C-7 Water Supply Replacement Plan

Aim and Objective

The aim of **C-7 Water Supply Replacement Plan** (WSRP) is to set out the approach to managing and mitigating the actual or potential impacts of the Project on the quality and quantity of community water sources as identified in the Project's Environmental and Social Impact Assessment (ESIA; 2019). This WSRP incorporates a minimum of 33 communities whose water supply may be impacted by the construction of the Project (**Annex C-7-1**), providing a temporary source during construction.

Summary of Impacts and Risks

Villages in and around the Project area rely on community water supplies which comprise of rainwater tanks, groundwater wells, springs, streams, and rivers, including the Tina River. During construction, it is possible that community water supplies may become contaminated or degraded as a result of the Project. The associated impacts and risks include:

- Perceived risks of contamination to community water supplies, whether or not this actually eventuates.
- Potential loss of access to clean and potable water due to river pollution, contamination and sedimentation;
- Potential impacts on people's health and wellbeing including outbreaks of gastrointestinal diseases and skin infections.
- Limited availability or access to alternative clean and potable water.
- Community grievances and political opposition due to actual or potential contamination of water supplies.

Note that the WSRP is to be implemented in conjunction with **P-1 Construction ESMP**, **P-6 Grievance Redress Mechanism, P-12 Waste Management and Point Source Pollution Plan**, **P-14 Spill Prevention and Emergency Response Plan**, **C-10 Drainage, Erosion and Sediment Control Plan**, **M-1 Suspended Sediment Monitoring Plan**, and **M-2 Water Quality Monitoring Plan**.

Mitigation and Management Actions

#	Issue or Risk	Action	Timing / Frequency	Responsibility
C-7-1.	Actual or perceived impacts to water supply from construction.	• Alternate water supplies will be provided by the contractor where construction activities are likely to adversely impact its current water supply. The communities supplied shall include the 33 villages identified in the ESIA 2019 (refer **Annex C-7-I**), the 7 additional downstream villages identified in the Water Source Replacement Plan 2021 (**Annex C-7-II**), plus any additional villages that are impacted through the course of construction. • Villages supplied water through the Community Benefic Sharing Project (CBSP) shall be excluded from the above requirement, to avoid duplication.	Along access roads: Prior to commencement of Lot 2 and 3 construction. River communities: before Main Works	HEC HSE Manager HEC CLOs CBSP PO
C-7-2.	Alternative water supply equipment does not meet applicable standards.	• Temporary water sources (at a minimum) will be supplied or installed during the construction phase, to address the daily demand based on the permanent population of each village (refer **Annex C-7-I** and **Annex C-7-II**). • Alternative water supplies for drinking water shall meet WHO drinking water standards. • The standards and quality of the equipment used in the water supply replacement are to meet local legislation and international standards. All equipment is to be installed under the specification of the manufacturer and by fully experienced, reputable and/or qualified technicians. • All water sources and equipment shall be monitored and maintained by the Project throughout construction to ensure the system is operational and water is fit for human consumption (as per WHO guidelines). Any repairs or rectifications necessary are to be performed in a timely manner by the Project, at the Project's cost, to ensure continuity of supply. • Where any intentional damage or modification to water supplies is done by communities, this shall be resolved through the **P-6 Grievance Redress Mechanism**.	Throughout construction	HEC HSE Manager
C-7-3.	Adverse effects on water quality from construction	• Implement the requirements of all ESMPs including but not limited to **C-10 Drainage, Erosion and Sediment Control Plan, P-12 Waste Management and Point Source Pollution Plan**, **P-14 Spill Prevention and Emergency Response Plan.** • Rehabilitate disturbed areas as soon as practicable in accordance with **C-4 Post-construction Rehabilitation and Revegetation Plan**.	Throughout construction	HEC HSE Manager
C-7-4.	Community complaints or disputes	• Engagement activities are to be undertaken in affected communities in accordance with **P-3 Stakeholder Engagement and Communications Plan** to ensure awareness and understanding of the Water Supply Replacement Programme, the proposed water supply system to be installed, along with the monitoring and maintenance process. Awareness raising of the Water Supply Replacement Programme versus the Community Benefit Sharing Programme shall also be undertaken. • Socialisation and implementation of **P-6 Grievance Redress Mechanism**.	Throughout construction	HEC HSE Manager HEC CLOs CBSP

Monitoring Requirements

#	Title	Description	Target / Performance Indicator	Timing / Frequency	Responsibility
C-7-A.	Water Source Replacement	• Replacement water supplies to be provided to the 33 villages identified in the ESIA 2019 (refer **Annex C-7-I**), the 7 additional villages identified in the Water Source Replacement Plan 2021 (**Annex C-7-II**), plus any additional villages that are impacted.	Water supplies provided to all identified communities Volumes are adequate for the permanent population served	Prior to commencement of Main Works	HEC HSE Manager THL/OE (review)
C-7-B.	Operations and maintenance	• Monthly checks of all water supply replacement systems to ensure ongoing adequacy for the community during the Project construction period.	System fully operational with sufficient water All repairs completed promptly	Monthly monitoring Reported in HEC Monthly Project and Quarterly E&S Reports	HEC HSE Manager
C-7-C.	Water quality monitoring	• Monthly water quality monitoring of all replacement water supplies used for drinking.	Drinking water supplies to meet WHO guidelines. If trigger values exceeded, corrective actions are taken	Monthly monitoring Reported in HEC Monthly Project and Quarterly E&S Reports	HEC HSE Manager

Supporting Documents		
Annex	**Name**	**Description**
C-7-I.	Water Supply Affected Communities	Table and map of water supply affected communities on the Tina River, identified in the ESIA 2019.
C-7-II.	Water Source Replacement Plan	Water Source Replacement Plan (Revision 1) prepared by Inogen and dated 19 August 2021 and approved for Lot 2 and 3.[1] Water Supply Replacement Plan Status Report prepared by HEC dated 20 December 2022.[2]
C-7-III.	Groundwater Impact Assessment	Groundwater Impact Assessment Report (final in tracked changes) prepared by Inogen and dated 17 November 2022. Cleared by Owners Engineer on 03 March 2022.

