DEVELOPMENT DEVELOPER**

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 Motor Group, is one of the largest Engineering construction companies in Korea.

KW & HEC set up a project company, Tina Hydropower Limited, in Solomon Islands and has signed the PPA with Solomon Islands Electricity Authority (SIEA) at 06 Dec. 2018. HEC will be primarily responsible for the Engineering Procurement and Construction (EPC) development and K-water 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 34 years from mobilisation. The expected approximately USD140.25M EPC budget includes nearly USD0.32M for environmental investigations and monitoring; the budget for ongoing maintenance and operation includes nearly USD 0.31M per annum for training and capacity building. Plans include employment and training for more than 50 locally recruited staffs.

Kwater-HEC is prepared to collectively hold 100% of the equity (\$10.8 million, KW: HEC = 80:20). The equity investment will be through a Special Purpose Company (Tina Hydropower Limited) 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.

### **3. DETAILS OF THE CONSULTANTS FOR THE ESIA**

#### **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 for review by World Bank's environmental and social safeguard specialists. 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.

#### **3.2 SUPPLEMENTARY STUDIES AND FINALISING TRHDP 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. 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.

Key information from the supplementary studies have been incorporated into the TRHDP ESIA document. The impact analysis has also been amended based on new relevant information obtained from the supplementary reports, and mitigation measures adjusted appropriately.

#### **3.3 ESIA QUALITY REVIEW AND FINAL EDIT**

The initial ESIA prepared by BRLi 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.

### 3.4 EIS PREPARATION

The current EIS expanded summary was prepared for SIG(MECDM) based on ESIA (2017) by THL EIS preparation team.

The following contact information applies to the Project:

Entity of Project Developer:	Tina Hydropower Limited
Address:	PO Box 419, 2 <sup>nd</sup> Floor, Alvaro2.0 Building, Mendana Avenue, Honiara, Solomon Islands, Tel) +677 25115
Principal Contacts for the ESIA:	Mr. Jaeil Ryoo, CEO <a href="mailto:jjryoo6901@gmail.com">jjryoo6901@gmail.com</a>  Joshua Kera, Environment and Social Assistant <a href="mailto:j.johnkera@gmail.com">j.johnkera@gmail.com</a>

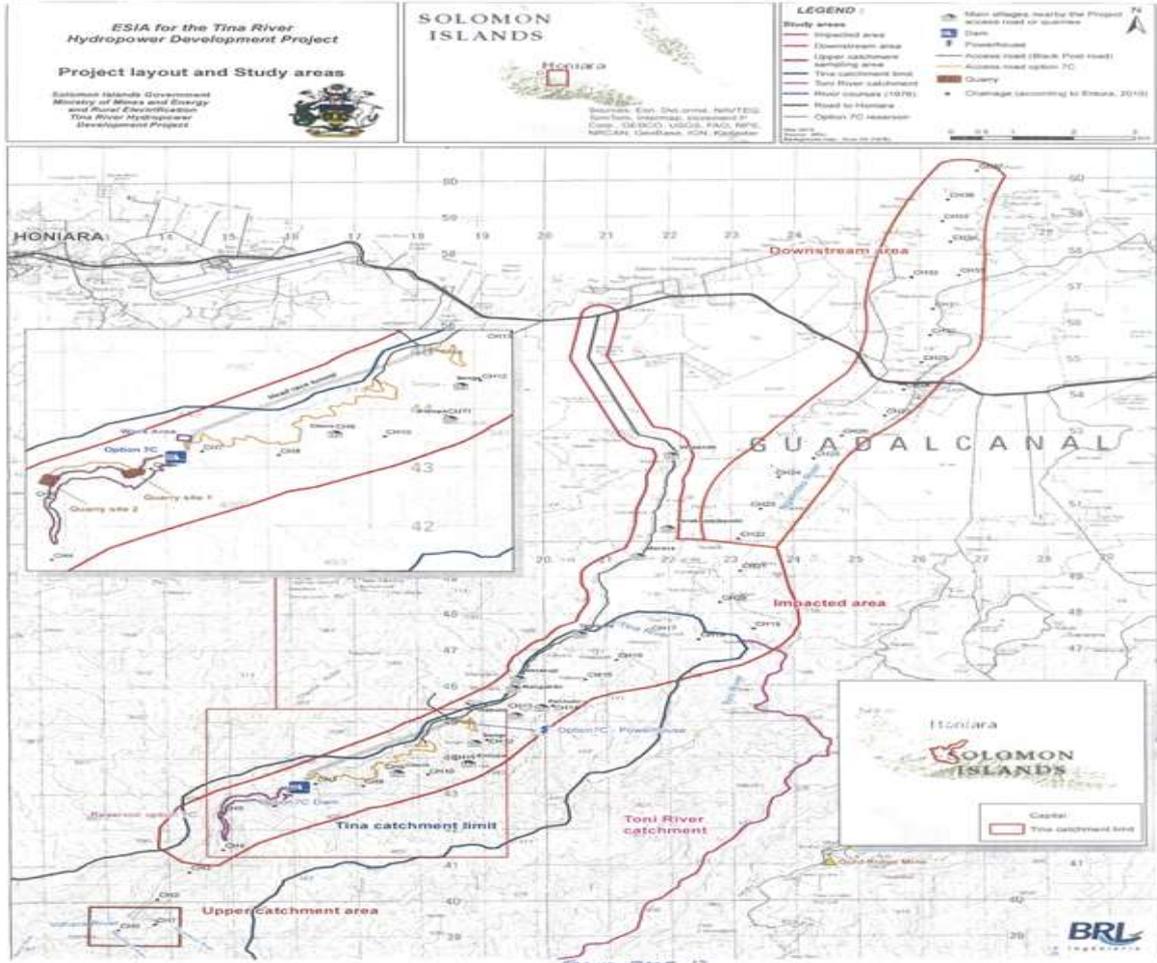
# 4. DESCRIPTION OF THE PROJECT

## 4.1 IDENTIFICATION OF THE PROJECT

### 4.1.1 General Area Description

The Tina River is derived from the combination of three rivers: the Mbeambea, the Voraha and the Njarimbisu rivers. The Tina River catchment area is roughly 150km<sup>2</sup>. The Tina River joins the Toni River, a much smaller river with a catchment of about 45km<sup>2</sup>, 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 4-1.

Figure 4-1 Map of Project Area

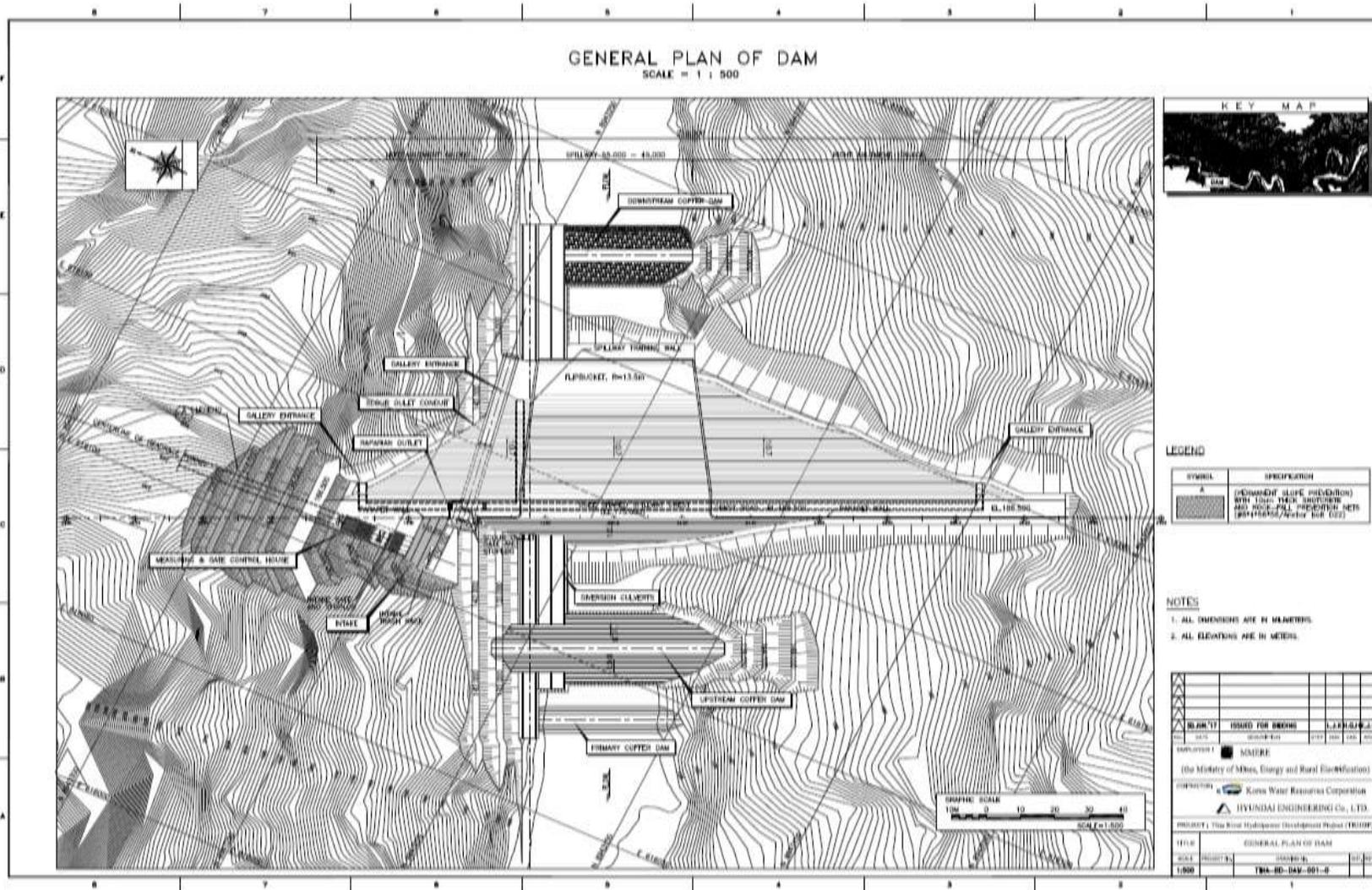


Source: ESIA, Aug. 2017

#### 4.1.2 Choice of Dam

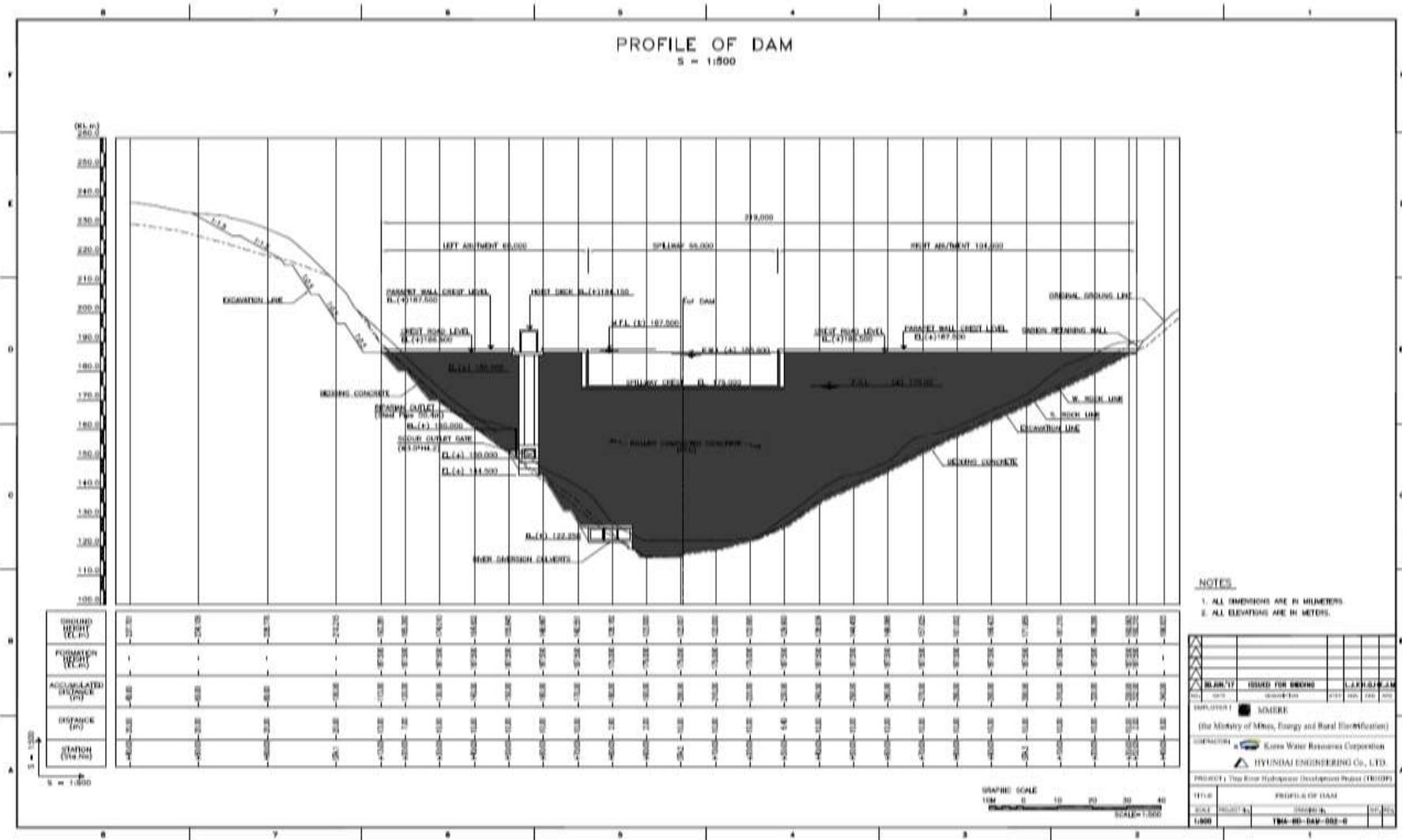
The dam will be a Roller Compacted Concrete (RCC) dam, located in the narrow gorge of the river. The spillway will release flood flows up to the 1:10,000-year flood level (3,290m<sup>3</sup>/s). Also, Technical Proposal (2017) based on feasibility study by Entura (2014) included the bidding design implemented by K-water and HEC and main dam drawings are as followings. Figure 4-2, 4-3, and 4-4 shows overview, profile, and section of dam

Figure 4-2 General Plan of Dam



Source: Technical Proposal, Jun. 2017

Figure 4-3 Profile of Dam







### 4.1.3 Reservoir

The reservoir will have a volume of 7Mm<sup>3</sup> at FSL and will extend upstream approximately 2.6 km with a surface area of about 0.28 km<sup>2</sup>. 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.

### 4.1.4 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 360m<sup>3</sup>/s was applied on a design flood.

With regard to the above, main consideration in Technical Proposals (2017) are 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 also 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.

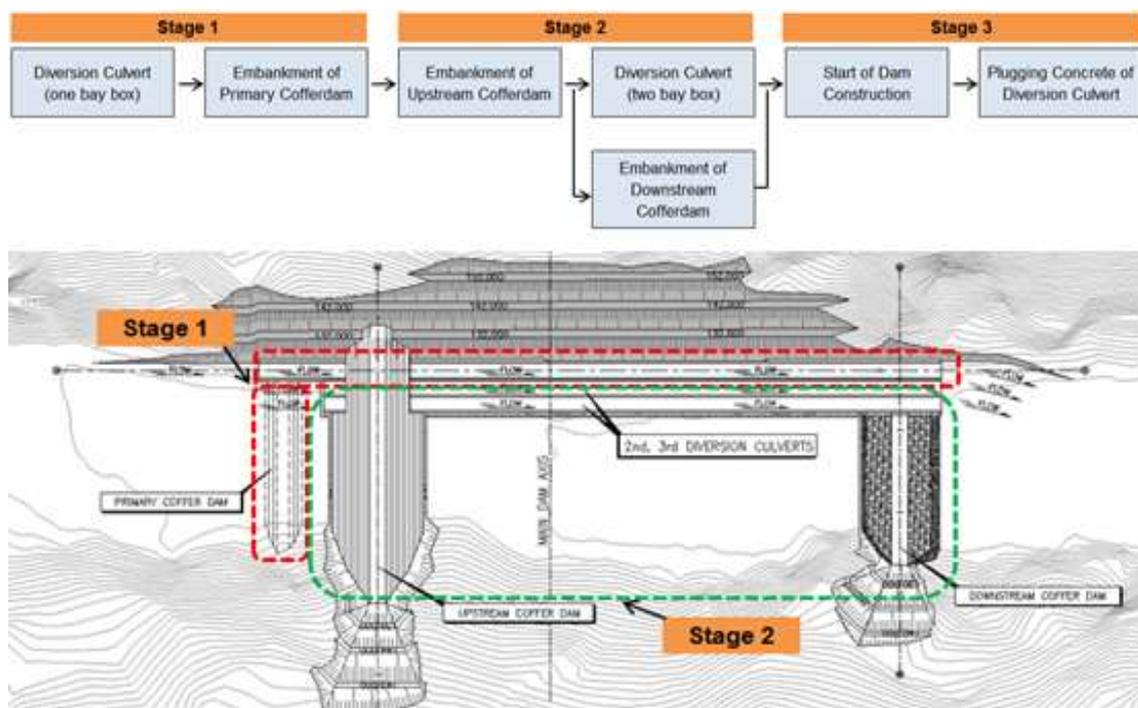
The diversion will consist of three components: upstream cofferdam, diversion conduit to pass low level floods and downstream cofferdam. These elements will ensure protection from floods during dry-season construction. The RCC dam will tolerate over-topping during

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 360m<sup>3</sup>/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 4-5) allowing for the installation of an outlet controlled by a valve to ensure 1 m<sup>3</sup>/s minimum river flow during initial reservoir filling (Note: this outlet is not shown on drawings).