[1] The draft Water Source Replacement Plan covers 25 communities, including 21 of the 33 villages identified in the ESIA 2019, plus 7 additional communities. It provides recommendations for supplies but does not provide a plan for implementation.
[2] This document appears inconsistent with the requirements of the ESIA (2019) and Water Source Replacement Plan (2021). The requirements of the original 2021 report still apply.

ANNEX C-7-I WATER SUPPLY AFFECTED COMMUNITIES

AFFECTED COMMUNITIES IDENTIFIED IN THE ESIA (2019)

Table of Water Supply Affected Communities on the Tina River

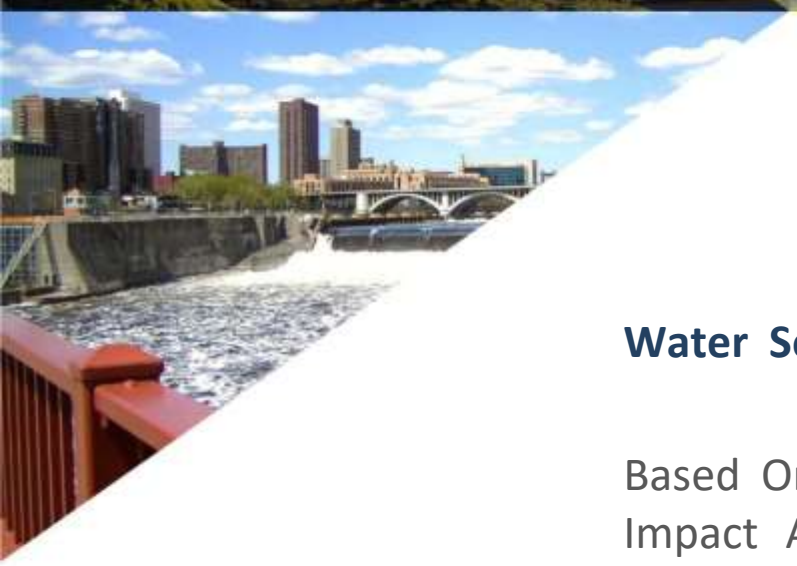
Communities & affiliation that rely on Tina River for their domestic use and/or as a drinking water supply	Villages/ hamlets	2013 households (approx.)	2013 population (approx.)
Senge community	Senge	3	16
	Choro	1	4
	Koropa	3	19
Pachuki community	Pachuki	14	65
	Habusi	6	33
Namopila comm.	Namopila	5	27
	Komureo	6	28
	Vatunadi	1	5
	Valekocha	5	26
Antioch community	Antioch	23	110
	Valesala	20	105
	Kolanji	2	10
	Komeo	0	0
Tina community	Tina	23	104
	Valebarik	6	22
	Valebebe	22	104
	Tahurasa	5	15
	Valemaota	4	12
Vuramali comm.	Vuramali	18	70
	Haimane	26	111
	Horohotu 2	17	84
	Vuvamali	16	77
Horohutu comm.	Horohotu 1	12	60
Verakuji community	Verakuji	11	56
	Managikiki	21	111
Marava community	Marava	28	168
	Ngongoti	1	20
	Vatupaua	5	50
	Rate school	?	?
Vera'ande community	Vera'ande	6	30
	Verakweli	6	24
	New Mahata	2	15
Verakabikabi comm.	Verakabikabi	44	219
Total		**362**	**1800**

Map of Tina River dependent affected communities

ANNEX C-7-II WATER SOURCE REPLACEMENT PLAN







Water Source Replacement Plan

Based On Community Water Source and Impact Assessment Report prepared by Prime Engineers and Builders of Honiara

19.08
2021

INOGEN ALLIANCE

EXECUTIVE SUMMARY

HEC appointed Prime Engineers and Builders of Central Honiara to prepare a Community Water Source Survey and Impact Analysis Report. This is now referred to as the Water Source Replacement Plan (C7 WSRP) which has been reviewed and upgraded by INOGEN on behalf of HEC. The attached report is the INOGEN revised version and includes this Executive Summary prepared by INOGEN supported by amendments, updates, restructuring and formatting of the original report.

At the outset it should be mentioned that increase in sediment in the river waters which are the most frequently used sources used by the communities appears to be their greatest water quality concern. These sediments originate not only from the Tina River upstream of the damsite but from all the downstream tributaries entering the river system including the Toni River which coalesce to form the Ngalimbui River. Sediment in itself is not a health issue, it is an aesthetic issue where colour, taste and odour are found objectionable and strong grounds for rejection unless filtered. The World Health Organisation states that to a large extent, consumers have no means of judging the safety of their drinking-water themselves, but their attitude towards their drinking water supply and their drinking-water suppliers will be affected to a considerable extent by the aspects of water quality that they are able to perceive with their own senses. It is natural for consumers to regard with suspicion water that appears dirty or discoloured or that has an unpleasant taste or smell, even though these characteristics may not in themselves be of direct consequence to health. The appearance, taste and odour of drinking-water should be acceptable to the consumer. Water that is aesthetically unacceptable can lead to the use of water from sources that are aesthetically more acceptable, but potentially less safe. Where the river is used for drinking water supply (**Figure ES-1**) it is subject to flooding and sedimentation.

Figure ES-1 Tina River at Habusi, used for drinking water supply

A preliminary construction schedule was prepared in 2019 at the time when construction was planned to start. The schedules relating to road construction, river diversion and dam construction are summarised on Table 5.1 in the main report. They indicate that road construction will commence 5 months after project go-ahead and continue until month 30. The major construction activities at the Dam will commence at Month 12 and continue through until Month 42. Therefore increased sedimentation along the Tina River and downstream to the Ngalimbui River will potentially be experienced from Months 5 to 42.