Figure 4-5 Sequence of River Division Works



Source: Technical Proposal, Jun. 2017

#### 4.1.5 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<sup>3</sup>, 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 4-1 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

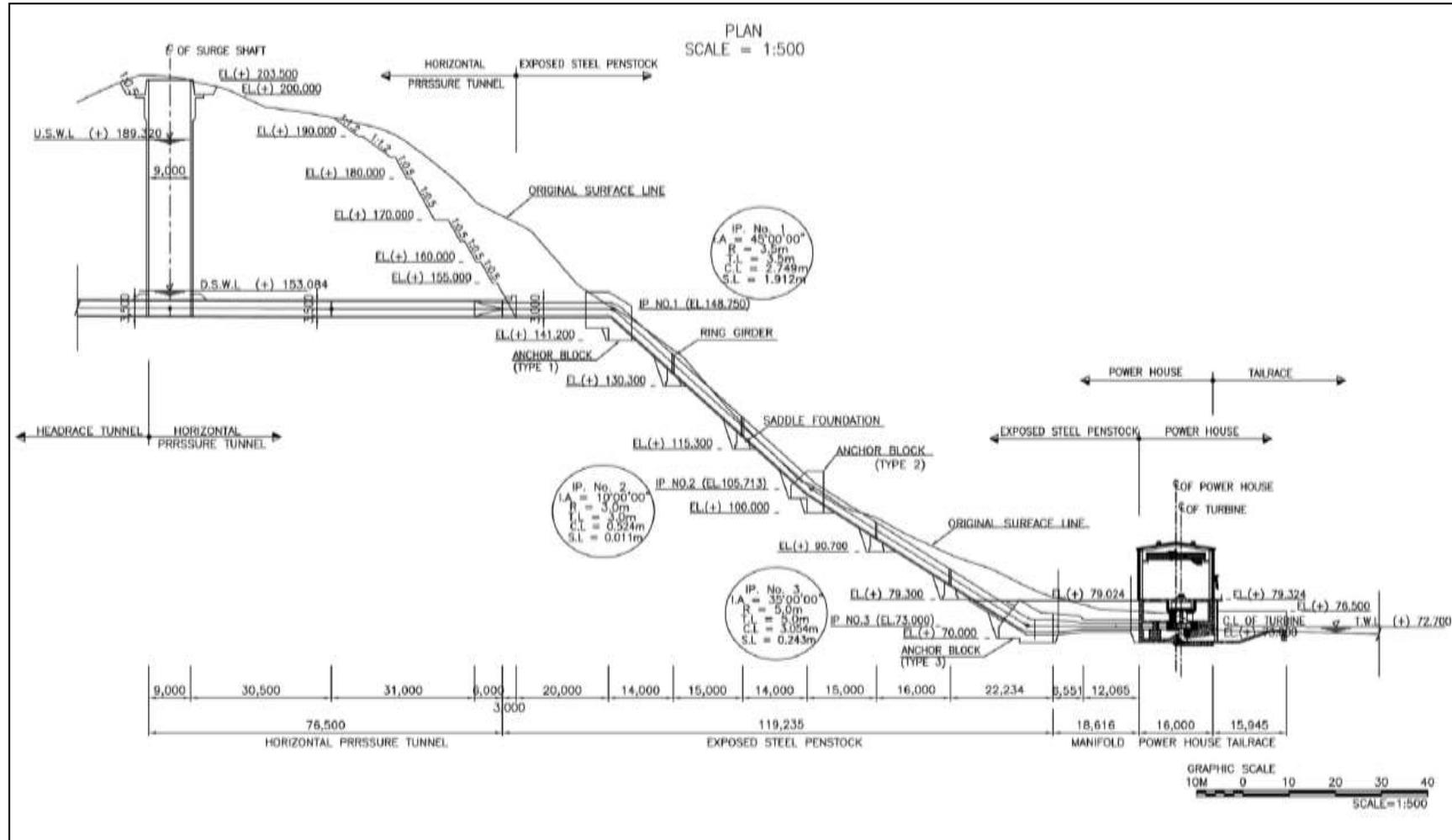
The power intake will be located in the left abutment and will contain trash-racks, isolation gate and a mini-hydro pipe. A flushing outlet (scour outlet at 150 masl) will be located upstream of the trash-rack to enable flushing of sediments that have been deposited over time near the intake.

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

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<sup>3</sup>/s. The head-race tunnel will be built to ensure a minimum of 20m surficial material remains over the crown. Figure 4-6 illustrates the tunnel system from Technical Proposal (2017).



Figure 4-6 Tunnel Longitudinal Section



Source: Technical Proposal, Jun. 2017



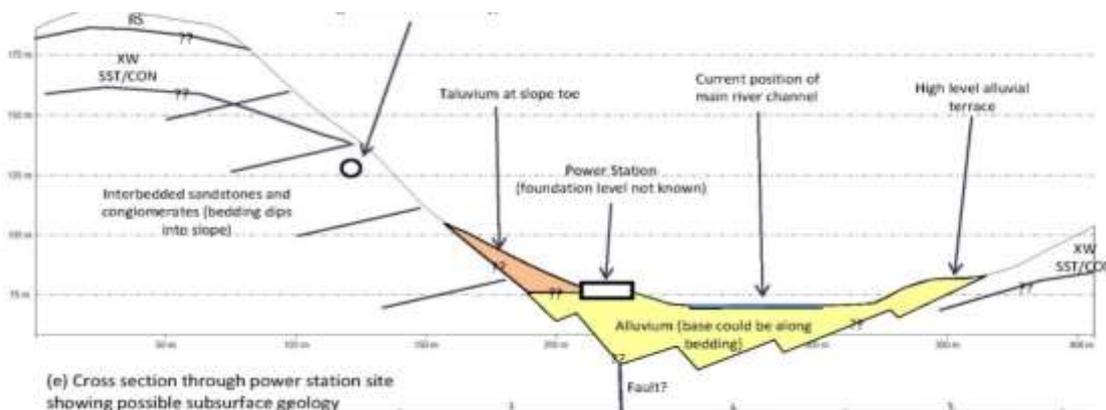
#### 4.1.6 Powerhouse

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 4-7 and 4-8 illustrates the geology and section design of powerhouse.

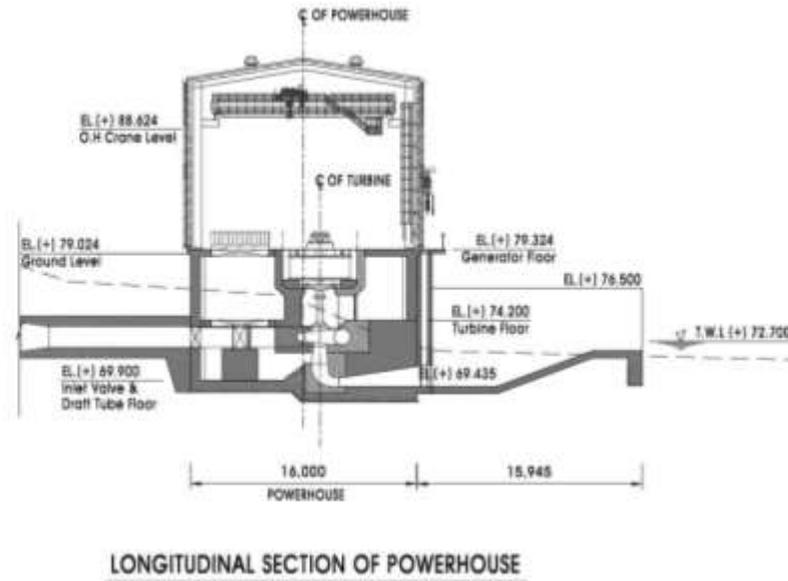
Figure 4-7 Geology at the Powerhouse site



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 (with space to allow for a 4<sup>th</sup> machine which may be installed later). 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).

Figure 4-8 Main Section of Power Station



Source: Technical Proposal, Jun. 2017

#### 4.1.7 Riparian (Environmental Flow) Outlet

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. Provision of a 1 m<sup>3</sup>/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<sup>3</sup>/s would maintain the riffle habitats that appear to be used by most fish species.

#### 4.1.8 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 Solomon Power (SIEA) will undertake an environment impact assessment (EIA) and submit a separate development consent application to MECDM prior to the implementation of component 3 – construction of transmission line.

#### 4.1.9 Category of the project

TRHDP is categorized as category A, since it includes the construction of a dam which is higher than 15m and has significant impact on environment based on WB and ADB environmental and social guideline such as WB Environmental and Social Review Procedure(ESRP) manual, and ADB Safeguard Requirements (SR) in Safeguard Policy Statement 2009 (SPS)

## 4.2 PROJECT MAIN COMPONENTS

The project comprises a 53m (river bed-crest) high dam located about 11.7km upstream from Ngalmibiu River, an approximately 3.3 km-long headrace tunnel on the left bank of the river, and a powerhouse located about 5.4km downstream. The Max total head is 102.3m. [Table 4-2 shows the Project main components](#)

Table 4-2 Main Project components

Project Component or Feature	Feasibility Study	Technical Proposal
Dam		
Type of dam	Roller Compacted Concrete (RCC)	Roller Compacted Concrete (RCC)
River Chainage	CH 7 km	CH 7 km
Height	53 m (river bed-crest)	53 m (river bed-crest)

Project Component or Feature	Feasibility Study	Technical Proposal
Base length at river	35 m	35 m
Base length at crest	207 m	219 m
River level at dam	122 masl	122 masl
<b>Spillway</b>		
Release of floods	Up to the 1:10,000 year flood level (3,290 m <sup>3</sup> /s)	Up to the 1:10,000 year flood level (3,290 m <sup>3</sup> /s)
Width	45 m	55 m
Height (FSL)	175 masl	175 masl
<b>Reservoir</b>		
Minimum operating level (MOL)	170 masl	170 masl
Normal operating level	172 masl	172 masl
Full supply level (FSL)	175 masl	175 masl
Maximum flood level (MFL)	186.5 masl	187.5 masl
River Chainage	CH 7 km – CH 4.5 km	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	7 M m <sup>3</sup>	7 M m <sup>3</sup>
Active Volume from FSL to MOL	1.4 M <sup>3</sup> +/-	1.4 M <sup>3</sup> +/-
Surface at FSL	30.7 ha +/-	30.7 ha +/-
Length	2.5 km	2.5 km
<b>Power water intake</b>		
Gate bottom EL.	162.5 masl	160.75 masl
Size	W3.3 m, H3.3 m	W3.5 m, H3.5 m
<b>Scour outlet</b>		
Inlet bottom elevation	150 masl	150 masl
<b>Head race tunnel</b>		
Size	W3.3 m, H3.3 m	W3.5 m, H3.5 m
Flow rate	19 m <sup>3</sup> /s	19 m <sup>3</sup> /s

Project Component or Feature	Feasibility Study	Technical Proposal
Length	3.300 km	3.245.5 km
<b>Powerhouse</b>		
River Chainage	CH 12.7 km	CH 12.7 km
Rated Gross Head at NOL	99.3 m	99.3 m
Turbine Center	73 masl	73 masl
Turbines	3 x Francis of 5 MW	3 x Francis of 5 MW
Operating capacity	15 MW, at 19 m <sup>3</sup> /s	15 MW, at 19 m <sup>3</sup> /s
<b>Environmental Flow Outlet Port</b>		
Riparian outlet for the environmental flow	170 masl	170 masl
Location	Intake→Mini hydropower plant	Sediment flushing system
Environmental flow	1 m <sup>3</sup> /s	1 m <sup>3</sup> /s
<b>Road</b>		
Length	-	21.5 km
Width	-	7.0 ~ 4.5 m

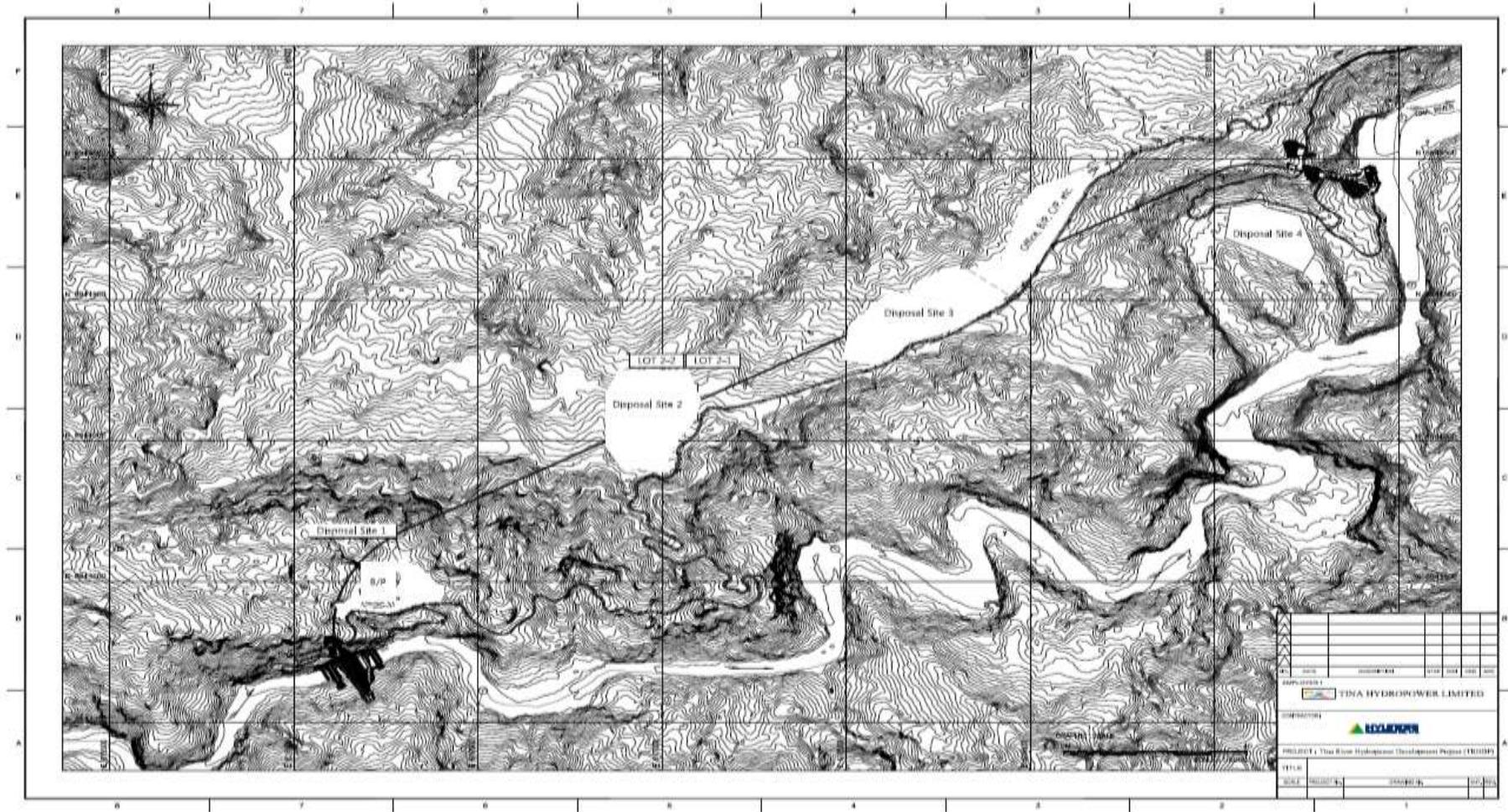
According to Entura (2014), the following activities will be included as temporary work:

- 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 and EPC contactor has plan of temporary work layout as below (see Figure 4-11).



Figure 4-11 Temporary Work Layout



Source: Tina Hydropower Limited, 2019

### **4.3 JUSTIFICATION AND NEED FOR 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.

### **4.4 THE STRUCTURE OF THE EIS EXPANDED SUMMARY.**

***Section 1: Executive Summary***

***Section 2: Details of the prescribed development proponent/developer***

***Section 3: Details of the consultants who carried out the study and prepared the EIS***

***Section 4: Description of the project/prescribed development***

***Section 5: Policy, legal and institutional framework***

***Section 6: Description of the environment***

***Section 7: Climate change***

***Section 8: Alternatives***

***Section 9: Impact assessment and mitigation measures***

***Section 10: Social impact assessment***

***Section 11: Economic assessment***

***Section 12: Environmental and Social Management Plan.***

***Section 13: Public consultation and information disclosure***

***Section 14: Difficulties encountered***

***Section 15: Conclusion and recommendations***

## **5. POLICY, LEGAL AND INSTITUTIONAL FRAMEWORK**

### **5.1 INSTITUTIONAL FRAMEWORK**

#### **5.1.1 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.

#### **5.1.2 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.

#### **5.1.3 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 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.

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

#### **5.1.4 Ministry of Lands, Housing and Survey (MLHS)**

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.

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

#### **5.1.6 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.

#### **5.1.7 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 preparation and subsequent monitoring of implementation of the National Development Plan, preparation and formulation of the annual Development Budget Estimates. The SIG prepares two budgets each year, the recurrent budget and the development budget and Aid coordination.

#### **5.1.8 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. 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.<sup>1</sup> The work of DI focuses on the sustainability of rural and urban livelihoods<sup>2</sup>.

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<sup>1</sup> Ministry of Infrastructure and Development Corporate Plan

<sup>2</sup> *ibid*

### **5.1.9 Guadalcanal Provincial Government**

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.

### **5.1.10 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. The MAL is currently subdivided into four departments: Livestock and Quarantine, Extensions and Training Department, Research Department, Planning and Management Department.

### **5.1.11 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.<sup>3</sup>

### **5.1.12 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).

## **5.2 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.

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<sup>8</sup> Ministry of Finance Corporate Plan

### **5.3 ASIAN DEVELOPMENT BANK REQUIREMENTS**

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.<sup>4</sup> 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.

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<sup>4</sup> ADB 2009, Safeguard Policy Statement (Manila, Philippines)

## **6. DESCRIPTION OF THE ENVIRONMENT**

### **6.1 INTRODUCTION**

This section describes the existing environmental conditions within the project-affected area. It includes discussion on the physical, ecological, and social-economic baseline conditions of the TRHDP site. Biological environmental baseline conditions are discussed in section 6.3.1(Aquatic) and section section 6.3.2(Terrestrial).

### **6.2 PHYSICAL COMPONENTS**

#### **6.2.1 Climate**

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 (also known as Henderson Airport), is 1972mm, with summer months being the driest. However, based on modelling 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. Tropical cyclones are most likely to occur between November and April and are associated with extreme rainfall events.

#### **6.2.2 Topography**

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 River. 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<sup>2</sup> compared to 45 km<sup>2</sup> for the Toni River. The gradient of the river increases with distance upstream. Downstream of the Tina/Toni confluence the gradient is 2.3 m/km. This increases to about 5m/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. The dam site is 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.

#### **6.2.3 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

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.

#### **6.2.4 Landslides, Rockslides, and Seismicity**

A significant number of landslides occur within the Tina River catchment, particularly on the steeper slopes. Slope instability is an active and ongoing process within the proposed reservoir area (Entura, 2014). A rockslide of 2Mm<sup>3</sup> to 3Mm<sup>3</sup> volume is visible at the upstream end of the proposed reservoir. A historic rockslide of 0.3Mm<sup>3</sup>, caused by an earthquake.

The proposed dam site is in an area of significant seismicity (GeoRisk Solutions, 2012). Fourteen earthquakes having a magnitude of greater than 7.5, have been recorded since 1900 for Solomon Islands. 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.

Peak Ground Acceleration (PGA), a measure of the amplitude of the earthquake motion, has been calculated for the TRHDP as being 0.286g, based on an earthquake of Richter magnitude ML 4 or greater, and 0.273g, 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.

#### **6.2.5 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. 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 greenhouse gases.

## 6.2.6 River (Fluvial) Geomorphology

The Tina River is a single channel meandering river. It has a 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, 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 the Tina River;
- Sandstone, where the Tina River flows through villages upstream of the Toni River.

The upper catchment area of the project site is characterized by sequences of pools and rapids and sharp meanders. Major boulders, some greater than 3 metres in 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.

The Tina River enters steep limestone gorges where its course is more confined and less meandering. The river's course is mostly consisting of rapids. In many areas, river banks are dominated by rock outcrops.

## 6.2.7 River Hydrology

### 6.2.7.1 Duration Curves of Specific Yield

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

### 6.2.7.2 Average Flow

Based on available data from the gauging station 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  $19.40\text{ m}^3/\text{s}$ , and the average flow at dam site in the dry season (April 1 to November 30), was estimated to be  $12.72\text{ m}^3/\text{s}$ . This data shows that the average flow appears higher than the average flow obtained from the extended records.