Although sediment concentrations are likely to increase during certain periods of construction HEC is developing erosion and sediment control plans (C10 Drainage, Erosion and Sediment Control Plan) which should effectively reduce the frequency and intensity of sediment discharges originating upstream of the damsite and hopefully alleviate to some extent the concerns of the community. A second important point is that during this pre-construction period microbial testing shows unacceptably e-coli concentrations for drinking water particularly in the lowlands with total coliforms exceeding 4,000 mg/l. Swimming and bathing in the rivers are also a potential sources of water related infections such that over time other permanent supplies of clean water should be made available through the Community Benefit Support Programme (CBSP). The Community Health Survey identified the prevalence of abdominal pain (31%) which could be the result of exposure to gardia in river waters, diarrhea (7%) and skin rashes (8%). These infections are all related either to drinking or exposure to contaminated water. Microbiological analysis on 27 sources was conducted in August 2020 during a community water quality survey and confirmed that the majority were contaminated by e-coli. The area of the survey lies within the Good Samaritan Health Zone 6 which is part of the annual Guadacanal Health Surveys with data available for 2017 to 2019. Zone 6 accounted for 91 villages and 22,046 population but other than malaria the incidence of other water borne diseases is not recorded.

Streamflow was recorded at a gauging station upstream of the damsite from 15 June 2010 to 21 September 2013 as reported and analysed in the ESIA (**Table ES-1**). The average monthly flow over the period, Error! Reference source not found., ranged between 9 and 22 cumecs with an absolute minimum of 2.85 cumecs. After dam construction the flow will be regulated, an environmental flow of 1 cumec maintained between dam and powerhouse and discharge from powerhouse of between 3.4 and 19 cumecs. After construction the risk of flooding and associated sedimentation from the catchment upstream of the dam reduces considerably but of course continues to remain a concern for the downstream tributaries. During the "dry" season of May to August rainfall is still reasonable at about 100 mm each month (**Figure ES-2**) and maintains the river flow.

Table ES-1 Average Pre-Construction monthly flow (cumecs) in Tina River upstream of Damsite

Month	Average	Minimum	Maximum
January	13.87	5.97	120.94
February	21.48	4.96	342.38
March	21.94	6.55	233.54
April	18.23	5.04	141.84
May	14.27	4.53	201.50
June	8.69	3.83	185.64
TJuly	10.55	3.42	222.93
August	10.81	3.01	234.85
September	11.62	2.85	220.06
October	12.90	3.91	176.93
November	17.12	3.26	445.62
December	20.46	4.83	298.33

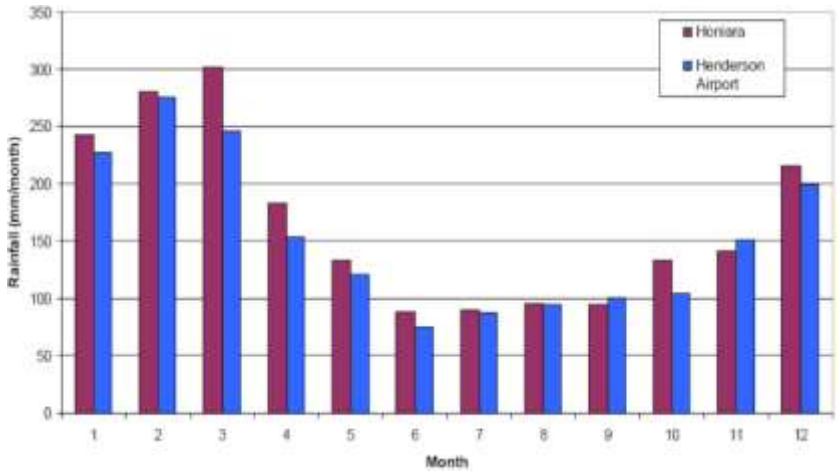


Figure ES-2 Monthly Rainfall

A total of 30 villages (**Figure ES-3**) were surveyed within/around the Project Area potentially impacted by construction activities associated with building new roads, upgrading existing roads and works at powerhouse and damsite. The survey identified all water sources used by the community and provided details such as coordinates, description of the sources, distance from community and water use (Appendix B of main report). This data was used by HEC's subcontractor to prepare a risk assessment of potential disruption or damage to the sources with a ranking ranging from not applicable to low, medium, high and extreme (Appendix C of main report) with an impact and mitigation assessment being made for each source. Use of the designation extreme can be questioned, highest risk is preferred for those sources which attract early mitigation and temporary water supply replacement.

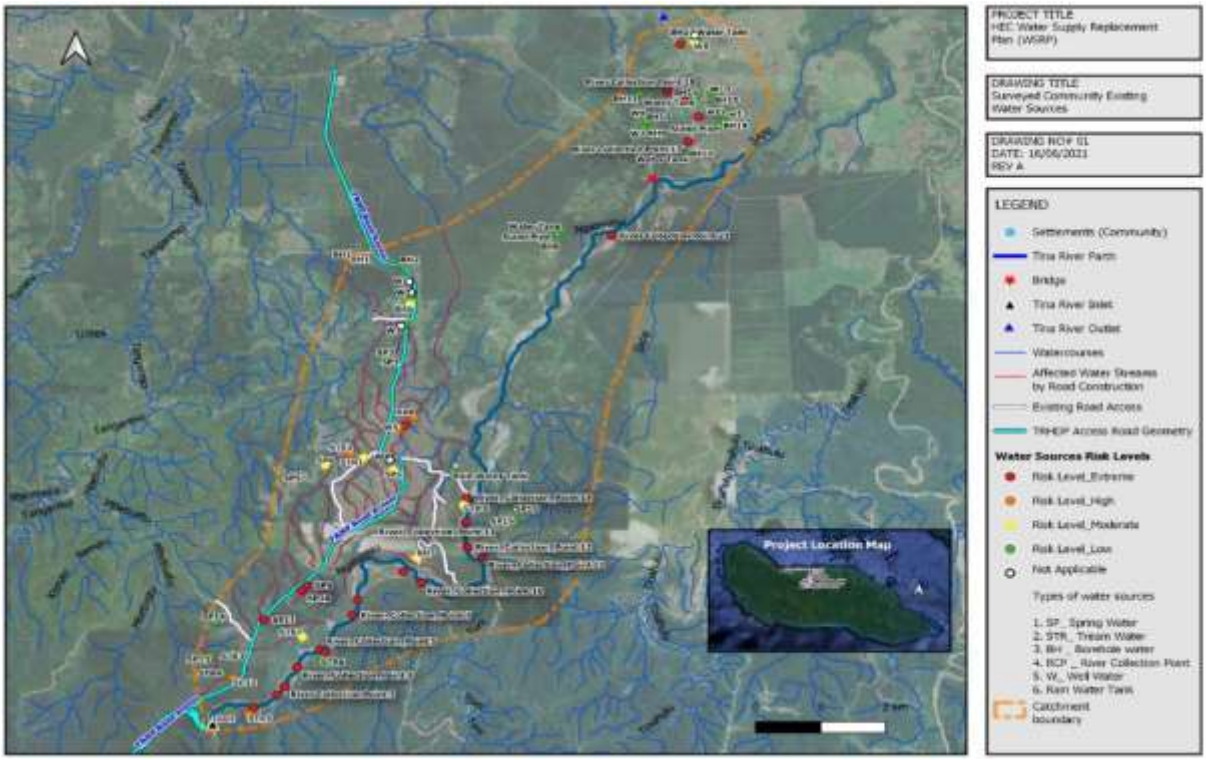


Figure ES-3 Water Source Survey

Sources are subdivided into various categories and some photos of typical installations together with water quality analyses are included in Appendix E of the main report.

- River water catchments along the banks of the Tina and Ngalimbui Rivers. These are shallow pits on the banks of the rivers which effectively filter out sediments from the turbid river waters and are used for drinking water and other purposes. Water is not taken directly from the rivers, but the rivers are commonly used for bathing, swimming and ablutions. During river floods the river becomes dangerous to access and also water sources can be damaged by flood waters.

Figure ES-4 River Collection Point Valekocha

- Streams are used as water sources, and these are generally of better quality than the river water in terms of sediment but as they are also used for bathing and ablutions the water could be contaminated with coliforms.
- Springs are also commonly used but are often very low supply and some distance from the communities. Their discharge varies seasonally and several fail during the dry season. Observations supported by analyses indicate that in some springs the water is of poor quality. In many cases the springs are at lower elevation than the communities and to develop as permanent supplies requires catchment protection at source then pumps, pipeline and tanks to transport the water and store within the villages. To install these facilities could have land title issues. One system has been installed at Verakai & Managikiki Village for the Managikiki spring to be used for washing and shower, only occasionally for drinking. There is a pipe here and diesel pump purchased in September 2019 that the village installed with the intention of pumping water up to the top of the hill. The pump discharge head (26 m) is too low to meet the actual discharge head of 136 m. Also the spring has a high count of E.coli bacteria. CBSP is proposing to develop several springs for community supply, the Posasa spring (**Figure ES-5**) is an example.

Figure ES-5 Posasa spring at Morava proposed for development by CBSP

- Groundwater is tapped from shallow large diameter wells and deeper smaller diameter boreholes. It should be understood that the alluvial plain constitutes an extensive aquifer system with high annual recharge and realistically there are no limits on how much groundwater can be abstracted from this aquifer for community water supply, refer Groundwater Impact Assessment. Total potential demand is a fraction of the volume of groundwater held in storage and annual recharge.
- Shallow wells are reasonably common on the floodplain along the lower reaches of the river system and generally about 5 m deep. They are equipped with hand pumps, diesel pumps and in one instance a solar powered pump. These wells are not maintained, the water is in most cases contaminated with coliforms and pump failure is common. Funds for purchase of diesel fuel are limited and the pumps often stand idle.

Figure ES-6 Dug Well at Taona

- Deeper boreholes have also been constructed on the floodplain to depths of up to 20 m. Similar problems are experienced with maintenance, pump failure and lack of funds for fuel. At Vera'ande, one of the few villages relatively well serviced by a variety of water sources a borehole (**Figure ES-7**,

depth not recorded) has been equipped with a solar pump and automatic water level controller and provides 20 lpd each to a number of households in the village. Date of installation is not recorded but the system appears to be working well and the water quality survey indicated that this is one of the few installations with low total coliform and e-coliform counts.

Figure ES-7 Solar pump on borehole at Vera'ande.

- Rainwater tanks are also reasonably common. They provide a sustainable supply of freshwater suitable for drinking, cooking and washing. Providing the communities have adequate training on maintenance and avoid excessive use of the water during dry season then rainwater provides a sustainable supply of freshwater suitable for drinking, cooking and washing.

Figure ES-8 Rainwater catchment from church roof, Old Selwyn

Figure ES-9 Community rainwater catchment, Old Selwyn

The minimum monthly rainfall during dry season is 100 mm and a roof catchment of 6 m by 6 m can yield up to 3,600 litres per month during dry season, considerably more during wet season. Each household has between 8 and 10 occupants so with suitable restrictions on use a single house roof can provide 120 lpd per household or about 12 lpd per capita. Depending on the number of households in a village, additional tanks can be installed and where there are churches, community halls and/or schools the roof area is larger. Based on published data on water consumption (**Table ES-2**) in rural areas the preferred supply is 50 lcpd but in some areas this is 20 to 25 lcpd reducing to 10 lcpd where supply is limited. Within the project area the largest demand is for ablutions and gardens where sediment is not an issue, and this is generally met from by the rivers. On that basis a supply of 12 lcpd can meet the freshwater demand within the communities.