The Phase 3 addendum report based on the 29 years of river flow modelling shows a dry season flow (between June and September) of  $7.5\text{ m}^3/\text{s}$  with increasing flow in September and a wet season flow up to  $20\text{ m}^3/\text{s}$  occurring in December to January.

Table 6-1 identifies flow percentiles of long-term estimated flow at the dam site. Flow percentiles provide precise information about occurrences of flows.

Table 6-1 Flow percentiles for long-term estimated flow at damsite

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

Source: Entura (2014)

### 6.2.7.3 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<sup>3</sup>/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).

### 6.2.7.4 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.

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

The dam can become a means of controlling flash flood for the downstream communities. The Hydro Power Station 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.

#### **6.2.7.5 Tina River Tributaries in the Reduced Flow Reach**

Several 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<sup>2</sup>). Given the specific yield of 0,097m<sup>3</sup>/s/km<sup>2</sup>, 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<sup>3</sup>/s (~1m<sup>3</sup>/s) on average. Hence, this represents only a small proportion of Tina River flow.

#### **6.2.8 River Sediment Transport**

Suspended sediments 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<sup>2</sup>/year (93,750 tons per year or 45,000m<sup>3</sup>) 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.

#### **6.2.9 Water Quality**

##### **6.2.9.1 General Water Quality**

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

### **6.2.9.2 Conclusions on Water Quality**

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 Ngalmibiu 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.

### **6.2.10 Ambient Noise Levels**

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-mechanized 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.

## **6.3 ECOLOGICAL COMPONENT**

### **6.3.1 Aquatic Environment Baseline**

#### **6.3.1.1 Methodology**

Various methods were used to characterize the aquatic environmental baseline conditions within the study area, including:

- Review of existing information (literature & previous studies);
- Multiple field surveys of the Tina river, carried out by Loïc Trébaol, with the assistance of Robson S. Hevalao;
- Supplementary field studies:
  - Fish and water quality survey carried out by Robson S. Hevalao in February 2014.
  - 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.

### 6.3.1.2 Fish and Aquatic Environment Survey

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.

### 6.3.1.3 Field Survey Methodology

#### 6.3.1.3.1 Obtaining Traditional Ecological Knowledge

Traditional ecological knowledge was obtained from local fishermen and river users along the Tina River.

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).

#### 6.3.1.3.2 Description of River

Photographs were taken at each station, and observations made regarding the physical and ecological environmental conditions of the rivers, including human uses.

#### 6.3.1.3.3 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.

#### 6.3.1.3.4 Water Quality Sampling

Water samples were collected in a 1.5L sterilized sampling bottle and analyzed for pH, conductivity, turbidity, nitrates and total phosphorus at the Solomon Water Laboratory in Honiara. Other physical parameters were also measured during field surveys including dissolved oxygen (DO). *Escherichia Coli* (E.Coli) contamination analysis were done for four (4) stations (Toni River, Valekocha, Birao and Ngalimbiu River Bridge) at the SIWA laboratory on 14 August 2013.

#### 6.3.1.3.5 Aquatic Ecology Baseline

This sub-section describes the aquatic ecology baseline for the project and includes information on the aquatic habitats, water quality, and aquatic biota with focus on fish assemblage.

#### 6.3.1.3.6 Aquatic Habitats

Several aquatic habitats of specific ecological interest have been identified along the river. These include:

Mountain streams - 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.

Runs and riffles - these habitats, which are common in the Tina River reach 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. Run and riffle areas are significantly harsh environments in the riverine system due to their velocity and depth.

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, 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. These dark areas shelter juvenile prawns and fish and are used as spawning substrate by Syciidinae. The cavities accumulate organic material, including algae and diatoms, providing a source of food for bottom dwellers and detritivores.

Pools - these habitats are deep (up to 2m or more) sections of the river 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.

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 Oligochaete worms, fish and larvae. Some areas are exposed to sunlight, which facilitates development of algae. Other areas are shaded under tree canopies. 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.

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. 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. Nutrients levels are high as a result of numerous connections to the many adjacent wetlands and swamps, estimated to cover 40ha.

#### **6.3.1.3.7 Fish Species Diversity**

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.

#### **6.3.1.4 Fish Assemblage**

##### **6.3.1.4.1 Gobioids**

In Solomon Islands, the fresh water fauna is dominated by Gobioid fishes, mainly members of Gobiidae and Eleotridae families. Most species are relatively small (< 10cm in length). 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. The Gobioid group was represented by 34 species (25 Gobiidae, 8 Eleotridae and 1 Rhyacichthidae) during the first BRLi survey, representing 71% of the entire ichthyofauna.

#### **6.3.1.4.2 Non-Gobioids**

A few non-gobioid species were observed upstream of the Tina River. During the fish survey, the giant Eel (*Anguilla marmorata*), pipefish (*Microphis sp. Chelon macrolepis*), jungle perch (*Kuhlia sp.*), mullet (*Liza vaiagensis*) and grunter (*Mesopristes argenteus* and *M. cancellatus*) were the species observed beyond Choro. Apart from eels, that are likely to be found very far upstream, most species have limited abilities to migrate upstream from the first encountered waterfalls.

#### **6.3.1.5 Migration Pattern and Life Cycle**

Almost all native species encountered in inland fresh water systems in Solomon Islands 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.

##### **6.3.1.5.1 Catadromous**

Catadromous migration involves downstream migration for adults to spawn, and upstream migration for juveniles to mature. Eels are catadromous, with adults migrating to the ocean to spawn, and juveniles (glass eels) migrating upstream into freshwater systems. During their upstream migrations, glass eels can migrate 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. 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).

##### **6.3.1.5.2 Amphidromous**

Amphidromous migration involves downstream migration of larvae and upstream migration of juveniles. 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 upstream as juveniles to the freshwater system to grow into adults.

#### 6.3.1.5.3 Potadromous

Potadromous fish are characterized as species that are born in the higher reaches of fresh water 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 Ngalmibiu River mouth.

#### 6.3.1.5.4 Oceanodromous (Marine form)

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 the lower reach of the River as juveniles, sub-adults or adults, to feed.

#### 6.3.1.5.5 Conclusions on Migration

Catadromous and Amphidromous regimes have been considered with much attention throughout the supplementary studies in the TRHDP project ESIA due to the impact it will have on their colonization upstream of the dam. Most of the Gobidae family species mature and spawn in the dam area (*Awaous*, *Sicyopterus*, *Stiphodon*, etc.).

#### 6.3.1.6 Locomotion Behavior

Regarding the abilities of juvenile fish to pass obstacles when migrating upstream, different locomotion behaviors can be observed. These have been considered when designing possible fish pass systems.

##### 6.3.1.6.1 Strict swimmers

Some species like silverfish *Mesopristes sp.*, *Kuhlia sp.*, river mullet (*Liza vaiensis*), 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.

##### 6.3.1.6.2 Crawlers and climbers

Other species of fish exhibit a benthic behavior (Syciinidae and other Gobiidae, prawns, eels), and can migrate upstream of cascades and waterfalls. They can be classified in two categories:

- Syciidinae juveniles or climbing gobies (genus *Lentipes*, *Sicyopterus*, *Sicyopus*, *Stiphodon*), are presumably the most abundant taxa in the Tina River.

- 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).

### 6.3.1.7 Habitat requirements

There is lack of published information regarding the habitat types in the Tina River. Measurements of fish species and number, water velocity and depth and substrate composition in small areas (2-4 m<sup>2</sup>) were made on 11 March 2016 and 13-14 July 2016 to determine habitat suitability for common fish species in the Tina River. Eels and most gobies are capable climbers and can penetrate to the headwaters of most streams. 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.

### 6.3.1.8 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 type is recorded. The habitat mapping between the Tina Village and dam site is presented in Table 6-2.

Table 6-2 Provide 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%

### **6.3.1.9 Cross-section selection**

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 8.7m<sup>3</sup>/s and 19.7m<sup>3</sup>/s and these were used to develop rating curves at each cross-section<sup>5</sup>.

### **6.3.1.10 Habitat suitability**

Water velocity is probably the most important characteristic of a stream. Its absence will result in the formation of a lake or pond. In gravel bed rivers, an average velocity of 0.2-0.3m/s tends to provide for most stream life, because velocities lower than this provide unsuitable habitat for several fish species and stream insects and allow deposition of sand and finer materials. In large rivers, water depth of more than 0.4m 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.

### **6.3.1.11 Method for determining habitat suitability**

The most suitable habitat was determined by the density of fish. 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).

Water levels were measured at flows of 8.7m<sup>3</sup>/s and 19.7 m<sup>3</sup>/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.

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.

#### **6.3.1.11.1 Invasive, Rare, Endangered, Endemic and Threatened Aquatic 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

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<sup>5</sup> 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.

or Critically Endangered), species protected by CITES, and those that are dependent on the river water system.

#### **6.3.1.11.2 Endemic Aquatic Insect Species**

Guadalcanal is rich in aquatic insect diversity. Polhemus et.al (2008) survey report provide recent published data on aquatic insect species in Solomon Islands. Nine survey locations were in Guadalcanal, four of which were in the TRHDP study area. According to Polhemus et.al (2008), 12 species of Sub Order Heteroptera (true bugs) occur on Guadalcanal, 4 of which are endemic across Solomon Islands, and 8 of which are endemic to Guadalcanal.

#### **6.3.1.11.3 Invasive Aquatic Species**

Two major invasive aquatic species, Mozambique tilapia (*Oreochromis mossambicus*) and mosquito fish (*Gambusia holbrooki*) are 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.

#### **6.3.1.11.4 Endemicity and IUCN Status**

According to Polhemus et al (2008), 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.

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.

#### **6.3.1.11.5 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.

#### **6.3.1.11.6 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 several other river catchments within Guadalcanal outside of the study area and well outside of the area of impact for the Project.

#### **6.3.1.12 Value of the Upper Tina River Catchment**

##### **6.3.1.12.1 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 in 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. The water temperature gradient found

along the Tina River is an important environmental indication that triggers 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.

#### **6.3.1.12.2 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 possess similar features with 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 having a 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 fish do not present a homing behaviour. Juveniles can colonize any river, rather than just their natal stream. Notwithstanding, all 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 can 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.

### **6.3.1.13 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.

## **6.3.2 Terrestrial Environmental Baseline**

This section presents baseline information on the flora and fauna 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 have about 4500 species of plants and is recognised as being rich in plant diversity, and endemism (MECDM, 2008). Solomon Islands support 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<sup>2</sup> that encompasses breeding range for two or more restricted-range land birds (Bird Life International, 2013).

Solomon Islands is rich in biodiversity and endemism, 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 (MECDM, 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 (MECDM, 2008; McCoy, 2008). The mountains of Guadalcanal reach elevations up to 2,310 meters and are uninhabited by humans. They provide pristine wildlife habitats.

### **6.3.2.1 Terrestrial Flora**

#### **6.3.2.1.1 Survey Locations and Methodology**

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.

#### **6.3.2.1.2 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.

#### **6.3.2.1.3 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.

#### **6.3.2.1.4 Conclusions on Flora**

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.

### **6.3.2.2 Terrestrial Fauna**

#### **6.3.2.2.1 Terrestrial Fauna Survey Results**

##### **6.3.2.2.1.1 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.

#### **6.3.2.2.1.2      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, 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.

#### **6.3.2.2.1.3      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 can '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.

A total of 9 amphibian species were observed from a total of 13 potential species<sup>6</sup> 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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<sup>6</sup> 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 which are Solomon Island's Treefrog (*Litoria lutea*), Giant Webbed Frog (*Discodeles Cornufer guppyi*), and San Cristobal Treefrog (*Hylarana Papurana krefftii*)

#### **6.3.2.2.1.4      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.

Many spiders were observed along the Tina River, including Spiny orb-weavers of the genus *Gasteracantha* and spiders of the genus *Argiope*.

#### **6.3.2.2.1.5      Reptiles**

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 porosus*) 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*)

Solomon's Bent-toed Gecko (*Cyrtodactylus salomonensis*)

Prehensile-tailed Skink (*Corucia zebrata*)

Schmidt's Crocodile Skink (*Tribolonotus schmidtii*)

Solomons Ground Boa (*Candoia paulsoni*)

#### **6.3.2.2.1.6      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. 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.

#### **6.3.2.2.1.7      Mammals**

Guadalcanal is home to some of the most cryptic and rare mammals in the Pacific, including flying foxes and giant native rats. 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 numbers.

It appears 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).

Recent 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<sup>2</sup>, 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.

### 6.3.3 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 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.

### **6.3.3.1 Natural habitat and critical natural habitat**

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.

### **6.3.3.2 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 are 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.

### **6.3.3.3 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.

### **6.3.4 Fisheries**

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. 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.

### **6.3.5 Protected Area and National Park**

The project area lies outside any formally recognized protected areas. However, there are nearby areas that are 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 have 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).

#### **6.3.5.1 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<sup>2</sup>:

- 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.

#### **6.3.5.2 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 National Park does not share any boundaries with the Project, or the Tina River catchment.

#### **6.3.5.3 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”. 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).

Since the late 1990s, the KCCAP has ceased to function and there are no longer any ecotourism activities. Figure 6-19 shows the boundaries of the KCCA.

## 6.4 SOCIO-ECONOMIC COMPONENT

### 6.4.1 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 consent prior to commencing fieldwork.

Table 6-3 lists the persons involved in the meeting:

Table 6-3 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			

## 6.4.2 Social Assessment Methods

### 6.4.2.1 Social Survey Team

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.

### 6.4.2.2 Dates of Surveys

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

### 6.4.2.3 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.

### **6.4.3 Community and Stakeholder Participation**

The TRHDP Office, which is embedded within MMERE, is a well-organized, and comparatively well-resourced organization, with an explicit mandate. The TRHDP Office 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>.

#### **6.4.3.1 Recording People's Responses**

The members of these communities were given the opportunity to inform the EIS 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.

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.

#### **6.4.3.2 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.

#### 6.4.4 Social Organization

##### 6.4.4.1 Key Contextual Factors

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 Guadalcanal 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 Guadalcanal 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 many indigenous land owners;
- the establishment of the Gold Ridge mine, with on-going grievances regarding distribution of benefits and royalties;
- the recent history of Guadalcanal revolting 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<sup>7</sup>.

The following sections provide a detailed description of the people and communities of the proposed project area and their socio-economic condition.

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<sup>7</sup> 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.

#### **6.4.4.2 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 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.

#### **6.4.4.3 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.

##### **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. 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.

##### **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 6-11. However, the available information indicates that there is a mix of clans present in any 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 seems 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.

During the fieldwork, it was common to hear people say that all 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.

### **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. 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*.

### **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.

Most villages in the project area, especially the smaller ones, do not have this level of organization or formal structure, hence most activity is organized through the churches and in association with village chiefs.

## **6.4.5 Socio-Economic Profile of the Communities of the Project Areas**

### **6.4.5.1 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.

### **6.4.5.2 Population**

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 village 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.

Household number (2013) was 124 and population(2013) was 693 in TRHDP area.

## **6.4.6 Local Peoples' Sources of Livelihood**

### **6.4.6.1 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.

#### **6.4.6.2 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), GPOL, 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.

#### **6.4.6.3 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 thing for Guadalcanal households is self-employment

(13.5% of 9% nationally), and wages and salaries (12%, both provincially and nationally).

The survey of householders in the project area indicates that the average weekly cash income for households is approximately SBD 870 <sup>8</sup>, and the median income is SBD 500. However, the range of weekly cash incomes as reported to the social team (Figure 6-22) is very wide, ranging from SBD 100 to SBD 6000.

#### **6.4.7 Human Capital**

##### **6.4.7.1 Work**

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.

##### **6.4.7.2 Household Production and Self-Employment**

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. 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.

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.

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<sup>8</sup> Approximately \$121 US.

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.

#### **6.4.7.3 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.

#### **6.4.7.4 Education**

At present, there are approximately seven schools within the TRHDP area (the closest ones shown on the map in Figure 6-23). 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 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.

#### **6.4.7.5 Health and Health Services**

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 over 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.

#### **6.4.7.6 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.

#### **6.4.7.7 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 can attend the clinic, local people may not be able to obtain the drugs or treatment necessary to their health problems. The National Referral Hospital (NRH) in Honiara is not easily accessible by local communities.

#### **6.4.7.8 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.

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.

#### **6.4.8 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.

##### **6.4.8.1 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.

### **6.4.8.2 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.

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.

### **6.4.8.3 Infrastructure**

#### **Roads**

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.

#### **Water Supply and Use**

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.

### **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 main electricity supply. The 2009 Census records that 27% of houses were connected to the main electricity grid. However, many 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.

## **6.4.9 Social Capital**

### **6.4.9.1 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.

### **6.4.9.2 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.

### **6.4.9.3 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, Assemblies of God, Bible Way and the Baptist Church.

## **6.4.10 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.

#### **6.4.11 Natural Capital**

##### **6.4.11.1 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.

##### **6.4.11.2 Land and Land Use**

###### **Land Ownership and Occupation**

To the indigenous people, no land is un-owned or is not connected with a clan, even if it 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).

###### **Garden Land**

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<sup>2</sup> 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<sup>2</sup>, 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.

#### **6.4.11.3 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<sup>9</sup> has held that flowing water is a public right, unowned by the owners of the land over which it passes.

#### **6.4.11.4 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.

#### **6.4.11.5 Forest Resources**

The village workshops confirmed that Malango's forests are essential to the livelihoods and wellbeing of Malango people, providing:

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<sup>9</sup> *Solomon Islands Water Authority v Commissioner of Lands* SBHC 58

- 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, megapod 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 in the upper parts of the catchment where TRHDP is planned, is presented in Section 6.3.2– Terrestrial Environmental Baseline.

#### **6.4.11.6 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.

#### **6.4.11.7 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 (Mullet, *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.

#### **6.4.11.8 The River**

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, spread 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.

#### **6.4.11.9 Conclusions**

In conclusion, the Social survey fieldwork was conducted successfully and in the expected timeframes, covering all 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 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.

## **6.5 CULTURAL HERITAGE AND GENDER ASPECTS**

Cultural heritage and gender aspects fieldwork was carried out by Lawrence Foana'ota, a member of the ESIA team.

### **6.5.1 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 can 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.

### 6.5.2 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).

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.

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.

### **6.5.3 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.

### **6.5.4 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.

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.

### **6.5.5 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).

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.

## **7. CLIMATE CHANGE**

### **7.1 INTRODUCTION**

This section discussed the possible impacts of climate change on the project.

#### **7.1.1 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.

#### **7.1.2 Status Quo Weather and Climate Conditions**

As noted in Section 6.2.6, 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.

#### **7.1.3 Cyclones, Severe Rainfall Events and Floods**

As noted in Section 6.2.1, 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 primary 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.

#### 7.1.4 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<sup>3</sup>/s will be released to the river below the powerstation (2.4 m<sup>3</sup>/s from one turbine plus 1 m<sup>3</sup>/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/generators sets in operation at a given time. The net effect would be the same – reduced power output for a given volume of water available.

#### 7.1.5 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.

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 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 °C and 2 °C, on average with 1.3 °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 °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 cyclone 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.

## **7.2 GHG EMISSIONS**

Reservoir impoundments emit GHG. Newly impounded reservoirs can emit large quantities of GHG, especially methane (CH<sub>4</sub>) 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. 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 7-1** shows the range of GHG emissions per m<sup>2</sup> of reservoir surface per day<sup>10</sup>.