Table ES-2 Typical rural water use (litres per capita per day)

Drink cook	Dish wash	House wash	Clothes wash	Bath shower	Garden	Toilet	Pool	Max.	Tina River
4	3	1	3	20	18	0	0	49	11

The results of the survey indicate that water is carried from source to community by women and children, often along steep slippery paths infested with centipedes and snakes using 1.5 L bottles and 20 L containers, on average about twice per day but where access is difficult only once per day. Some households state that they use 20 to 25 lpd from individual sources. This equates to about 20 to 50 L per household per day (3 to 6 lcpd) and confirms that the above estimate of water useage at 11 lcpd is conservative.

The remit of HEC is to provide temporary supplies of water to communities over the period when construction activities may increase sedimentation in the rivers. Additionally existing sources will need to be protected during road construction such that mitigation measures need to be developed for springs, wells and boreholes which the Risk Assessment considers may be potentially impacted. Should the existing sources be damaged then HEC will be obliged to either reinstate, replace or support CBSP in their plans to construct permanent clean water sources. Initially the Highest Risk communities will be addressed and three of these, Ngongoti, Verakambilkambi and Valesala (Antioch) have already been provided with water tanks (**Figure ES-7**) currently serviced from the existing borehole at the Camp site and later from deep boreholes to be installed at Camp and Office during the period of construction.

An allocation of 20,000 lpd has been made for community supply during construction. Water tanks are the preferred temporary water supply replacement plan. Of the 30 communities surveyed, except for seven which are located on the floodplain area, only 12 are accessible by truck, the remaining 11 will require the water tanks to be placed at the most accessible point to the village, likely to be equal or less walking distance than from existing river, stream and spring sources. It is recommended that at the Highest Risk locations the CBSP install rainwater roof catchments as soon as practicable which will then allow the tanks to be relocated to the villages.

The downstream village water sources were first surveyed in 2019 and HEC's local water engineer has recently undertaken another survey of water sources which may potentially be impacted by access road construction and main works. INOGEN will use these survey details to revisit and update the preliminary risk and mitigation matrix presented in Appendix C of the main report. The intention will be to provide temporary water supply replacement where required, protect existing water sources and improve water quality. Note that this more recent survey indicates that communities have significantly reduced their dependence on river waters.

After agreement with Lenders and OE an Action Plan will be prepared in which the Works to be undertaken by HEC will be detailed.

The community has expressed a preference for boreholes and solar pumps and clearly this will need to be addressed by CBSP. It is our considered opinion that this is not a preferred solution given the cost and maintenance requirements and very limited experience with these systems to date. Where springs are returning negative coliform counts then these may also be adapted for permanent supply by CBSP.

The CBSP is a supplementary project running concurrently with the Temporary Water Supply Replacement Plan and will provide permanent water systems for communities within the project region of Bahomea and Malango. Eighteen community-based water packages have been identified in total and will be covered under the CBSP. As far as practicable the Temporary Water Replacement Sources to be installed by HEC should be upgraded by CBSP and integrated with their Permanent Water Supply Programme.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

1.1 Background

The project has a Management Plan named C7 Water Supply Replacement Plan (WSRP) to set out HEC's approach to manage and mitigate the impacts of the Project on the quality and quantity of downstream/down gradient water sources during construction of roads and at the damsite and powerhouse. However, it lacked in details and verification, additional information through field and desktop survey was required as instructed by the stakeholders.

Accordingly, Prime Engineers and Builders Company was subcontracted to conduct additional surveys and assessments of the water sources in the communities around the Tina River Hydropower Development Project and downstream communities along the Tina/Ngalimbiu River. The report comprises results and plans to manage and mitigate residual impacts of the project on the quality and quantity of downstream/down gradient water sources.

It is foreseen that the results of these assessment works will form input to the C7 Water Supply Replacement Plan (WSRP) to help design reliable water supply options for the communities in the region as mentioned in the terms of reference document.

This report provides detailed information through field and desktop survey of the water Supply replacement plan of the project and other associated surveys conducted in the past for all the water sources and captured all the issues as specified below:

- Acquire catchment data to understand the hydrology of the region. This will help in planning mitigation strategies and allow existing sources to be used to compensate other affected sources and wherever applicable.
- Water demand/consumption including for on-potable use is still the element.
- Conduct Feasibility Study and validate hydrological mapping data, particularly for villages with water supply sources that may be impacted by construction activities of Access Road or Main dam.
- The Plan will recommend feasibility and design studies.

This report concerns the provision of carrying out water supply replacement survey of communities in the Tina River catchment and the downstream villages along the Tina/Ngalimbiu River. The findings of the survey will demonstrate the following:

a. Water source availability
b. Water source impact analysis
c. Water source protection
d. Community water sources affected by access road construction
e. Community water sources affected by main dam construction

Therefore, as all the issues about community water sources are believed to have been captured, the information's about the catchment area has been examined including hydrology data and report on the existing Community water sources. In addition, the report will be helpful to carry out the impact analysis and mitigation measures for each water source for the C7 Water Supply Replacement Plan (WSRP).

1.2 Overview

The construction of new roads and upgrading of existing roads may disturb and damage existing water resources used by villages adjacent to the road (e.g., Marava, Vera'ande, Verakabikabi, Valesala/Antioch, Verakuji, and Mangakiki). The construction of the new section of road near Marava may also damage the catchment area for the Verakabikabi water supply, and minimally, will impact the water quality. Water quality may also be reduced due to the construction activities at the dam and powerhouse.

During the ESIA study period, 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.

The village workshops and the household survey both enquired into local water supplies. Households typically listed three sources of freshwater for drinking and cooking, the Tina River (as naturally filtered water) or an adjacent stream, and rainwater. Half the respondents said that their household used rainwater. However, there were relatively few rainwater tanks in evidence throughout the villages and presumably this referred to buckets or other utensils. Another 39% of households said that they obtained their water from a local well.

Those who take their drinking water from the river use a natural filtration method for ensuring clean water: they dig a hole in the gravel and sand immediately beside the river channel, and water seeps through the sand into the whole from where it is collected. At Senge and the other upstream communities, people take their water directly from the river channel without filtering it. During wet periods or flood events when the rivers and streams are high and discoloured and access to the river is dangerous, most villagers store water in anticipation of such conditions, and also collect rainwater in buckets and basins.

At Mangakiki, Marava, and Verakabikabi, householders have to walk some distance, sometimes up and down steep hills, to fetch water from local springs or small streams. Several sources are used at Mangakiki, and in some cases, villages have installed small dams and piping to make it easier to access the water. Villages at Vera'ande have several boreholes close by which are used for different purposes. Villages located on the downstream flood plains tend to have greater access to wells and communal taps, and generally don't use the Ngalimbiu River for drinking water.

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 sedimentation during the construction of the dam, is a major 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 also concerned that construction activities will impact their sources of water. Already increased river water sedimentation occurs after heavy rains, due to land disturbances, such as logging.

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

- All communities using the river as the main supply source for fresh water will be provided with reliable alternative clean water supply prior to start of construction; and

- Consultations will continue with project-affected people and communities, including downstream communities, throughout the life of the Project, using culturally appropriate, inclusive and proven methods and arrangements of stakeholder engagement.
- Note in **Figure 1-1** that there are no palm oil plantations south of Valele and Verakambi but become increasingly prevalent on the lowlands to the north.

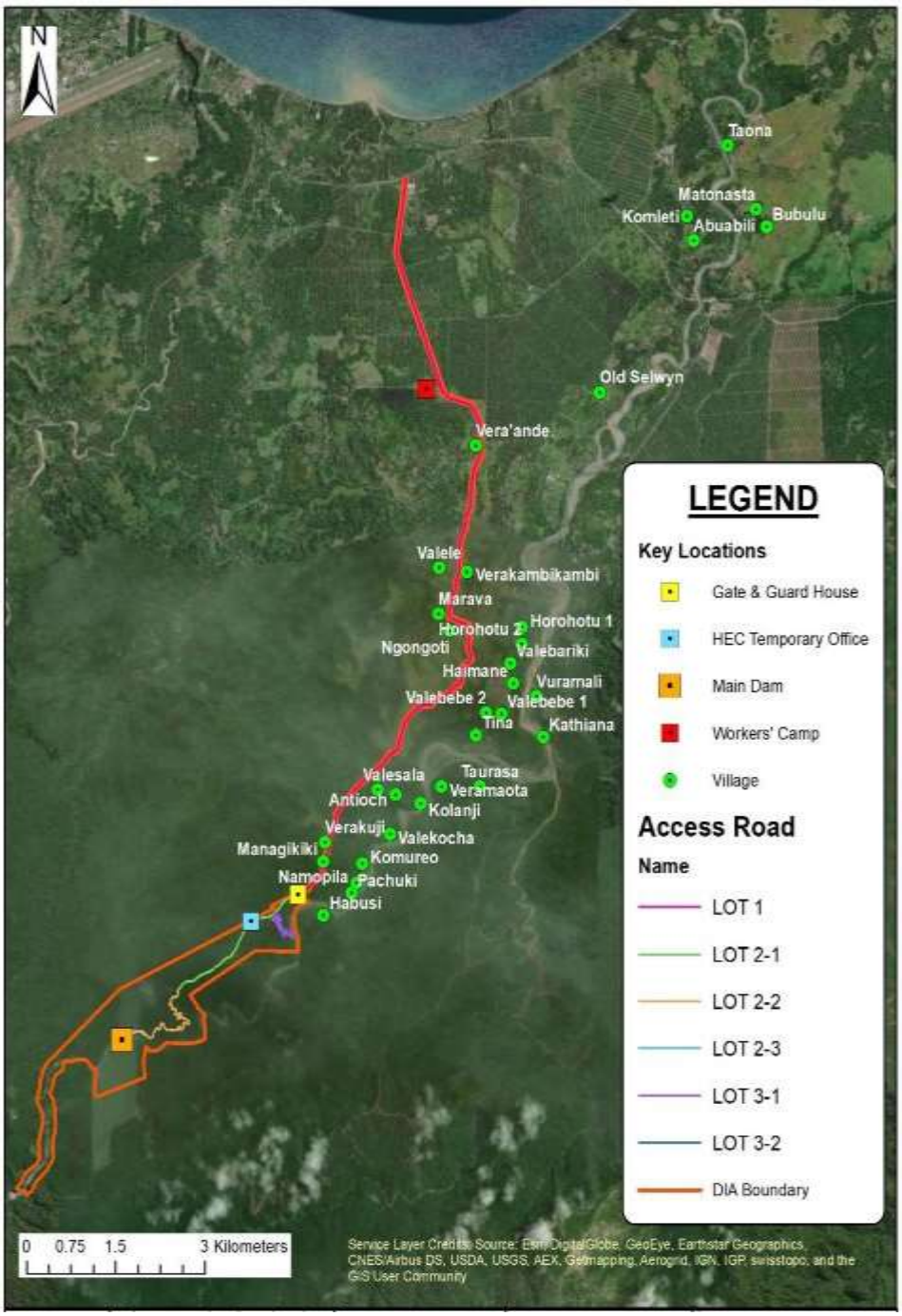


Figure 1-1 Overview of Potentially Impacted Communities

2 SCOPE OF WORK

The assessment of potential surface and groundwater-related impacts arising from the Dam construction and Road construction works have been implemented as follows:

- Carry out all necessary surveys, field verification, studies, collection of data, and analysis required to prepare the replacement plan.
- Record the water sources of communities that were not identified or captured in the previous surveys or studies.
- Undertaking GPS Survey and Mapping of all the water sources in the area and provide a detailed assessment of impact due to construction activities.
- Hydrological mapping survey, particularly for villages with water supply sources that may be impacted by construction.
- Verify and develop the mitigation measures proposed by HEC in the Water Supply Replacement plan for the overall project
- Collect some of the suggested data that needs to be presented in the report include Household water consumption, water quantity yield from the existing water source, water requirement, water quality.
- Specific identification and developing alternative water sources viable to the location shall be presented for each location wherever required.