Table 7-1 Range of average carbon dioxide and methane gross emissions from freshwater reservoir in tropical regions

GHG pathway	CO <sub>2</sub> in mmol/m <sup>2</sup> /d	CH <sub>4</sub> in mmol/m <sup>2</sup> /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/m<sup>2</sup>/d means that there are “X” millimoles of the molecule per m<sup>2</sup> of the reservoir released per day. **Table 7-2** converts mmol of CO<sub>2</sub> and CH<sub>4</sub> to grams, where 1 mol = 44g of CO<sub>2</sub> and 1 mol of CH<sub>4</sub> = 16g. A negative value means that the reservoir acts a carbon sink.

Table 7-2 Converting mmol of CO<sub>2</sub> and CH<sub>4</sub> into grams

GHG pathway	CO <sub>2</sub> in g/m <sup>2</sup> /d	CH <sub>4</sub> in g/m <sup>2</sup> /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 7-3** are obtained, considering that the Tina Reservoir will cover an area of 305,200m<sup>2</sup> (30.52ha at FSL).

<sup>10</sup> Note: the data does not mention time of monitoring, or whether it was done at the time of reservoir impoundment.

Table 7-3 Estimated daily CO<sub>2</sub> and CH<sub>4</sub> releases (kg) from Tina Reservoir

GHG pathway	CO <sub>2</sub> in kg/d in Tina reservoir	CH <sub>4</sub> 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
<b>Total</b>	<b>6,514.5 to 39,690.6</b>	<b>30.8 to 2,541</b>

Using the model “GHG Risk Assessment Tool (Beta Version) 8 (2012)”, the predicted CO<sub>2</sub> and CH<sub>4</sub> gross flux, following the first years of impoundment for the Tina Reservoir, are much lower, as shown in Table 7-3. 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 outside of the calibration range of the model, which makes it less accurate. **Table 7-4** shows the gross flux of both CO<sub>2</sub> and CH<sub>4</sub> 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 7-4 GHG gross emissions from the model

Years after impoundment	CO <sub>2</sub> in kg/d applied to Tina reservoir	CH <sub>4</sub> 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 (+/-)

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<sub>2</sub>eq/GWh for a 100% diesel-based system, the net GHG emission reduction potential of the 78.35 GWh Project is 49,500 tCO<sub>2</sub>eq 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.<sup>11</sup>

SIG's Intended Nationally Determined Contribution (INDC) commits to reducing GHG by 18,800 tons of carbon dioxide equivalent (tCO<sub>2</sub>eq) per year by 2025 and by 31,125 tCO<sub>2</sub>eq per year by 2030 with appropriate international assistance.

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<sup>11</sup> 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.

## **8. ALTERNATIVES**

### **8.1 INTRODUCTION**

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.

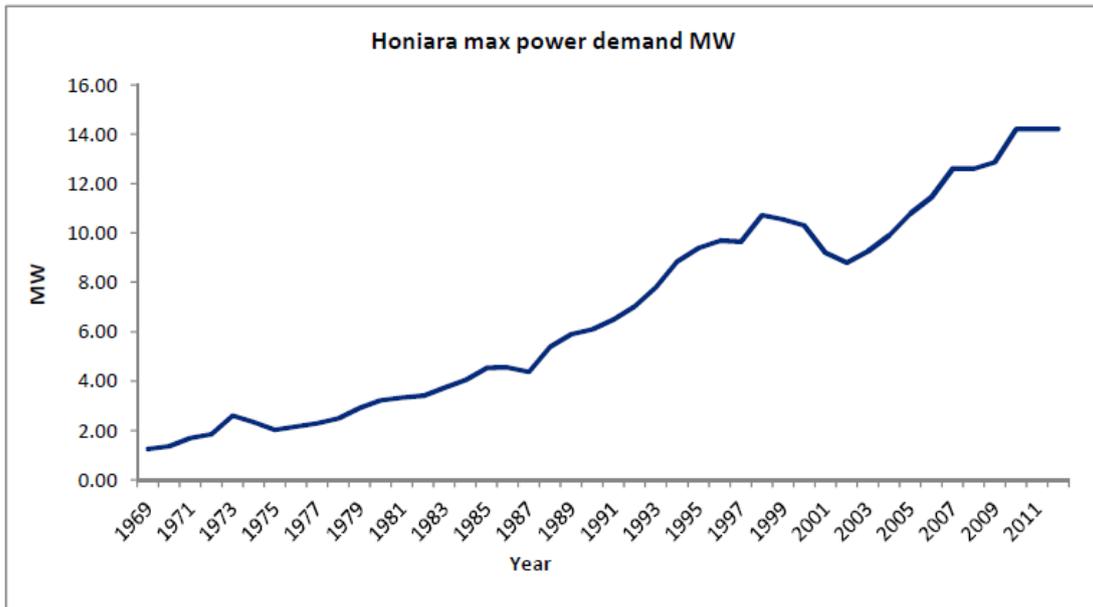
### **8.2 ENERGY DEMAND AND SUPPLY**

#### **8.2.1 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 8-1. The stagnation of demand growth since 2009 is 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 8-1 Honiara historical maximum power demand

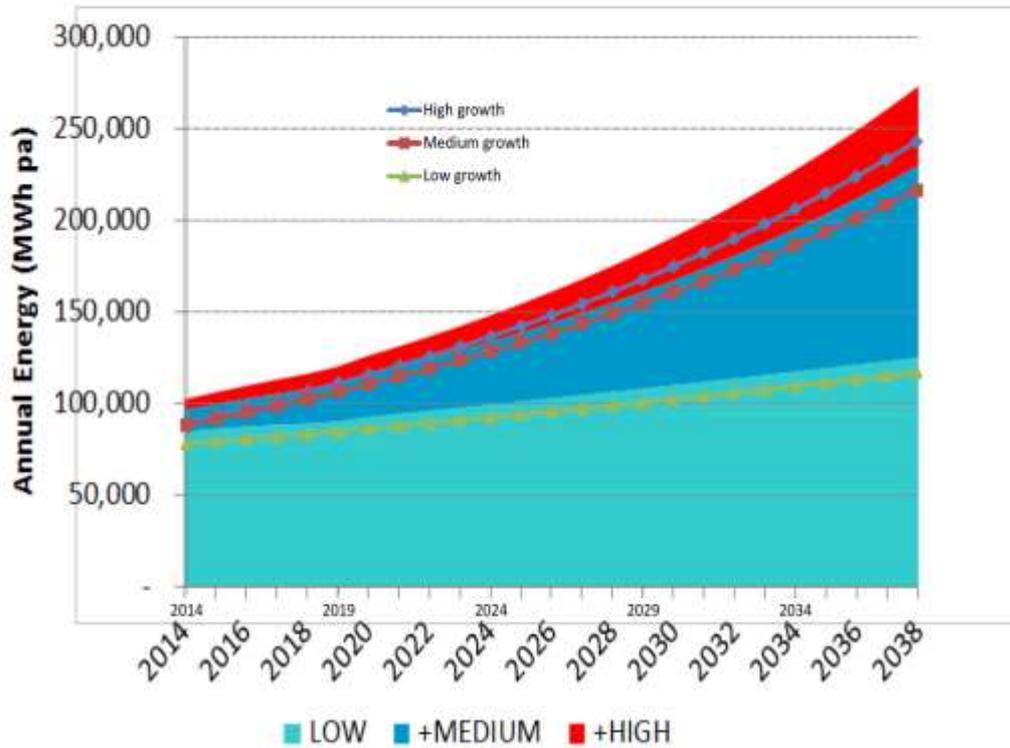


SISEP estimated new generation capacity requirements as 7 MW over the next 25 years for the Low demand growth scenario and an additional requirement for the High demand growth scenario as 25 MW.

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 8-2).

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.

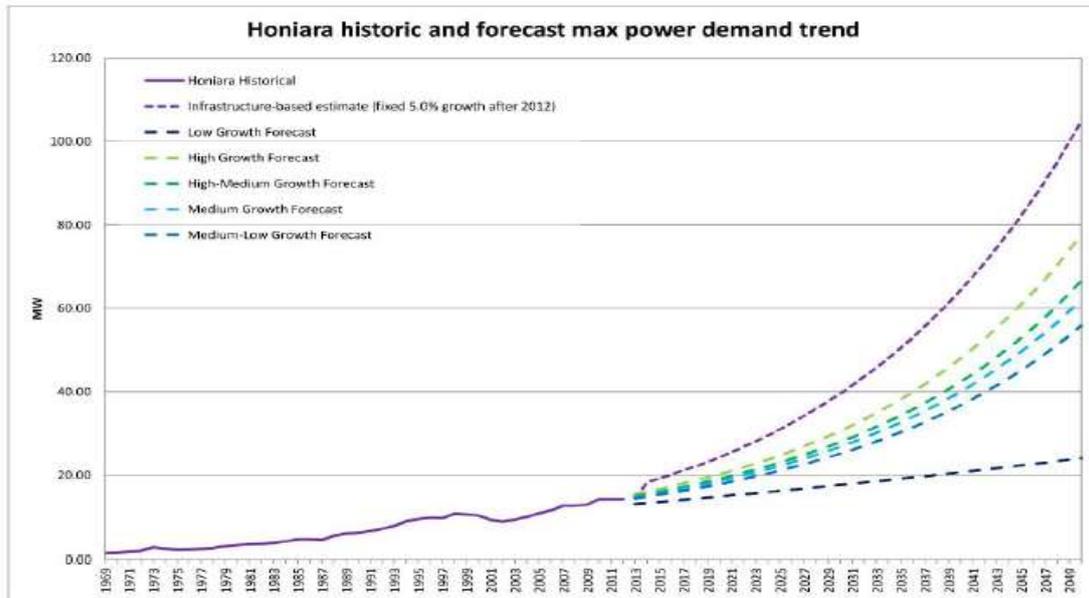
Figure 8-2 Honiara Energy Growth Scenarios



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 below shows the extrapolated to demand forecast to 2050 combined with the historical demand records.

Figure 8-3 Combined Historical and Demand forecast to 2050 based on extrapolation of the 5-year forecast

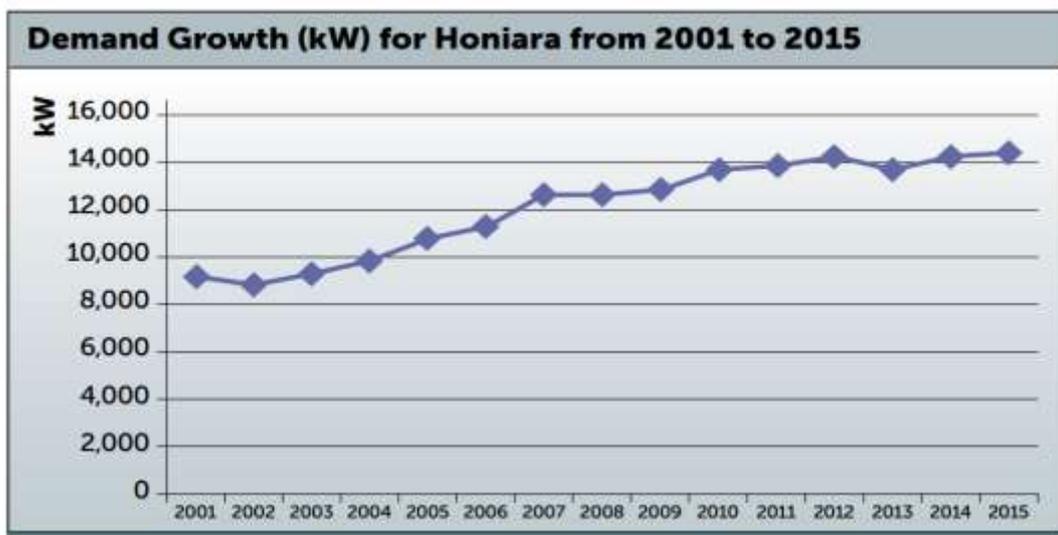


### 8.2.2 Energy Supply

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.

The demand for electricity in 2015 in Honiara peaked at 14,425 Kilowatts compared with a figure of 14,100 Kilowatts in 2014. Figure 8-4 below shows the demand growth for Honiara from 2001 to 2015

Figure 8-4 Honiara Electricity Demand Growth Solomon Power Annual Report 2015. Source:



Solomon Power annual Report 2015

## **8.3 IDENTIFICATION OF POTENTIAL ALTERNATIVES TO THE PROJECT**

### **8.3.1 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.

### **8.3.2 Energy Resources Barred from Development**

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

### **8.3.3 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). 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.

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.

### **8.3.4 Demand Side Management (DSM)**

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.

### **8.3.5 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 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.

According to the World Bank, “the previous studies highlighted the unsuitability of the Lungga and Komarindi sites.

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.

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).

#### **8.3.5.1 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.

In summary, pumped storage depends on either:

1. Having a “must run” source of energy such as nuclear or geothermal; 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.

#### **8.3.5.2 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 decentralized 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.

### **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 millimetres 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.

However, 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.

### **8.3.5.3 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.

To ascertain whether there is a commercial wind resource in usable 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.

#### **8.3.5.4 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

#### **8.3.5.5 Gas Fired Thermal**

A gas fired power station is a power station which burns fossil fuel to produce electricity. 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.
- **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.

#### **8.3.5.6 Transmission of Electricity from Other Islands**

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.

#### **8.3.5.7 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 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.

#### **8.3.5.8 Preferred Project Alternative**

The feasibility study 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

## **8.4 ALTERNATIVE LOCATIONS AND CONFIGURATIONS FOR THE PREFERRED PROJECT - THRD**

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.

## 8.5 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.

## **9. IMPACT ASSESSMENT AND MITIGATION MEASURES**

### **9.1 ASSESSMENT METHODOLOGY**

Impacts significance is studied using a standardized method based on the integration of 6 criteria:

1. identification of impact sources
2. determination of affected components' value
3. Impact duration
4. Impact extent
5. Impact intensity
6. Impact occurrence probability

#### **Criteria #1 Impact sources**

An impact identification matrix presents activities (in lines) as well as components (in columns) and identifies all sources of impacts.

#### **Criteria #2 Environmental and Social Components value**

Each component of the natural environment will be analysed according to their value in the study area. Value assessment will be based on Experts' knowledge on the component, field surveys, public consultation, etc. Value analysis does not take into account foreseen impacts, it is purely based on the component intrinsic value. Three threshold levels are defined: Low, Moderately and Highly valued components.

#### **Criteria #3 Impact duration**

Each impact is identified according to its duration. Temporary and permanent impacts can be distinguished based on their reversibility: temporary are reversible and permanent are irreversible (or will last all through the Project lifespan).

#### **Criteria #4 Impact extent**

Each impact is defined by its geographical extent. Three levels are established: point source impact (punctual), local impact and regional impact. Point source impacts affect a component on a very small scale of the study area, i.e. a small proportion of the study area species population. Local impacts affect a component on the entire or the majority of the detailed study area in opposition to regional impacts that affect a component on a larger scale such as the entire extended study area or outside its boundaries.

#### **Criteria #5 Impact intensity**

Impact intensity refers to level of disruption on the component. Disruption of natural component refers to death of species, displacement, fragmentation and loss of habitats. Three threshold levels of intensities are defined: Minor, Moderate and Major.

Impact significance is based on the four previous criteria. Positive impact is assessed using the same four criteria.

Major impacts represent high level of perturbation of the component, these impacts are seldom mitigable and most of the times require compensation or offsets, followed by measurable monitoring measures. Moderate impacts represent noticeable perturbation of the component; however, these impacts can be mitigated and need to be monitored. Minor impacts most of the time only require mitigation measures without the need for monitoring. Negligible impacts do not require any particular measures.

#### **Criteria #6: Impact occurrence probability**

Assessment of the probability that an impact will take place will be based on the expert's experience

on similar assignments.

Three thresholds will be used.

- High probability: Analysis of the baseline coupled with Project characteristics concludes that the impact will take place
- Potential occurrence: Based on previous experiences, it is possible that the impact will occur.
- Risk (low probability): Analysis of baseline coupled with Project characteristics only reveals a risk of impact occurrence.

#### **Residual impact**

After the implementation of measures, residual impact is assessed and impact significance reevaluate.

## **9.2 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.

### **9.2.1 Description of Impact Generating Activities**

#### **9.2.3.1 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. Drilling and cutting of new tracks to move equipment onto survey sites will be limited to minimal area.

#### **9.2.3.2 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.

#### **9.2.3.3 Construction of New Access Roads**

Black Post Road will be extended from Managikiki 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.

#### **9.2.3.4 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. 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. 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<sup>3</sup>, 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.

#### **9.2.3.5 Construction of Dam and Powerhouse**

An area of 130m x 90m (11,700m<sup>2</sup>) will be required for construction work areas (e.g., staging, fabrication, materials stockpiling, equipment maintenance, etc.) and will involve forest clearing and topsoil removal.

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<sup>2</sup> of terrestrial habitat on the right slope of the gorge and 3,700m<sup>2</sup> 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<sup>2</sup> (Entura, 2014).

### **9.2.3.6 Quarrying**

Rock quarries will be developed to provide aggregate for the RCC dam. Entura (2014) estimated that 160,000m<sup>3</sup> 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.

Quarry exploitation will require the removal of superficial deposits in or close to the river, which may release suspended material into the water.

### **9.2.3.7 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. 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.

### **9.2.3.8 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). An estimated 10 ha storage area will be necessary for the generation of 327,900 m<sup>3</sup> of topsoil, using 10 round shape piles of 50m wide and 5m high.

### **9.2.3.9 Operation Activities**

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.

## **9.2.4 Assessment of Construction Impacts**

### **9.2.2.1 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.

#### **9.2.2.2 Local Slope Stability and Geology Impacts**

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.

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 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.

#### **9.2.2.3 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.

#### **9.2.2.4 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.

### **9.2.2.5 Regional and Local Air Quality**

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.

### **9.2.2.6 Noise and Vibration**

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.

## **9.2.3 Assessment of Operational Impacts**

### **9.2.3.1 Hydrology Impacts**

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.

The Project will also 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.

### **9.2.3.2 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 affect downstream use for road surfacing and building construction. Sediments will be stored behind the dam, however flushed out through a low-level port that the accumulated sediments can be accessed.

### **9.2.3.3 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.

## **9.2.4 Mitigation Measures**

Mitigation measures are addressed below.

### **9.2.4.1 Construction Impacts Mitigation Measures**

#### **9.2.4.1.1 Induced Seismicity**

Given the unlikelihood of induced seismicity from such a small reservoir no mitigation measure is proposed for this potential impact.

#### **9.2.4.1.2 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.

#### **9.2.4.1.3 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.

#### **9.2.4.1.4 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 following methods:

- ▶ 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.

#### **9.2.4.1.5 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.

#### **9.2.4.1.6 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.

### **9.2.4.2 Operational Impacts Mitigation Measures**

#### **9.2.4.2.1 Surface Hydrology**

The following mitigation measures are recommended to address surface hydrology:

- Environmental Flow of 1m<sup>3</sup>/s impacts of surface hydrology during operation, to provide water for aquatic life and water for use by downstream villagers;

- Maintaining a flow of 1m<sup>3</sup>/s during reservoir impoundment;
- Maintaining a flow of 2.4m<sup>3</sup>/s through the power station during overnight reservoir re-fill.