Note: The outputs from GPS survey and mapping should be presented using a Geographic Information System (e.g., software like ArcGIS, Google Earth Pro, and QGIS)

3 LEGISLATION

3.1 National Legislation and Regulation

The following SIG legislation and regulations apply:

- River Waters Act 1964;
- River Waters Ordinance 1970;
- Environmental Health Act 1980 and Environmental Health (Public Health Act 1970) Regulations.

3.2 International Policies and Guidelines

The following international standards and Guidelines apply:

- Natural Resources & Environment of South Pacific Region (SPREP Convention), Ratified 10/9/98;
- World Bank Environmental and Social Performance Standard 4: Community Health, Safety, and Security;
- World Health Organization Drinking-Water Quality Guidelines (Fourth Edition, 2017). This is a most useful document and provides guidance and Water Safety Plans for a range of water source options including wells and rainwater harvesting. As the name implies it only addresses drinking water quality.

ANZEEC, 1992, Australian Water Quality Guidelines for Fresh and Marine Waters, National Water Quality Management Strategy.

3.3 Appropriate Water Quality Guidelines

The community main concern is with increased sedimentation in the river and siltation of wells and springs by surface water runoff during road construction. No concern was expressed about coliform bacteria. Sediment is actually more of an aesthetic concern as it affects taste, colour and odour of the water which make it objectionable for drinking, it is not considered a health concern. In community supplies filtration is required to remove sediment and the communities have adapted to this by using natural filtration methods.

Analysis for coliform bacteria for the water sources surveyed during this study indicate that the majority of sources are contaminated by fecal coliforms.

In terms of sediment the acceptable concentration is determined by the consumer and is reflected in colour, taste and turbidity. A limit of 15 Pt-Co is recommended for water colour in raw water (ANZEEC) but it is dependent on what the consumer is prepared to accept and doesn't find objectionable. Sediment grains less than 20 microns are included in Total Dissolved Solids rather than Total Suspended Solids. Sediment levels in the rivers are related to natural erosion with highest concentrations during flood events. If there are other sources from industrial effluents and fertilisers such as from palm oil plantations this would be of greater concern.

In terms of coliforms as per ANZEEC Guidelines, up to 10 coliform organisms may be occasionally accepted in 100 mL in water used for drinking. There should be no faecal coliforms per 100 mL.

4 HYDROLOGY AND HYDROGEOLOGY

- Acquire catchment data to understand the hydrology of the region. This will help in planning mitigation strategies and allow existing sources to be used to compensate other affected sources, wherever applicable.
- Water demand/consumption including for on-potable use is still the element which has not been fully verified, despite all the additional surveys.
- Conduct Feasibility Study and validate hydrological mapping data, particularly for villages with water supply sources which may be impacted by construction activities of Access Road or Main Dam.
    - Catchment mapping (delineate sub-catchments/source catchments for all water sources)
    - Field validation of hydrological flows estimated for all available community water sources.
    - Confirm hydrological status/classification of water sources like temporary or permanent and determine their reliability in terms of quality and quantity.
    - Analyze or identify interactions between surface water and groundwater systems. (e.g. surface to aquifer connectivity).
    - The identification of all possible known sources of contamination within each water source catchment and pathways of exposure/migration of contaminants (e.g. land cover, land use,

farm or wild animals, human waste sources, other water takes, known discharges upgradient/upstream). This should be validated via confirmation with local residents in each village.

These Terms of Reference were issued to Prime Engineers and Builders and within their report they undertook the requested hydrological mapping as presented in **Appendix A.**

Subsequent to these studies this present version of the WSRP has committed to provide water storage tanks to the affected communities supplied by trucking water from Boreholes to be constructed at the Camp and Office. An allocation of 20 kL/d has been allocated for this purpose. It is proposed that this system will ultimately be upgraded by CBSP to include roof rainwater catchments as permanent and sustainable water supplies. On that basis the proposed systems are independent of any hydrological, hydrogeological and pollution concerns.

The attached hydrological analysis may however be useful for CBSP when looking to provide groundwater or spring supplies as such installations could potentially be impacted by land clearing or contamination within the individual source capture zones.

5 CONSTRUCTION SCHEDULE

A preliminary construction schedule was prepared in 2019 at the time when construction was planned to start. The schedules relating to road construction, river diversion and dam construction are summarised on **Table 5-1**. They indicate that road construction will commence 5 months after project go-ahead and continue until month 30. The major construction activities at the Dam will commence at Month 12 and continue through until Month 42. Therefore increased sedimentation along the Tina River and downstream to the Ngalimbui River will potentially be experienced from Months 5 to 42.

Table 5-1 Schedules of Road Construction, River Diversion and Dam Construction

6 THE TINA RIVER

6.1 Rainfall

Total annual rainfall in the lowland area potentially impacted by increased sedimentation is 2,500 mm with monthly averages ranging between about 100 mm in the dry season to 300 mm in the wet season. Climate change may affect this in the future, no evaluation has been made for this report, and could possibly decrease or increase. This rainfall pattern and the amount of rainfall available for capture make roof rainwater harvesting a viable option for permanent and sustainable water supplies.