#### **9.2.4.2.2 Groundwater Hydrology**

As risk level is low and unlikely, no mitigation measures are proposed for this impact.

#### **9.2.4.2.3 Sediment Transfer**

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. In addition, during heavy rainfall events in the upper Tina River catchment, water will spill over the dam's spillway.

Based on the available mitigation measures, these impacts will persist as low to moderate residual effects that are considered to be not significant.

#### **9.2.4.2.4 Temperature Change**

As temperature changes are expected to be minimal, no mitigation measures are proposed.

#### **9.2.4.2.5 GHG Emissions**

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.

#### **9.2.4.2.6 Regional and Local Air Quality**

As positive impacts identified, no mitigation measures proposed.

## **9.3 ASSESSMENT OF IMPACTS ON THE BIOLOGICAL (TERRESTRIAL) ENVIRONMENT**

### **9.3.1 Pre-construction and Construction Activities**

#### **9.3.1.1 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 total area of terrestrial habitat disturbance is estimated to cover approximately 1.5ha.

#### **9.3.1.2 Reservoir Preparation**

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.

#### **9.3.1.3 Construction Traffic**

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.

#### **9.3.1.4 Worker Accommodation**

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. There will not be a workers camp that would be a source of direct impact on terrestrial habitat.

### **9.3.2 Operation Activities**

#### **9.3.2.1 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.

### **9.3.2.2 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.

### **9.3.3 Assessment of Construction Impacts**

#### **9.3.3.1 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. Man-made habitats (e.g., gardens, settlements, oil palm plantations) have been omitted in the table since the TRHDP will not affect them.

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.

#### **9.3.3.2 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.

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**

The Project will 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.

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. Cliff habitat and riparian habitat (partially disturbed), approximately 15 ha of each, will be affected by reservoir preparation. The 50 ha represents 0.3% of all forest in the catchment. 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. 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 statutory restrictions on logging at elevations above 400 masl (which if enforced would represent the vast majority of the upper catchment).

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.

### **9.3.3.3 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.

### **9.3.3.4 Indirect Impacts on Flora**

#### **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. Native plant species may be out-competed by invasive plants with adverse environmental consequences. Also, invasive plant species may adversely affect agricultural and garden plants and pasture, thereby affecting livelihoods. Lastly, invasive plant species may affect infrastructure, thereby leading to economic consequences for the Project.

*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, and native plants also. Water Hyacinth (*Eichhornia crassipes*) is by far the biggest threat to any hydropower projects in tropical countries. It is the world's worst 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 have not been observed in the study area likely because of the fast-flowing nature of the Tina River. Moreover, it would likely not thrive in the reservoir due to the extreme daily fluctuations in water levels and the expected low concentration of nutrients.

#### **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 heliophytic 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.

### **Local Hydrological Changes**

Many small tributary streams within the Tina River catchment area are free flowing perpendicular to the future access road. 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.

### **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. 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.

### **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.

#### **9.3.3.5 Mitigation Measures**

##### **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 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 in ESMP will be made 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 as well as other watercourse crossing method. More measures will be detailed in ESMP.
- 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 included in ESMP, 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.

- 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 CO<sub>2</sub> 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. This will determine the depth of soil stripping that is required. 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<sup>3</sup> of topsoil will be removed from the access road right-of-way.

- 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. 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.

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.

- 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 - 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<sup>3</sup> 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.

#### **9.3.3.6 Residual Effects and Their Significance**

By applying the mitigation measures recommended above, 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.

#### **9.3.3.7 Conclusions Regarding Impacts on Flora**

##### **9.3.3.7.1 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. 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.

### **9.3.3.7.2 Conclusions Regarding Indirect Impacts**

With application of appropriate mitigation, monitoring and management methods, minimal indirect impacts will accrue to flora within the project area.

### **9.3.3.8 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 which 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.

### **9.3.3.9 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.

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;
- ▶ Whose means of communication will be interfered by traffic noise
- ▶ 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). The 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. In the Solomon Islands, they threaten the survival of many native small mammals and ground birds such as pigeons. 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.

#### *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. 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. 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

#### *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.

### **9.3.3.10 Mitigation Measures**

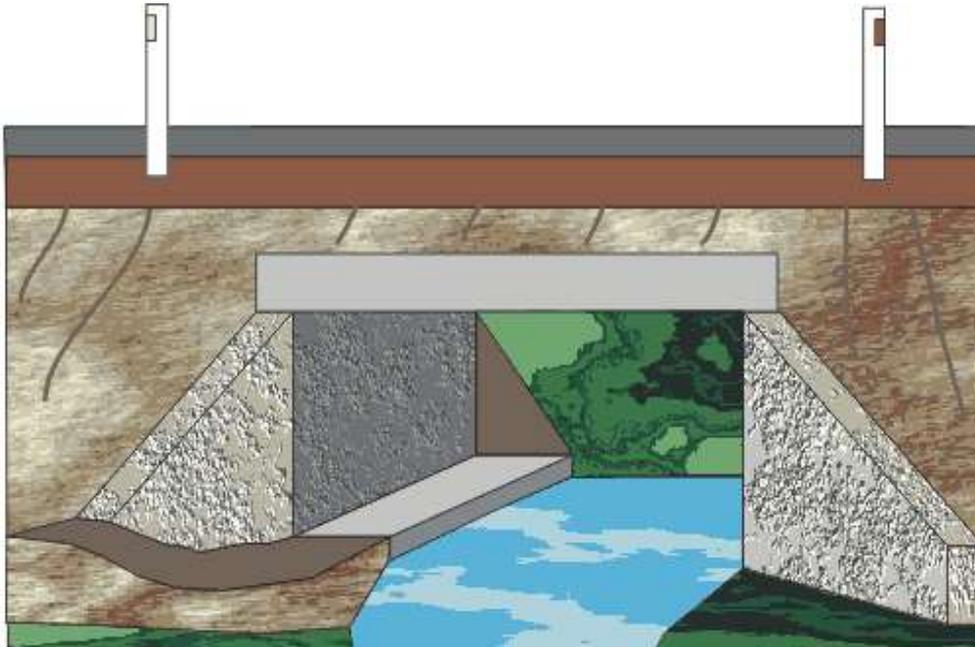
#### **Habitat Fragmentation and Barrier Effects, and Vehicle Wildlife Interactions**

To mitigate habitat fragmentation and barrier effects, and vehicle-wildlife interactions, the following measures will be implemented:

- ▶ 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 9-1](#)). 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).

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 9-1 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.

#### **9.3.3.11 Residual Effects and Their Significance**

By applying the mitigation measures recommended above, 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.

### **9.3.3 Assessment of Operation Impacts**

#### **9.3.3.1 Operation Impacts on Flora**

##### **9.3.3.1.1 Identification of Direct Impacts and mitigation measures**

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. Other than vegetation control, there will not be any additional work involving forest clearing during operation.

##### **9.3.3.1.2 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.

#### **9.3.3.2 Indirect Impacts on Flora**

##### **Ongoing Encroachment by Invasive Species**

Once the dam and the hydropower plant are 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.

##### **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.

##### **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.

### **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<sup>2</sup> 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.

#### **9.3.3.2.1 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. 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 9.3 – 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:

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 for 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.

#### **9.3.3.2.2 Residual Effects and Their Significance**

By applying the mitigation measures recommended above, 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.

#### **9.3.3.2.3 Conclusions Regarding Impacts of Operation on Flora**

Impacts on flora during project operation are mostly indirect and will accrue due to 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.

### **9.3.3.3 Operation Impacts on Fauna**

#### **9.3.3.3.1 Direct Impacts on Fauna**

Assessment of the species specific and direct impacts that could potentially accrue to fauna as a result of project construction 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.

#### 9.3.3.3.2 Indirect Impacts on Fauna

##### **Changes in Accessibility to Bush Meat**

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. 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.

##### **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.

#### 9.3.3.3.3 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.

#### **9.3.3.3.4 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.

### **9.3.4 Impacts on Natural and Critical Habitats**

#### **9.3.4.1 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. 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.

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 km<sup>2</sup>. 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 9-4. Identification of these 'discrete management units' does not mean that the project has management obligations across them.

#### **9.3.4.2 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 km<sup>2</sup> of the DMU).

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 km<sup>2</sup> of the DMU).

Many of the terrestrial areas of natural habitat within the DMU (covering 184 km<sup>2</sup>) 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.

### 9.3.4.3 Impacts on Critical and Natural Habitat

Direct project impacts on the various ecosystems in the project area are summarized in [Table 9-1](#).

Table 9-1 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
		<b>Sub-total - critical habitat</b>	<b>31.16</b>
Natural Habitat		Disturbed forests	29.65
		Remnant forests	21.87 (of which 10 ha is temporary)
		Cliffs	16.12
		<b>Sub-total - natural habitat, including critical habitat</b>	<b>98.80</b>
Modified Habitat		Grasslands	6.09
		Garden	0
		Fallow brush land	6.40
		<b>Sub-total - modified habitat</b>	<b>12.49</b>
		<b>Total</b>	<b>111.29</b>

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.

### 9.3.4.4 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.

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.

### **9.3.5 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.

## 9.4 ASSESSMENT OF IMPACTS ON THE BIOLOGICAL (AQUATIC) ENVIRONMENT

### 9.4.1 Activities Affecting the Aquatic Environment

#### 9.4.1.1 Operation of the headrace tunnel

##### 9.4.1.1.1 Reduced flows in the bypassed river section

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.

A reduction in flow from the median flow of 11.1 m<sup>3</sup>/s to an environmental flow of 1 m<sup>3</sup>/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%.

The analysis of habitat variation with flow suggested that a flow of 2-4 m<sup>3</sup>/s would provide maximum habitat for most of the common species, fish density and species richness. For the species that live in very swift water (*Sicyopterus cyanocephalus* and *S. lagocephalus*), habitat suitability is greatest at flows greater than 10 m<sup>3</sup>/s.

The standard of environmental protection provided by an environmental flow can be assessed by comparing the amount of habitat (m<sup>2</sup>/m of river length) at the environmental flow with the amount of habitat at median flow.

A flow of 1 m<sup>3</sup>/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 9-5). 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 *Stiphodon* 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.

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.

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<sup>3</sup>/s environmental flow is similar to the amount of habitat at a median flow of 11.1 m<sup>3</sup>/s for the most of 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<sup>3</sup>/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 during that period at least equal to what is needed to operate one turbine at minimum capacity, i.e., 2.43 m<sup>3</sup>/s. When added to the environmental flow of 1 m<sup>3</sup>/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<sup>3</sup>/s.

#### **9.4.1.1.2 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.

### **9.4.1.2 Operation of the dam and powerhouse**

#### **9.4.1.2.1 Changes in hydrology**

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.

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 2.43 m<sup>3</sup>/s power station discharge during the night, leaving only 3.43 m<sup>3</sup>/s including environmental flow in the river. This means that the flows could fluctuate between 18 m<sup>3</sup>/s and 3.43 m<sup>3</sup>/s on an almost daily basis.

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<sup>3</sup>/s and 19.7 m<sup>3</sup>/s and a rating curve

(relationship between water level and discharge) was developed. This indicated that a flow changes from minimum generation (2.4 m<sup>3</sup>/s) to maximum generation (18 m<sup>3</sup>/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.

Maintaining the minimum flow downstream of the powerhouse of 3.43 m<sup>3</sup>/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.

#### 9.4.1.2.2 Reservoir establishment - Change from riverine to lacustrine (lake) habitat

##### 9.4.1.2.2.1 Sediment in the reservoir.

The reservoir volume up to the invert of the sediment scour outlet (155m) is 2344x10<sup>3</sup> m<sup>3</sup>, and 6900x10<sup>3</sup> m<sup>3</sup> up to Full Supply Level (175 m). Entura (2014) estimated that the annual suspended sediment load would be about 500 t/km<sup>2</sup>/year, which would deposit about 45000 m<sup>3</sup>/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.

##### 9.4.1.2.2.2 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.

##### 9.4.1.2.2.3 Water quality

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<sup>3</sup>/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. 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.

#### **9.4.1.2.2.4 Water temperature**

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<sup>3</sup>/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.

#### **9.4.1.2.2.5 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. 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.

#### **9.4.1.2.2.6 Upstream passage**

Because of their climbing ability, it is relatively easy to provide effective upstream passage for gobies and eels using either a natural stream channel<sup>12</sup> 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 photo of a ramp and trap components of a trap-and-haul system for climbing fish is shown in **Figure 9-2**. 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

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<sup>12</sup> 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.

will provide very 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 9-2 Photo of ramp and trap at dam

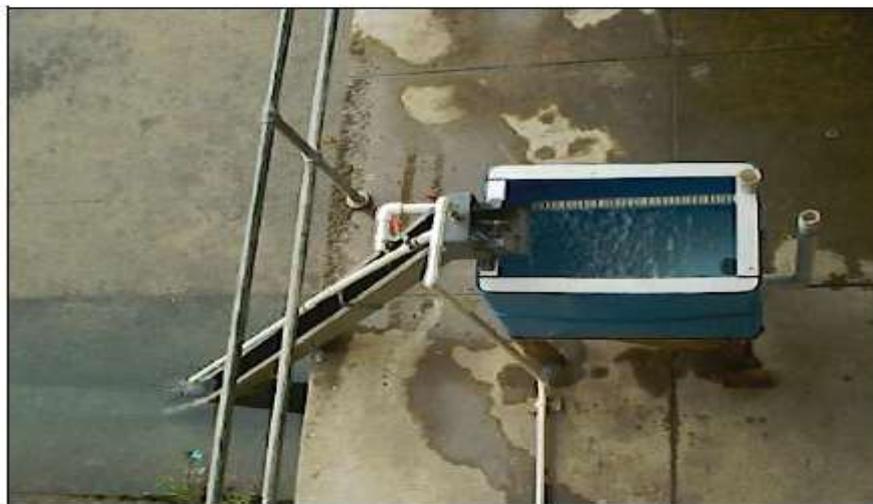


Figure 9-3 Principle of Trap and Haul system

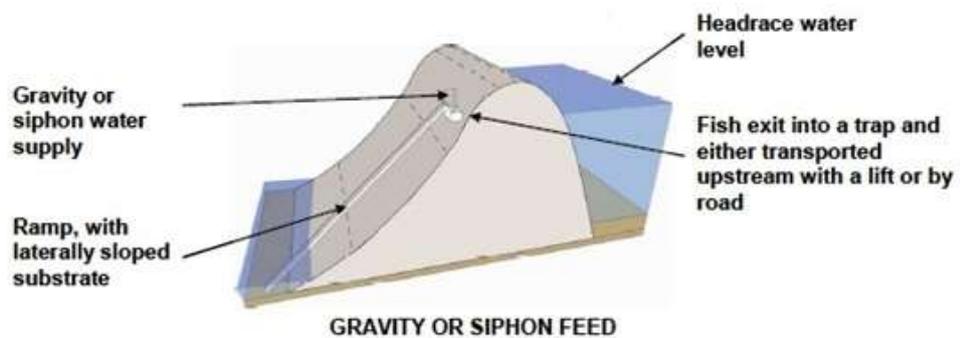


Figure 9-3 shows the trap system with ramp leading to a holding tank and piped water supply installed at Waitaki Dam, New Zealand. The optimum slope is about 15 degrees.

#### **9.4.1.2.2.7      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.

## **9.5      BIOLOGICAL (AQUATIC) IMPACT ASSESSMENT**



Table 9-2 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
	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

Potential impact causing activities	Impacts on hydrology and sediment dynamics	Impacts on water quality	Impacts on aquatic life	Impacts on 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 Disturbance of amenity values in the reduced flow section of the river		Degradation of aquatic habitats Barrier to migratory species	Disturbance of water uses

## 9.5.1 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 ecology and other sources of information dealing with species migratory behaviour and habitat requirements.

### 9.5.1.1 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.

#### 9.5.1.1.1 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. Turbidity levels observed during the rainy season when it was 16.1NTU at Tina village (Tina River).

##### 9.5.1.1.1.1 Impact Identification and Rating

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. Table 9-12 summarises the impact significance rating for suspended sediments on the aquatic ecosystem and water uses.

##### 9.5.1.1.1.2 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 ESMP, which will be prepared:

- ▶ Reservoir preparation;
- ▶ Point source pollution management, including concrete work;
- ▶ Spoil soil management during earthwork;

- ▶ Forest clearance practices;
- ▶ Stream crossing practices;
- ▶ Drainage and erosion control;

#### **9.5.1.1.1.3      Residual Effects and Their Significance**

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 ESMPs 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.

#### **9.5.1.1.2    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).

#### **9.5.1.1.2.1      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.

#### **9.5.1.1.2.2      Mitigation Measures**

River pollution is an avoidable impact if ESMP is implemented during construction. ESMP 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.

#### **9.5.1.1.2.3 Residual Effects and Their Significance**

Even with the implementation of ESMPs, 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 ESMPs are properly implemented.

#### **9.5.1.2 Disturbance to Aquatic Habitats and Aquatic Life**

##### **9.5.1.2.1 Impact Identification and Rating**

Water quality degradation, including increased TSS, and streambed 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. In the event of an accidental spill of fuel /oil or other toxic substance, the effects on aquatic life might manifest far downstream.

##### **9.5.1.2.1.1 Mitigation Measures**

Disturbance to the aquatic ecosystem is unavoidable and is the consequence of constructing a hydropower dam. ESMP will be implemented to minimize disturbance wherever possible. ESMP for controlling the disturbance to aquatic habitats and aquatic life will 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.

##### **9.5.1.2.1.2 Residual Effects and Their Significance**

Even with the implementation of ESMP, 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 ESMP is properly implemented.

#### **9.5.1.2.2 Overfishing**

##### **9.5.1.2.2.1 Impact Identification and Rating**

The presence of workers in the construction area where 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.

##### **9.5.1.2.2.2 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.

##### **9.5.1.2.2.3 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.

#### **9.5.1.2.3 Diminished Water Quality and Water Quantity**

##### **9.5.1.2.3.1 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<sup>3</sup> 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%.

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.

#### **9.5.1.2.3.2      Mitigation Measures**

Mitigation measures, such as the provision of domestic water supply system to local affected communities, is proposed to offset the impact of the Project withdrawing a quantity of water during construction that could affect availability of water to downstream communities. In addition, the same ESMP that would be used for pollution control would apply to protecting water quality.

#### **9.5.1.2.3.3      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 ESMP to control potential pollution, and compensation measures, such as distribution of water for domestic use, the post-mitigation residual effects are considered to be not significant.

#### **9.5.1.2.4      Temporary River De-Watering During Reservoir Filling.**

##### **9.5.1.2.4.1      Impact Identification and Rating**

Reservoir filling is estimated to take 7 days, based on a FSL reservoir of 7Mm<sup>3</sup>, and an average filling rate of 11.5m<sup>3</sup>/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.

#### **9.5.1.2.4.2 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<sup>3</sup>/s be maintained through this outlet during reservoir filling.

#### **9.5.1.2.4.3 Residual Effects and Their Significance**

With a minimum EF release of 1m<sup>3</sup>/s at all time during reservoir filling, the post-mitigation residual impact of dewatering the river is considered to be not significant.

#### **9.5.1.2.4.4 Conclusions Regarding Construction Impacts**

**Table 9-3** 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 9-3 Pre-mitigation and residual impact ratings for construction phase

<b>Impact from construction</b>	<b>Pre-mitigation impact rating</b>	<b>Post-mitigation Residual impact rating</b>
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

### **9.5.1.3 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.

#### **9.5.1.3.1 Reservoir Operation**

##### **9.5.1.3.1.1 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 (river bed-crest) 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.

##### **9.5.1.3.1.2 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.

##### **9.5.1.3.1.3 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.

#### **9.5.1.3.2 Reservoir Sedimentation**

##### **9.5.1.3.2.1 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<sup>3</sup>/y, it is estimated that the dead storage volume would be full within a period of 65 years (Entura, March 2014).

Impact significance is considered to be moderate.

#### **9.5.1.3.2.2 Mitigation Measures**

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.

#### **9.5.1.3.2.3 Residual Effects and Their Significance**

As there is no feasible mitigation, residual impacts are considered to be moderate, but not significant.

#### **9.5.1.3.3 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.

#### **9.5.1.3.3.1 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. 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 53 m (river bed-crest));
- (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.

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.

#### Impacts on Fish Movement at the Mouth of the Ngalimbiu River

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.

#### **9.5.1.3.3.2 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.

#### **9.5.1.3.3.3 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.

#### **9.5.1.3.4 Changes of Flow Downstream of the Dam**

##### **9.5.1.3.4.1 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 18m<sup>3</sup>/s (3 turbines x 6 m<sup>3</sup>/s).

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<sup>3</sup>/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 bypassed river section is estimated to be about  $1\text{m}^3/\text{s}$  and will add to the  $1\text{m}^3/\text{s}$  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 9-10.

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  $1\text{m}^3/\text{s}$  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 bypassed river section is estimated to be about  $1\text{m}^3/\text{s}$  and will add to the  $1\text{m}^3/\text{s}$  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 9-10.

Flows will not change upstream of the reservoir as a consequence of the Project.

#### Flow Variation within a Typical Day

During the nighttime (off-peak hours), thus not releasing any water. During nighttime, flow downstream of the powerhouse will equal the  $1\text{m}^3/\text{s}$  EF plus the  $\sim 1\text{m}^3/\text{s}$  of inflow from the lateral tributaries (green line). During nighttime, the flow will, therefore, be significantly reduced until the confluence with Toni River ( $\sim 2\text{m}^3/\text{s}$ ) 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 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  $2\text{m}^3/\text{s}$  in the Tina River will be slightly lower than the lowest recorded flow of  $2.85\text{m}^3/\text{s}$ , which is the lowest recorded flow between 2010 and 2013, The daytime flow of approximately  $24\text{m}^3/\text{s}$  will be higher than the average flow during a typical wet season month (i.e., March with  $21.94\text{m}^3/\text{s}$ ).

#### **9.5.1.3.5 River System Response to Rainfall**

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<sup>3</sup>.

It should be noted that this regulation effect is only valid for a moderate rainfall event. The regulation volume of 1Mm<sup>3</sup> 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.

#### **9.5.1.3.5.1 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 mouth would need to be implemented.

#### **9.5.1.3.5.2 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<sup>3</sup>/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.

### **9.5.1.3.5.3      Residual Effects and Their Significance**

With the implementation of EF of 1m<sup>3</sup>/s EF, combined with an expected additional 1m<sup>3</sup>/s dry season inflow from smaller lateral streams, and designing the system to release up to 2m<sup>3</sup>/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.

### **9.5.1.3.6    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<sup>3</sup>/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.

A trap-and-haul system combined with an EF of 1m<sup>3</sup>/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<sup>3</sup>/s has the further advantage of ensuring river users along the by-passed section of 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.

#### **9.5.1.3.6.1 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)<sup>13</sup>, and includes the following five steps:

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.

#### **9.5.1.3.7 Changes in Sediment Downstream Dynamics**

##### **9.5.1.3.7.1 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<sup>3</sup>/y of suspended sediment, and 45,000m<sup>3</sup>/y of bed load material.

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<sup>13</sup> EBRD, Environmental and Social Guidance Note for Hydropower Projects (undated).

#### **9.5.1.3.7.2 Mitigation Measures**

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. 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 to 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.

#### **9.5.1.3.7.3 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.

#### **9.5.1.3.8 Reservoir Stratification**

##### **9.5.1.3.8.1 Impact Identification and Rating**

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.

##### **9.5.1.3.8.2 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.

##### **9.5.1.3.8.3 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.

### **9.5.1.3.9 Reservoir Water Quality**

#### **9.5.1.3.9.1 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.

#### **9.5.1.3.9.2 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.

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.

#### **9.5.1.3.9.3 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.

### **9.5.1.3.10 Alteration of Water Quality Downstream of the Reservoir**

#### **9.5.1.3.10.1 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.

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.

#### **9.5.1.3.10.2 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 to confirm this prediction.

#### **9.5.1.3.10.3 Residual Effects and Their Significance**

No residual impacts are anticipated and, therefore, impacts are low and not significant.

#### **9.5.1.3.11 On-Going Disturbance to Downstream Aquatic Habitats and Aquatic Life**

##### **9.5.1.3.11.1 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, but is permanent.

##### **9.5.1.3.11.2 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<sup>3</sup>/s below the powerhouse plus inflows (equivalent to the minimum operational discharge of one turbine (2.43 m<sup>3</sup>/s), in addition to the by-passed reach environmental flow (1 m<sup>3</sup>/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.

#### **9.5.1.3.11.3 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.

#### **9.5.1.3.12 Establishment of a Lake Ecosystem in the Reservoir**

##### **9.5.1.3.12.1 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 rheophilic 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.

#### **9.5.1.3.12.2 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.

#### **9.5.1.3.12.3 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.

#### **9.5.1.3.13 Ongoing Disturbance to Water Uses**

##### **9.5.1.3.13.1 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. 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.

##### **9.5.1.3.13.2 Mitigation Measures**

Proposed mitigation measures 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.

#### **9.5.1.3.13.3 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.

#### **9.5.1.3.14 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  $1\text{m}^3/\text{s}$  (almost  $2\text{m}^3/\text{s}$  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  $1\text{m}^3/\text{s}$  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.

## **10. SOCIAL IMPACT ASSESSMENT**

### **10.1 INTRODUCTION**

This section addresses the potential social impacts of construction and operation of the project, while taking into account the issues identified by the local communities, stakeholders and 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.

### **10.2 APPROACH**

To assess the TRHDP, identification and evaluation of the social and cultural impacts were based on the records of consultations and awareness campaigns undertaken by the Project Office, similar projects, and consultation via community workshops, and a householder survey, carried out by the ESIA team

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).

### **10.3 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 visits 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.

### **10.3.1 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. The community workshops were participatory and interactive. Each key topic of the project was discussed and displayed on a whiteboard.

### 10.3.2 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.

### 10.3.3 Requirement for Free, Prior, and Informed Consent

The World Bank Performance Standards 1 and 7 stipulate that Free, Prior, and Informed Consent (FPIC) is required for the affected indigenous peoples at each stage of the project development as shown below.

#### Free, Prior and Informed Consent

There is no single internationally agreed definition of FPIC and "no single, nor a one-size fits all mechanism for its implementation" (UN Collaborative Program on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries, 2013). International development agencies define FPIC as follow:

- "Free" - implies the absence of coercion, intimidation or manipulation (including bribery or rewards).
- "Prior" - implies that sufficient time is provided to indigenous communities and stakeholders during consultations and decision-making processes. This allows community members and stakeholders to receive adequate information, come together, discuss the proposal, and make decisions prior to providing any formal response (e.g., consent).
- "Informed" - implies that the affected communities and stakeholders have access to relevant information on the project to engage in consultations and decision-making processes.

Providing 'access' to information implies that the information is:

- in a form and language that is suitable for the particular communities and stakeholders;
- accurate;
- delivered in a culturally appropriate and inclusive way; and

- made available to every member of the community.
- “Consultation” refers to an inclusive and fair process of interaction, engagement, and dialogue between various stakeholders with respect to a proposed development or activity. The intention is to achieve a clear shared understanding of the proposal, the issues and concerns of all parties, and of any future actions and decisions. It does not imply common agreement or consensus as an outcome.
- “Consent”, in the context of IFC PS, refers to a “broad agreement” within and between the affected communities and stakeholders that the proposed project or activity can proceed, as determined through local customary decision-making practice. It does not imply universal agreement amongst stakeholders or all members of a community

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.

#### **10.3.3.1 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.

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.

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.;
- Hydroelectric development is widely seen as the most preferred and least destructive development opportunity for the Tina/Ngalimbiu River catchment;
- 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.

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.

#### **10.3.3.2 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.

#### **10.3.4 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). 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.

## **10.4 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.

### **10.4.1 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.

## 10.4.2 Health, Safety and Wellbeing - Impacts and Mitigation

### 10.4.2.1 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 the Construction phase Environmental and Social Management Plan (C-ESMP). Alternative drinking water supplies should also be installed throughout the project area, prior to the beginning of the construction phase.
- Unfortunately, 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 vicinity of 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 officers engaged by the THL.

#### **10.4.2.2 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 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<sup>3</sup>/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 river's 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 these hazards, 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.

### **10.4.3 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. 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. Measures to avoid or mitigate short and longer terms impact concerns are outlined in the relevant sections.

#### **10.4.3.1 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.

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.

#### **10.4.3.2 Women's Work and Roles**

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.

### **10.4.3.3 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 of 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). 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.

## **10.4.4 Social Relations and Social Organisation – Impacts and Mitigation**

### **10.4.4.1 Identification of Potential Social Conflicts**

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.

The implementation of a social impact management plan and the benefit-sharing program aims to deal positively with the issues raised above.

#### **10.4.4.2 Project Construction Workforce**

The TRHDP PO has indicated that the peak construction workforce for the TRHDP will include approximately 175 workers. Feasibility study 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. Suitable accommodation will be planned for well in advance, by the construction contractor, to cope with a temporary (seasonal) increase in Honiara's population.

#### **10.4.4.3 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. 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.

#### **10.4.5 Local Customs and Way of Life – Impacts and Mitigation**

##### **10.4.5.1 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.

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. 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.

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).

#### **10.4.5.2 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. 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.

#### **10.4.6 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.

#### 10.4.6.1 Infrastructure

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.

#### 10.4.6.2 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.

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 area.

Table 10-1 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 brushland (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									

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.

#### **10.4.6.3 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.

As confirmed from Geotech investigation, 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 downstream of the dam should be carried out to confirm whether any impacts on downstream gravel users are likely to occur.

#### **10.4.6.4 Natural Capital**

##### **10.4.6.4.1 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<sup>2</sup> project Core Area<sup>14</sup>.

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.

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

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<sup>14</sup> 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.

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.<sup>15</sup>

#### **10.4.6.4.2 Water Use**

##### **Water Quantity**

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**

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.

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.

#### **10.4.6.4.3 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

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<sup>15</sup> See Project Office press release, "Tina River Core Land Owners Give Consent" dated 17 July, 2014)

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.

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.

#### **10.4.6.4.4 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. 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.

#### **10.4.7 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.

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.

## **10.5 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.

### **10.5.1 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.

### **10.5.2 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 175 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 Tina Hydropower Limited (THL)**. The required operational workforce is still under consideration.

### 10.5.3 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.

### 10.5.4 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<sup>16</sup>.

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, working with SIG and local training providers, should facilitate community participation in the project, by providing:

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<sup>16</sup> 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>)

- 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).

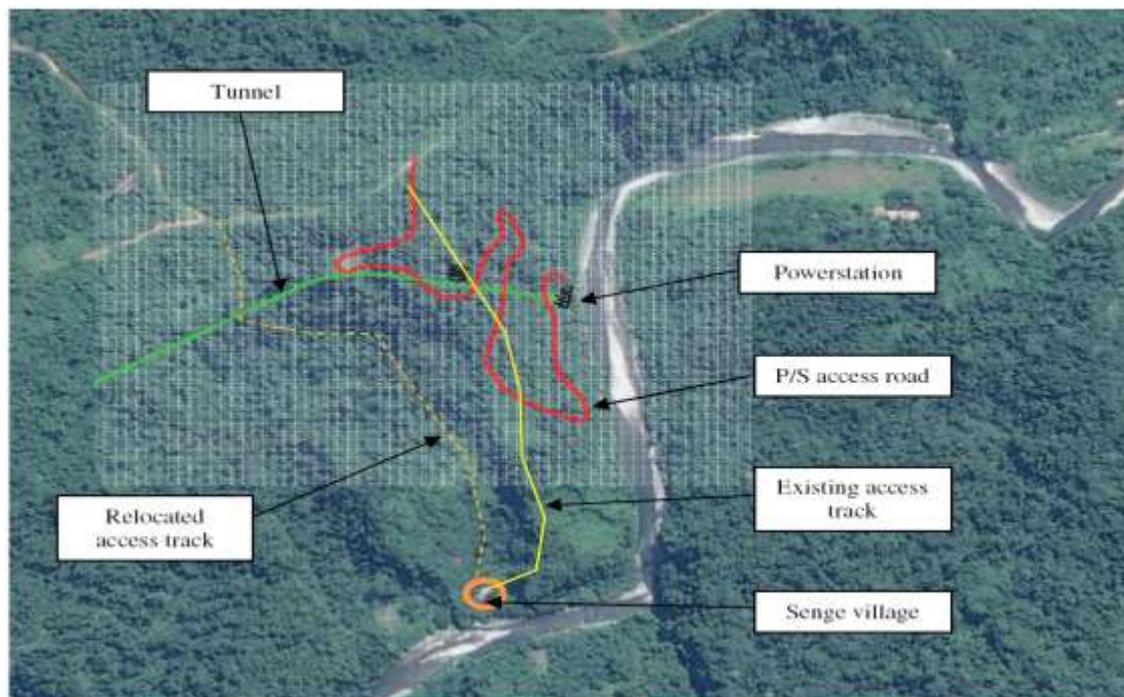
As part of a promised benefits sharing program the SIG has begun implementing a much needed and well-received \$2 million upgrade to schools in the Bahomea area. The project could also support transportation to the schools.

### 10.5.5 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 10-1), which used to run a small-scale ecotourism operation<sup>17</sup> (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 10-1 Relocation of the footpath to Senge



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

<sup>17</sup> See [http:// www.sengevillage.com](http://www.sengevillage.com).

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.

### **10.5.6 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.

#### **10.5.6.1 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.

#### **10.5.6.2 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.

### **10.5.6.3 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.

### **10.5.7 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.

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<sup>18</sup>. As a case in point, only a small amount of 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.

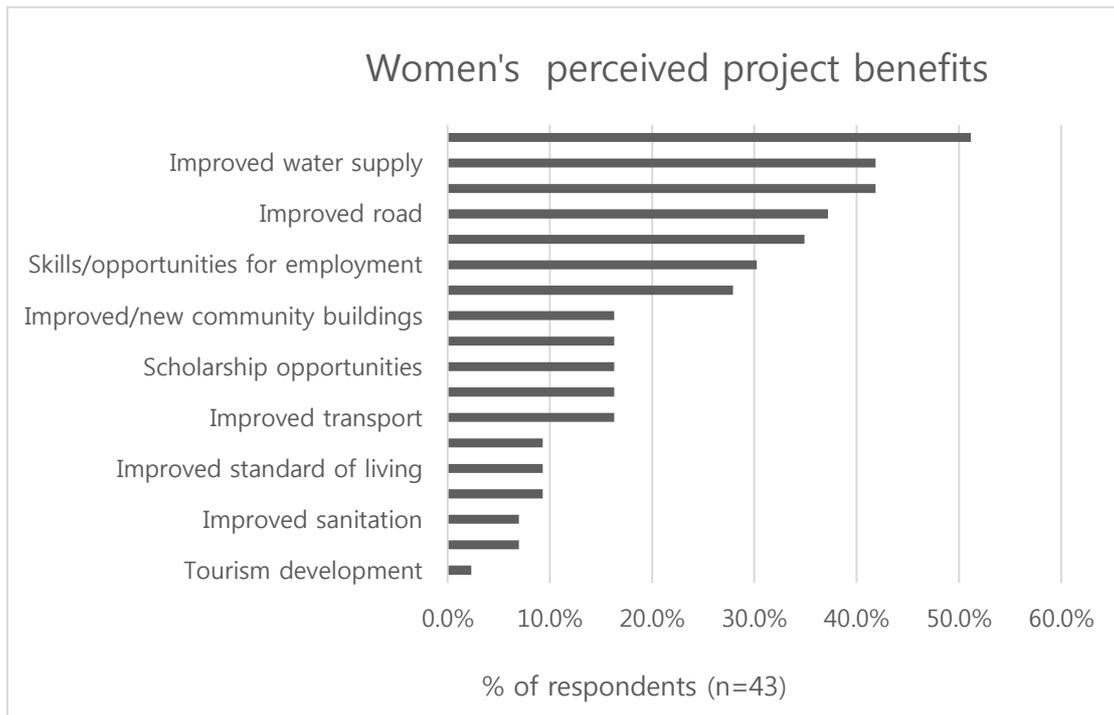
### **10.5.8 Potential Project Benefits for Women**

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 10-5). Other potential benefits of the Project are reflected in the survey results.

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<sup>18</sup> 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 '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).

Figure 10-2 Women's perception on the benefits of the TRHDP



# **11. ECONOMIC ASSESSMENT**

## **11.1 INTRODUCTION**

This section describes the economic 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.

## **11.2 ECONOMIC EFFECT**

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.

## **11.3 POTENTIAL ECONOMIC BENEFICIALS FOR LOCAL COMMUNITIES**

During the mitigation workshops, participants were asked to share their expectations and hopes on the benefits of the Project to them and their communities.

### **11.3.1 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. Having their own electricity supply will enable households to take advantage of modern electrical appliances and machines.

### **11.3.2 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 175 workers at its peak. 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.

### **11.3.3 Livelihoods Strategies**

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.

### **11.3.4 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.

### **11.3.5 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.

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.

### **11.3.6 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.

### **11.3.7 Local 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.

## 12. ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

### 12.1 INTRODUCTION

This section sets out TRHDP's Environmental and Social Management Plans Framework. It is, among other things, the basis for the construction (CESMP) and operations (OESMP) ESMPs that will be prepared by the THL and EPC contractor (HEC). Information is provided on environmental and social mitigation measures, monitoring programs, capacity development and training, implementation schedule and budget, and project integration. Information is provided on environmental and social mitigation measures, monitoring programs, capacity development and training, implementation schedule, an indicative budget, and project integration.

The THL and EPC contractor (HEC) will prepare the CESMP and an OESMP as stand-alone documents. The developer will also prepare a number of management sub-plans. 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, 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. The Ministry of Mines, Energy and Rural Electrification will be the key actor for measures applicable to the access road upgrade from the Black Post turnoff to Managikiki (Lot 1) and will delegate the day to day management to the road construction contractor.

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.

## **12.2 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.

## **12.3 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).

### **12.3.1 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 7)
- Impacts of increased suspended solids and siltation on aquatic life (see section 9.4)
- Impacts of River Pollution on aquatic life (see section 9.4)
- Disturbance to aquatic habitats and aquatic life (see section 9.4)
- Impacts of temporary diminished water quality and quantity on aquatic environment (see section 9.4)
- Temporary de-watering impacts on aquatic environment (see section 9.4)
- Reservoir Water Quality (see section 9.4)

Reservoir Impoundment:

- Impacts on Surface Hydrology (see section 9.2)
- Impacts on aquatic life of reduced flow (see section 9.4)
- Impacts on water users (see section 10)

**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<sup>3</sup>/s during reservoir impoundment at all times.

Implementation Actor:	Oversight Actor:	Costing/Funding Source:
Developer  Local Community (for reservoir clearing)	TRHDP PO	PPA

### 12.3.2 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 9.2)

Indirect impacts on fauna species (see section 9.3)

Impacts of changes of flow downstream of dam on aquatic life (see section 9.4)

On-going disturbance to downstream aquatic habitats (see section 9.4)

Impacts on water users (see section 10)

##### Reduced Overnight Flow:

Impacts of reduced river flows downstream of dam site during overnight reservoir refill on surface hydrology (see section 9.4)

Impacts on aquatic life of reduced flow (see section 9.4)

Impacts on water users (see section 10)

##### Reduced Sediment Transport:

Impact of physical reduction of sediment transport (see section 9.2)

Impact of reduced sediment transport on aquatic life (see section 9.4)

Impact of reduced sediment transport on gravel extraction activities (see section 10)

Impacts of reservoir sedimentation on aquatic environment (see section 9.4)

#### Measures:

##### Reduced Flow Between Dam and Powerhouse:

Maintain a minimum environmental flow of 1m<sup>3</sup>/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<sup>3</sup>/s flow below the power station during over night reservoir refill. One option for achieving this is to maintain the 1m<sup>3</sup>/s environmental flow and continue to run 2.4m<sup>3</sup>/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.		
<b>Implementation Actor:</b>	<b>Oversight Actor:</b>	<b>Costing/Funding Source:</b>
Developer	TRHDP PO	PPA

**12.3.3 Barrier to Fish Passage, and Fish Entrainment**

<b>Impacts Addressed:</b>		
<u>Barrier to Fish Passage:</u> Barrier to passage of migratory fish species (see section 9.4)		
<u>Fish Entrainment:</u> Barrier to passage of migratory fish species (see section 9.4) On-going disturbance to downstream aquatic habitats (see section 9.4)		
<b>Measures:</b>		
<u>Barrier to Fish Passage:</u> Implement a trap and haul system in accordance with section 9.4		
<u>Fish Entrainment:</u> 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.		
<b>Implementation Actor:</b>	<b>Oversight Actor:</b>	<b>Costing/Funding Source:</b>
Developer	TRHDP PO	PPA

### 12.3.4 Access Road Location, Design, Construction and Operation

#### **Impacts Addressed:**

##### Location and Design:

Slope stability and geological impacts (see section 9.2)

Erosion (see section 9.2)

Human encroachment to upper Tina (see section 10)

##### Installation of Drainage Works and Stream Crossings:

Construction and operation impact on fauna (see section 9.3)

Impacts of hydrological changes on flora (section 9.3)

Impacts of increased suspended solids and siltation on aquatic life (see section 9.4)

Impacts of River Pollution on aquatic life (see section 9.4)

Impacts of diminished water quality and quantity on aquatic environment (see section 9.4)

Disturbance to aquatic habitats and aquatic life (see section 9.4)

##### Environmentally and Culturally Sensitive Areas:

Impact of deforestation on environmentally and culturally sensitive areas (see section 9.2)

##### Road Access Restrictions:

Operational impacts on flora (see section 9.3)

#### **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 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 be 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 considering 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.

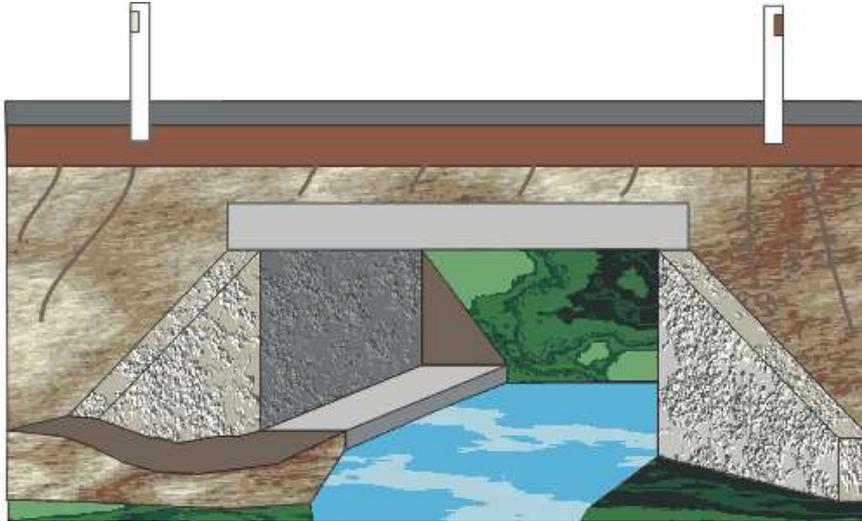
Culverts and stream crossings will be constructed with the use of an excavator, instead of a bulldozer, to avoid excessive soil disturbance and to avoid sediment laden soils from entering the watercourse.

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 12-1](#)).

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 minimize 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 12-1 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 Managikiki) 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 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 Managikiki 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 for rangers or security staff.

These measures will be developed and implemented with the assistance of the TCLC, and set out in the Biodiversity Management 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:
<p>Ministry of Mines, Energy and Rural Electrification (MMERE)</p> <p>Road Design Contractor</p> <p>Road Construction Contractor</p> <p>Developer with respect to maintenance of the access road:</p> <ul style="list-style-type: none"> <li>- from Mengakiki to dam site for BOOT period</li> <li>- from Black Post turnoff to Mengakiki until commissioning</li> </ul> <p>Ministry of Infrastructure Development (MID) with respect to maintenance of access road from Black Post turnoff to Mengakiki following commissioning</p> <p>Tina Core Land Company (for controlling access to Core Lands)</p>	<p>TRHDP PO</p>	<p>Incorporated into Road Design Contract</p> <p>To be incorporated into road construction contract between MMERE and road construction contractor</p> <p>PPA (with respect to road closure)</p>

**12.3.5 Vegetation and Forest Clearance**

<b>Impacts Addressed:</b>
<u>Extent of Clearing:</u>

Physical impact of soil compaction and erosion (see section 9.2)

Impact of sediment run-off on aquatic life (see section 9.4)

Clearing and Grubbing:

Impacts of vegetation burning on regional and local air quality (see section 9.2)

Physical impact of soil compaction and erosion (see section 9.2)

Loss of or disturbance to terrestrial natural habitat (see section 9.3)

Impacts of increased suspended solids and siltation on aquatic life (see section 9.4)

Impacts of River Pollution on aquatic life (see section 9.4)

Disturbance to aquatic habitats and aquatic life (see section 9.4)

Impacts of diminished water quality and quantity on aquatic environment (see section 9.4)

Construction impacts on grassland dependent birds (see section 9.3)

Construction impacts on river dependent birds (see section 9.3)

**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 12-2). However, for the transmission line, electrical grid protection prevails over this measure.

Figure 12-2 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

### 12.3.6 Drilling and Blasting

Impacts Addressed:
Construction impacts on physical environment of noise and vibration (see section 9.2)

Construction impacts on fauna (see section 9.3)		
<b>Measures:</b>		
<p>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.</p>		
<b>Implementation Actor:</b>	<b>Oversight Actor:</b>	<b>Costing/Funding Source:</b>
Developer	TRHDP PO	PPA

### 12.3.7 Accidental Release of Sewage and Other Wastewater

<b>Impacts Addressed:</b>		
<p>Impacts of Point Source Pollution on Flora (section 9.3)  Impacts of River Pollution on aquatic life (see section 9.4)  Disturbance to aquatic habitats and aquatic life (see section 9.4)  Impacts of diminished water quality and quantity on aquatic environment (see section 9.4)</p>		
<b>Measures:</b>		
<p>The presence of on-site toilet facilities for workers mandatory.  All sanitary wastewater will be regularly transported outside of the study area for treatment.</p>		
<b>Implementation Actor:</b>	<b>Oversight Actor:</b>	<b>Costing/Funding Source:</b>
Developer	TRHDP PO	PPA

### 12.3.8 Hazardous Materials, Explosives and Concrete Works Handling

#### Impacts Addressed:

Impacts of Point Source Pollution on Flora (section 9.3)

Impacts of increased suspended solids and siltation on aquatic life (see section 9.4)

Impacts of River Pollution on aquatic life (see section 9.4)

Disturbance to aquatic habitats and aquatic life (see section 9.4)

Impacts of diminished water quality and quantity on aquatic environment (see section 9.4)

#### 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 inside a designated bunded area, 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 water bodies 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 CO<sub>2</sub> 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

**12.3.9 Excavation and Movement of Soils**

<b>Impacts Addressed:</b>
<p><u>Soil Stripping and Stockpiling:</u></p> <p>Construction impacts of soil management on flora (section 9.3)</p> <p>Impacts of increased suspended solids and siltation on aquatic life (see section 9.4)</p> <p>Impacts of River Pollution on aquatic life (see section 9.4)</p> <p>Impacts of diminished water quality and quantity on aquatic environment (see section 9.4)</p> <p>Disturbance to aquatic habitats and aquatic life (see section 9.4)</p>

Accidental Colonisation by Invasive Species:

Impacts of Colonisation by Invasive Species on Flora Species (see Section 9.3)

Impacts of invasive species on Fauna Species (see Section 9.3)

**Measures:**

Soil Stripping and Stockpiling:

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 Managikiki 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 Veraande. 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 geo-fabric 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

### 12.3.10 Activities Causing Disturbance to Wildlife

#### Impacts Addressed:

##### Workers Affects on Fauna:

Construction and operational impacts on fauna (see section 9.3)

##### Lighting Disturbance:

Construction impacts on fauna (see section 9.3)

##### Transmission Line Operation:

Operational impacts on bats, birds and marsupials (section 9.3)

##### Harvesting by Workers:

Impacts of over fishing (see section 9.4)

Operational impacts on fauna (see section 9.3)

#### 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 to 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 Disturbance:

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:

<p>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.</p> <p>Project's food services / caterers will be prohibited from purchasing fish from local villagers.</p> <p>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.</p>		
<b>Implementation Actor:</b>	<b>Oversight Actor:</b>	<b>Costing/Funding Source:</b>
Developer  Solomon Power (for transmission line)	TRHDP PO	PPA

**12.4 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.

#### 12.4.1 Siting of Workers Camps

<b>Impacts Addressed:</b>		
Local Customs and Way of Life (see section 10)		
Health Safety and Wellbeing During Construction (see section 10)		
<b>Measures:</b>		
<p>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.</p> <p>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.</p>		
<b>Implementation Actor:</b>	<b>Oversight Actor:</b>	<b>Costing/Funding Source:</b>
Developer	TRHDP PO	PPA

#### 12.4.2 Employment and Recruitment Practices

<b>Impacts Addressed:</b>
Uninvited Job Seekers (see section 10)
Increase in Employment Opportunities (see section 10)
<b>Measures:</b>

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)

### 12.4.3 Worker Behaviour, and Activities that could Affect Worker Health and Wellbeing

<b>Impacts Addressed:</b>		
Local Customs and Way of Life (see section 10)		
Moro Movement (see section 10)		
Health Safety and Wellbeing (see section 10)		
<b>Measures:</b>		
<p>The Developer is required to implement the workers' code of conduct 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 women workers who interact with local communities.</p> <p>The Developer shall conduct Code of Conduct pre-commencement training with workers.</p> <p>The construction contractor will provide tailored workplace health and safety training for construction workers before the start of the project.</p> <p>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.</p>		
<b>Implementation Actor:</b>	<b>Oversight Actor:</b>	<b>Costing/Funding Source:</b>
Developer	TRHDP PO	PPA

### 12.4.4 Activities that could Affect Villagers' Safety, Wellbeing, and Amenities

<b>Impacts Addressed:</b>
Health Safety and Wellbeing – Construction (see section 10)
Health Safety and Wellbeing - Operation (see section 10)

**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 will 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 behaviours which will encourage sexual behaviours. Outside parties will be engaged to carry out this awareness program.

Condoms will be 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
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#### 12.4.5 Activities that could Affect Vulnerable Groups and Minorities

<b>Impacts Addressed:</b>		
Minority and Vulnerable Groups (see section 10)		
<b>Measures:</b>		
<p>Social Impacts Monitoring Plan shall include monitoring of impacts of the project's construction and operation phases on squatters and settlers. The Stakeholder Engagement Plan shall assist communities in having their issues dealt with as the project progresses. This should include a grievance/complaints mechanism, and nominated community representatives for CLAs.</p> <p>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.</p>		
<b>Implementation Actor:</b>	<b>Oversight Actor:</b>	<b>Costing/Funding Source:</b>
Developer	TRHDP PO	PPA

#### 12.4.6 Activities that could Affect Water Supplies

##### Impacts Addressed:

##### Water Quality and Quantity (9.4)

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 12-1 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.)
	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
<b>Total</b>		<b>362</b>	<b>1800</b>

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

Figure 12-3 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.

<b>Implementation Actor:</b>	<b>Oversight Actor:</b>	<b>Costing/Funding Source:</b>
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Developer	TRHDP PO	PPA
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#### 12.4.7 Activities that could Affect Ecotourism Opportunities

Impacts Addressed:		
Ecotourism Opportunities (see Section 10)		
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 are not affected by traffic.		
Implementation Actor:	Oversight Actor:	Costing/Funding Source:
Developer	TRHDP PO	PPA

#### 12.4.8 Damage to, or Loss of, Core Area Resources

Impacts Addressed:
Natural Capital (see section 10)
Measures:
<p>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.</p> <p>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.</p> <p>Where construction activities damage or destroy resources outside of the acquired Direct Impact Area, compensation for these resources should be payable using transparent formulae.</p> <p>Where feasible, the TRHDP PO should contract out the reservoir vegetation clearing work to local community members.</p>

<b>Implementation Actor:</b>	<b>Oversight Actor:</b>	<b>Costing/Funding Source:</b>
Developer	TRHDP PO	PPA

#### 12.4.9 Activities that could affect Cultural heritage

<b>Impacts Addressed:</b>		
Cultural Heritage (see section 10)		
<b>Measures:</b>		
<p>As part of the Construction ESMP (CESMP), the Developer shall put in place a protocol for managing cultural heritage. This should include arrangements for relocation and for compensation.</p> <p>This Cultural Heritage Protocol is presented in the Cultural Heritage Management Plan (see section 10).</p> <p>Prior to any construction commencing, the Developer, with the assistance of the Project Office, 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.</p> <p>Prior to construction, the Developer, 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.</p> <p>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.</p>		
<b>Implementation Actor:</b>	<b>Oversight Actor:</b>	<b>Costing/Funding Source:</b>

Developer	TRHDP PO	PPA  Tambu Site Disturbance Compensation – Component of allocated SIG budget for land compensation
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#### 12.4.10 Decisions Made on the Project

Impacts Addressed:		
Social Impacts (see section 10)		
Measures:		
<p>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.</p> <p>The Developer will address any issues raised by communities and should report any corrective measures to the communities and to the SIG.</p>		
Implementation Actor:	Oversight Actor:	Costing/Funding Source:
Developer	TRHDP PO	PPA

#### 12.4.11 Dam Failure and Emergency Flow Releases

Impacts Addressed:
Fear of dam failure (see section 10)
Measures:
<p>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.</p> <p>Through training and sensitization carried out by the Developer, powerhouse start-up and shut-down procedures must be clearly understood by local communities to</p>

avoid any accident with sudden release of water at power station outlet (peak hour releases).		
<b>Implementation Actor:</b>	<b>Oversight Actor:</b>	<b>Costing/Funding Source:</b>
Developer	TRHDP PO	PPA

**12.4.12 Daytime Peaking Flow Releases**

<b>Impacts Addressed:</b>		
Operational Impacts (Section 10)		
<b>Measures:</b>		
<p>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.</p> <p>This plan shall be part of the design report.</p> <p>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:</p> <ul style="list-style-type: none"> <li>• The need to train local communities on actions to follow in the event of floods,</li> <li>• How to recognise and respond to the powerhouse flow release / flood warning system.</li> </ul>		
<b>Implementation Actor:</b>	<b>Oversight Actor:</b>	<b>Costing/Funding Source:</b>
Developer	TRHDP PO	PPA

**12.4.13 Changes Associated with Diminished River Flows**

<b>Impacts Addressed:</b>
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Sediment Recruitment:

Extraction of Aggregates from the River (section 10)

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 10)

**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.

<b>Implementation Actor:</b>	<b>Oversight Actor:</b>	<b>Costing/Funding Source:</b>
Developer	TRHDP PO	PPA

12.4.14 **Activities that could affect fishing effort**

**Impacts Addressed:**

Livelihood Impacts (Chapter 10)		
<b>Measures:</b>		
<p>Fish monitoring is to be undertaken in accordance with a fish monitoring plan to be prepared by the Developer in accordance with section 9.4.</p> <p>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.</p> <p>Where monitoring identifies statistically relevant reductions in fish quantities or species during operations, adaptive management procedures for fish migration are to be implemented.</p> <p>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.</p>		
<b>Implementation Actor:</b>	<b>Oversight Actor:</b>	<b>Costing/Funding Source:</b>
Developer	TRHDP PO	PPA

**12.4.15 Activities that could Strain Relations with Project-Affected Communities**

**Impacts Addressed:**

*Community Liaison, and Capacity Building:*

Social Impacts (numerous, see section 10)

**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.

<b>Implementation Actor:</b>	<b>Oversight Actor:</b>	<b>Costing/Funding Source:</b>
Developer TRHDP PO Community Liaison Committees	TRHDP PO	PPA Pre-employment training through JSDF Grant.

## 12.5 MANAGEMENT PLANS

In preparing the CESMP and OESMP, the constructor/operator shall develop and include several detailed management plans. A list of these plans, the timeframes for these and the framework for review and approval is set out in Table 12-2.

### 12.5.1 Table of Management and Monitoring Plans

Table 12-2 Management Plan Timeframes and Approvals

No.	Name	Completion Date	Prepared by	Implemented by	Review/Approval by	Applicable Policy/PS
<b>Dam Safety Plans</b>						
DS-1	Construction and Quality Assurance Plan	By appraisal (as TOR of Owner's Engineer)	THL	THL and Owner's Engineer	MMERE/WB	PS4 (OP4.37)
DS-2	Instrumentation Plan	Before tendering EPC (as part of PPA MFS and EPC contract)	THL	EPCC	MMERE/WB	PS4 (OP4.37)
DS-3	Operation and Maintenance Plan	Draft by appraisal; final 6 months before reservoir filling	THL	THL and O&M Contractor	MMERE/WB	PS4 (OP4.37)
DS-4	Emergency Preparedness Plan	Framework by appraisal; plan 1	THL	THL throughout PPA; O&M	MMERE/MECDM/WB	PS4 (OP4.37)

No.	Name	Completion Date	Prepared by	Implemented by	Review/Approval by	Applicable Policy/PS
		year before reservoir filling		Contractor during operation		
<b>Preparation Phase Plans</b>						
P-1	Construction ESMP (CESMP)	Before contractor mobilization	EPCC	EPCC	THL/MMERE/MECDM /WB/ADB	PS1
P-2	Biodiversity Management Plan	Before contractor mobilization	EPCC	EPCC, PC and O&M Contractor	THL/MMERE/MECDM /WB/ADB	PS6.OP4.04
P-3	Stakeholder Engagement and Communications Plan	Before contractor mobilization	THL	THL	MMERE/WB/ADB	PS1.PS4
P-4	Human Resources and Labour Management Plan	Before engagement of contractor employees	THL/EPCC	THL/EPCC	THL/MMERE/WB/ADB	PS2, PS4
P-5	Influx Management Plan	Before contractor mobilization	EPCC	EPCC	THL/MMERE/WB/ADB	PS2.PS4
P-6	Grievance Redress Mechanism	Before contractor mobilization	EPCC and THL	EPCC and THL	THL/MMERE/WB/ADB	PS1,PS2,PS4
P-7	Security Management Plan	Before contractor mobilization	EPCC and THL	EPCC and THL	THL/MMERE/WB/ADB	PS4
P-8	Worker's Health and Safety Plan	Before contractor mobilization	EPCC	EPCC	THL/MMERE/WB/ADB	PS2 EHS Guidelines
P-9	Workers Code of Conduct	Before contractor mobilization	EPCC	EPCC	THL/DMMERE/WB/ADB	PS2.PS4

No.	Name	Completion Date	Prepared by	Implemented by	Review/Approval by	Applicable Policy/PS
P-10	Community Health and Disease Vector Management Plan	Before contractor mobilization	EPCC	EPCC and THL	THL/MMERE/WB/ADB	PS4
P-11	Traffic Management Plan	Before contractor mobilization	EPCC	EPCC	THL/MMERE	PS1, PS4
P-12	Waste Management and Point Source Pollution Plan	Before contractor mobilization	EPCC	EPCC	THL/MMERE/WB/ADB	PS3 EHS Guidelines
P-13	Hazardous Materials Management Plan	Before contractor mobilization	EPCC	EPCC	THL/MMERE/WB/ADB	PS3 EHS Guidelines
P-14	Spill Prevention and Emergency Response Plan	Before contractor mobilization	EPCC	EPCC	THL/MMERE	PS1,PS3
P-15	Air Quality Management and Dust Control Plan	Before contractor mobilization	EPCC	EPCC	THL/MMERE	PS1,PS4
<b>Construction Phase Plans</b>						
C-1	Cultural Heritage Management Plan	Two months before land clearing	EPCC	EPCC	THL/MMERE/WB/ADB	PS8
C-2	UXO Management Plan	Before land clearing	EPCC	EPCC	THL/MMERE	PS1,PS2
C-3	Forest Clearance Plan	Before land clearing	EPCC	EPCC	THL/MMERE/MECDM /WB/ADB	PS6,OP4.04, OP4.36

No.	Name	Completion Date	Prepared by	Implemented by	Review/Approval by	Applicable Policy/PS
C-4	Post-construction Rehabilitation and Revegetation Plan	Before land clearing	EPCC	EPCC	THL/MMERE/MECDM	PS1,PS6
C-5	Quarry Management Plan	Before construction start	EPCC	EPCC	THL/MMERE/MECDM	PS1,PS2,PS4 EHS Guidelines
C-6	Reservoir Preparation Plan	Before biomass removal	EPCC	EPCC	THL/MMERE/MECDM /WB	PS1,PS6
C-7	Water Supply Replacement Plan	Before construction start	EPCC	EPCC	THL/MMERE	PS4
C-8	Watercourse Crossing Management Plan	Before land clearing	EPCC	EPCC	THL/MMERE	PS1
C-9	Spoil and Topsoil Management Plan	Before land clearing	EPCC	EPCC	THL/MMERE	PS1
C-10	Drainage, Erosion and Sediment Control Plan	Before land clearing	EPCC	EPCC	THL/MMERE	PS1
C-11	Drill and Blast Management Plan	Before construction start	EPCC	EPCC	THL/MMERE/MECDM /WB/ADB	PS2,PS4 EHS Guidelines
C-12	Stormwater Management Plan	Before construction start	EPCC	EPCC	THL/MMERE	PS1
C-13	Noise and Vibration Management Plan	Before construction start	EPCC	EPCC	THL/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

No.	Name	Completion Date	Prepared by	Implemented by	Review/Approval by	Applicable Policy/PS
<b>Operations Phase Plans</b>						
O-1	Operations ESMP (OESMP)	3 months before reservoir filling	O&M Contractor	O&M Contractor	MMERE/MECDM/WB/ADB	PS1
O-2	Reservoir Operation & Management Plan	3 months before reservoir filling	O&M Contractor	O&M Contractor	MMERE/MECDM/WB/ADB	PS1,PS6
<b>Decommissioning Phase Plans</b>						
D-1	Decommissioning Plan	1 year before station closure	PC (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	PC (SIG, if it continues to operate after PPA period)	THL	MMERE	PS2
<b>Transmission Line Plans</b>						
T-1	ESIA/ESMP	Before start of construction	SIEA	SIEA	MMERE/MECDM/WB/ADB	OP4.01,4.04,4.10,4.11,4.36 EHS Guidelines
T-2	LALRP	Before right of way clearance	SIEA	SIEA	MMERE/WB	OP4.10, 4.12
<b>Monitoring Plans</b>						
M-1	Suspended Sediment Monitoring Plan	Before land clearing	EPCC	EPCC and THL	THL/MMERE/MECDM/WB/ADB	PS1,PS

No.	Name	Completion Date	Prepared by	Implemented by	Review/Approval by	Applicable Policy/PS
M-2	Water Quality Monitoring Plan	Before land clearing	EPCC	EPCC and THL	THL/MMERE/MECDM /WB/ADB	PS1
M-3	Fish, Algae, and Macro-Invertebrate Monitoring Plan	Before land clearing	EPCC	EPCC and THL	THL/MMERE/MECDM /WB/ADB	PS6
M-4	Social Impacts Monitoring Plan	Before contractor mobilisation	TRHDP-PO	TRHDP-PO	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	THL/MMERE/MECDM /WB/ADB	PS1
M-7	Air Quality and Noise Monitoring Plan	Before land clearing	EPCC	EPCC	THL/MMERE/MECDM /WB/ADB	PS1,PS3

*THL – Tina Hydropower Limited*

*EPCC – Engineering Procurement and Construction Contractor for the Tina River Hydro Project*

*SIG – Solomon Islands Government*

*TRHDP PO – Tina River Hydropower Development Project, Project Office*

*MMERE – Ministry of Mines, Energy and Rural Electrification*

*MECDM – Ministry of Environment, Climate Change, Disaster Management and Meteorology*

*WB – World Bank*

*ADB – Asian Development Bank*

**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.

## 12.6 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. 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.

## 12.7 COMMUNITY BENEFIT SHARE

TRHDP Office [had prepared](#) a benefit 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 scheme.

### 12.7.1 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.

### **12.7.2 Operational Period Community Benefit Share Fund**

The structure of the ongoing benefit sharing package is already finalised. The flow of finances from the benefit sharing scheme will be associated with the flow of funds under the Power Purchase Agreement, but the precise methodology has yet to be agreed. The magnitude of funds will be calibrated so as to enable investments in community development that will result in significant impacts.

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:

- 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.

## **12.8 LAND ACQUISITION AND LIVELIHOOD RESTORATION PLAN (LALRP)**

### **12.8.1 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 Lungga 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 Lungga 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.

### **12.8.2 Summary of the LALRP**

#### **12.8.2.1 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.

#### **12.8.2.2 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.

## **12.9 INSTITUTIONAL RESPONSIBILITIES FOR ESMP IMPLEMENTATION**

A full description of Government, NGOs and Stakeholders, and their roles with respect to this ESIA, is set out in Section 5.1 – Institutional Framework. This section describes the roles and responsibilities of key actors with respect to the implementation and oversight of the ESMP.

## **12.9.1 Construction and Operation Contractor (Developer)**

### **12.9.1.1 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 Special Purpose Company (THL), 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 Access Road or Transmission Lines which are intended to lie with the road design/construction contractors and Solomon Power respectively. However, the Developer is responsible for operational measures relating to the use of the Access Road and for the maintenance of the road from Mengakiki to the dam site (during the BOOT period) and from the Black Post turnoff to Mengakiki (until commissioning).

The required ESMP list will form an annexure to the Power Purchase Agreement (PPA) between Solomon Power and the THL and is also proposed to form part of the Implementation Agreement between SIG and the THL. Compliance with the ESMP will become a contractual obligation and Solomon Power and SIG will hold contractual rights to enforce these requirements.

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 is anticipated to 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 EPC 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.

### **12.9.1.2 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.

## **12.9.2 TRHDP Project Office**

### **12.9.2.1 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 12-2](#).
- Undertake audits; 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.

### **12.9.2.2 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 others 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.

### **12.9.3 Environment and Conservation Division of MECDMM**

#### **12.9.3.1 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.

#### **12.9.3.2 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 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.

## **12.9.4 Solomon Power**

### **12.9.4.1 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.

### **12.9.4.2 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.

## **12.9.5 Road Design and Road Construction Contractors**

### **12.9.5.1 Role**

The Access Road upgrade and construction from the Black Post turn off to the dam site shall be designed and constructed by contractors engaged by the Ministry of Mines, Energy and Rural Electrification.

As a component of the road design contract, the road design consultants shall prepare a stand-alone environmental impact assessment report for review and approval by MECDMM under the *Environment Act*. This EIA shall incorporate the conditions of this ESMP document.

The road design contractors shall incorporate access road design measures, including culverts and drainage measures, into the final road design.

The road construction contractor has not yet been engaged. Contractual arrangements will require the contractor to comply with the measures set out in this ESMP and the detailed stand-alone access road EIA to be completed as a component of the road design contract.

### **12.9.5.2 Capacity**

Contractors selected through international tender are anticipated to have sufficient skills and experience to implement the mitigation measures.

## 12.9.6 Ministry of Infrastructure Development

### 12.9.6.1 Role

The Ministry of Infrastructure Development (MID) plays a role in maintaining the access road from the Black Post turnoff to Managikiki once the Project is commissioned.

### 12.9.6.2 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.

## 12.10 IMPLEMENTATION SCHEDULE AND BUDGET

### 12.10.1 Budget

K-Water 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 34 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.

### 12.10.2 Contractual Arrangements

The environment and social safeguard measures will be accommodated and enforced through contractual and approval arrangements between institutional actors [Table 12-3](#) sets out the key project agreements and actors.

Table 12-3 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)	EPC	THL
Financial Agreements	SIG (Ministry of Finance)	Financiers

Project Agreements	THL	Financiers
Development Consent	THL	MECDM
Subsidiary Finance Agreement	Solomon Power	SIG
Project Agreement (Transmission Line)	Solomon Power	Financiers
Works Contract	Road Contractor	MMERE

## 12.11 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.

## 12.12 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. 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 reviewed for adequacy by the TRHDP PO. As required by law, the document will then form part of the constructor's Environment Impact Statement to be reviewed and assessed by the Ministry of Environment, Climate Change, Disaster Management and Meteorology prior to the granting of development consent under the *Environment Act*.

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.

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; 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.

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## 13. CUMMULATIVE IMPACT ASSESSMENT (CIA)

This section provides a cumulative impact assessment (CIA) for the TRHDP.

### 13.1 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.

### 13.2 SCOPE AND METHODOLOGY OF THE CIA

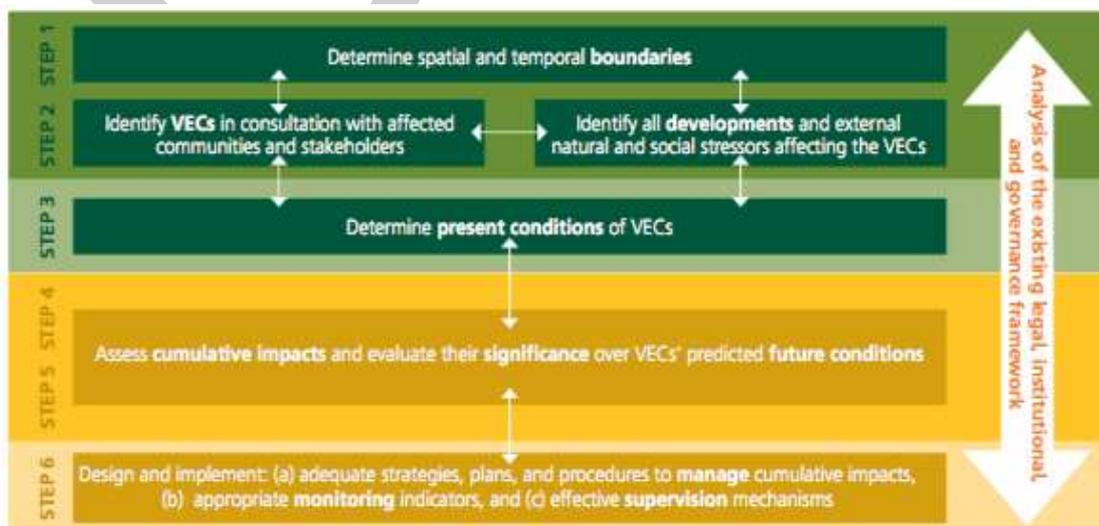
The CIA for the TRHDP examines the cumulative impacts of the Project against past, present and reasonably foreseeable projects and activities within the Tina/Ngalimbiu River catchment.

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 ( VECs).

The six-step process used to undertake the CIA is illustrated in Figure 13-1.

Figure 13-1 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.

## **13.3 ENVIRONMENTAL AND SOCIAL CONTEXT**

### **13.3.1 Regional Context**

#### **13.3.1.1 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<sup>2</sup>. 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.

#### **13.3.1.2 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<sup>2</sup>, 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).

#### **13.3.1.3 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.

#### **13.3.1.4 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<sup>2</sup> 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).

### 13.3.2 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<sup>19</sup> 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.

### 13.3.3 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.

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<sup>19</sup> 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.

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

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).

## **13.4 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.

### **13.4.1 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 13-1.

Table 13-1 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
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

VECs	Rationale for Selection	Area of Influence Boundaries	
		Spatial	Temporal
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

### 13.4.2 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.

#### 13.4.2.1 Mining Activities

##### 13.4.2.1.1 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<sup>2</sup> (see Figure 13-2). 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.

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.

#### **13.4.2.1.2 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.

#### **13.4.2.2 Oil Palm Plantation Activities**

##### **13.4.2.2.1 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 (dimethylamine 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.

##### **13.4.2.2.2 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.

### **13.4.2.3 Timber Harvesting Activities**

#### **13.4.2.3.1 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. Since logging is a poorly documented activity, the full extent of both social and environmental impacts is difficult to assess.

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.

#### **13.4.2.3.2 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.

### **13.4.2.4 Gravel Extraction in the Ngalimbiu River**

#### **13.4.2.4.1 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).

#### **13.4.2.4.2 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.

#### **13.4.2.5 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.

### **13.4.3 Assessment of Cumulative Impacts**

#### **13.4.3.1 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 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. 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.

#### **13.4.3.2 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 Ngalmibu 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.

#### **13.4.3.3 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 flare 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.

#### **13.4.3.4 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.

#### **13.4.3.5 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.

#### **13.4.3.6 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.

#### **13.4.3.7 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.

#### **13.4.3.8 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.

#### **13.4.3.9 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.

#### 13.4.3.10 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.

### 13.5 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.

### 13.6 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.

### 13.7 CONCLUSIONS ON CUMULATIVE IMPACTS

A summary of the CIA analysis is presented in [Table 13-2](#).

Table 13-2 CIA summary

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				Cumulative impacts along the Ngalimbiu River

Impacts of TRHDP	Timber Harvesting	GPPOL Oil Palm	Gold Ridge Mine	Gravel Extraction
Disturbance to aquatic habitats and aquatic life during construction	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	Aquatic habitat disturbance from drainage of the palm fields in the Ngalimbiu River Catchment	If new gold mines are exploited in the SPL 194, there is a high risk of cumulative impacts in the Tina/Ngalimbiu River Catchment	
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

<b>Impacts of TRHDP</b>	<b>Timber Harvesting</b>	<b>GPPOL Oil Palm</b>	<b>Gold Ridge Mine</b>	<b>Gravel Extraction</b>
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 Catchment if SPL 194 is developed	Major increase of turbidity in the Tina/Ngalimbiu River Catchment

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

## **14. 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.

### **14.1 IMPACTS OF SEVERE WEATHER OR CLIMATE RELATED EVENTS**

The occurrence of severe weather or climate related events would have an impact on the project. Impacts of severe weather or climate related events is comprehensively discussed in Chapter 7-Climate Change of this EIS report.

### **14.2 IMPACTS OF SEISMIC EVENTS**

As noted in Section 6.2.4, 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 14-1 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 unlikely event 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 14.2. An earthquake could also cause trees to topple over and block the access road, or knock out the transmission line.

## 14.3 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 6.2.4, a significant number of landslides occur within the Tina River catchment, particularly on the steeper slopes. However, they remain relatively small (100m<sup>3</sup> to 200m<sup>3</sup>), 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

## 14.4 DAM SAFETY

The World Bank's operational policy 4.37 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 12 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 Assurance 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.

## **14.5 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.

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## **15. PUBLIC CONSULTATION AND INFORMATION DISCLOSURE**

This Chapter outlines the public and stakeholder involvement in preparation of the TRHDP ESIA. The purpose of public consultation and stakeholder engagement during the Environmental Impact Statement (EIS) process is to ensure that all relevant stakeholder are aware of the TRHDP, and have the opportunity to comment on issues of relevance to them.

As part of the assessment process, consultation was conducted with the local community and other relevant stakeholders within the affected area of the project. A range of consultation activities has been undertaken throughout the project's ESIA preparation phases. The consultation program was developed to ensure that all issues and concerns raised by the affected communities and stakeholders were considered in developing the ESIA.

Detailed activity for public consultation and information disclosure was written in section 10.

## 16. DIFFICULTIES ENCOUNTERED

It is a requirement in the environmental impact statement (EIS) development process to provide an indication of any difficulties encountered by the project proponent in compiling the required information. No major/significant technical difficulties were encountered in preparation of this ESIA report.

A difficulty encountered during the process of developing this ESIA is the lack of published information and data about certain aspects of the project area. To address this, supplementary special studies were conducted to obtain additional information and input from specialists.

Several difficulties were encountered when undertaking the water quality study, including but not limited to the following:

- 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.

The quality of analyses by SIWA Laboratory could not be verified, since blank samples needed for quality control, were lost by the laboratory.

Fish biodiversity in the Tina River system is difficult to assess with certainty, given the following:

- Scientific information on the fish of Solomon Islands is still poor, with taxonomic uncertainty and absence of field guides.
- 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.

## 17. CONCLUSIONS AND RECOMMENDATIONS

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 **53 m (river bed-cres)** 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 12) of this ESIA.

The most significant potential impact is the barrier presented by the 72.5m 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 tCO<sub>2</sub>e/year. The estimated net GHG emissions abated attributable to the operation of the TRHDP

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