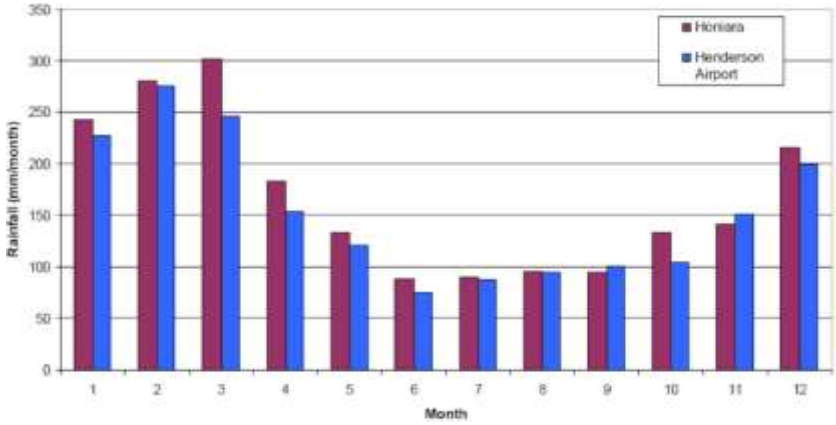


Figure 6-1 Monthly Rainfall

6.2 Streamflow

Streamflow was recorded at a gauging station upstream of the damsite from 15 June 2010 to 21 September 2013 as reported and analysed in the ESIA. The average monthly flow over the period **Table 6-1** ranged between 9 and 22 cumecs with a minimum of 2.85 cumecs.

Rainfall at the damsite is higher than in the lowlands but there is a general connection between rainfall patterns and river flow. Post – Dam construction an environmental flow of one cumec will be maintained in the river stretch between Dam and Powerhouse and an average discharge from the PowerHouse of 3.4 to 19 cumecs. The installation of the Dam and PowerHouse will serve to regulate flows in the downstream stretches of the river and also reduce sediment loading during floods.

Note that the catchment areas downstream of the damsite along the Toni River and Ngalimbui Rivers are unaffected by the construction activities and will continue to experience flooding and sedimentation albeit somewhat attenuated along the Ngalimbui River.

Table 6-1 Average monthly flow (cumecs) in Tina River upstream of Damsite

Months	Average	Minimum	Maximum
January	13.87	5.97	120.94
February	21.48	4.96	342.38
March	21.94	6.55	233.54
April	18.23	5.04	141.84
May	14.27	4.53	201.50
June	8.69	3.83	185.64

Months	Average	Minimum	Maximum
July	10.55	3.42	222.93
August	10.81	3.01	234.85
September	11.62	2.85	220.06
October	12.90	3.91	176.93
November	17.12	3.26	445.62
December	20.46	4.83	298.33

6.3 Water Quality

There have been measurements of sediment concentration (expressed as sediment, colour,**Table 6-2)**) and coliform counts (**Table 6-3 and Table 6-4**) from the upper sections of the Tina River down to the lowlands. Photographs in Appendix D show relatively clear water in the upper sections increasing downstream. This is confirmed by water quality measurements including coliform counts which increase significantly in the lowlands **(Table 6-3 and Table 6-4**) and is probably be related to community use for swimming, washing and ablutions. Note that additional locations were sampled in August 2020 (**Table 6-4)**. There were three samples collected across the river at each location, with the furthest downstream locations at the foot of each table.

Table 6-2 Sediment concentration in 2020 expressed as Colour (Pt-Co units)

Location	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
A1	84,24	17,91	24	243	14	19	25	449		77	340	373
A2	50,12	15,18	19	302	3	18	14	423		68	282	257
A3	50,74	11,17	35	278	1	16	13	429		71	280	285
B1	35,68	15,22	28	296	10	31	25	107		98	284	247
B2	34,64	12,07	30	289	3	20	23	24		82	233	264
B3	31,06	10,41	16	247	4	17	16	453		75	320	254
C1	34,19	12,8	29	0	22	18	30	455		194	302	305
C2	74,53	20,74	26	283	42	22	183	485		128	313	229
C3	44,67	20,93	27	346	78	22	21	457		221	257	263
D1	280,83	45,35	316	250	96	46	385	460		339	372	302
D2	294,54	29,01	312	455	34	42	449	241	53	304	385	296
D3	308,33	26,43	34	312	66	52	440	509		374	274	291
E1	320,51	69,28	95	388	301	74	507	366	196	379	264	357
E2	324,73	273,92	136	361	319	107	521	147	152	390	386	325
E3	323,89	240,01	49	488	321	454	544	339	169	428	312	278
ANZEEC Guideline	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15	<15

Table 6-3 Coliforms and Total Suspended Solids, January 2020

Location	Coliform	E-coli	Total Suspended Solids	Colour
A1	2092	27	45	84.24
A2	922	29	50	50.12
A3	1454	28	40	50.74
B1	1842	19	40	35.68
B2	2406	24	25	34.64
B3	1842	19	45	31.06
C1	1986	9	50	34.19
C2	1299	10	40	74.53
C3	1034	5	40	44.67
D1	3466	62	50	280.33
D2	1960	62	25	294.54
D3	>4000	41	30	308.33
E1	3972	26	60	320.51
E2	>4000	204	45	324.73
E3	>4000	1732	45	323.89
Acceptable Values (WHO)	<10	0		<15

Table 6-4 Coliform August 2020

Sample ID	Total Coliform	*E.coli*
	MPN/100ml	MPN/100 ml
A1	3249	21
A2	3249	34
A3	3883	30
B1	>10,000	13
B2	4966	171
B3	>10,000	10
C1	4966	914
C2	2616	1221
C3	2166	769
D1	1293	19
D2	2616	30
D3	1717	10
E1	21	<1
E2	21	<1
E3	8	<1
F1	814	<1
F2	1293	<1

Sample ID	Total Coliform	*E.coli*
	MPN/100ml	MPN/100 ml
F3	1818	3
G1	122	<1
G2	2727	<1
G3	122	<1
H1	>10,000	1088
H2	1778	262
H3	1778	61
I1	<1	<1
I2	3	<1
I3	<1	<1
WHO Guideline	***<10***	***0***

6.4 Community Health

There are various water supply projects conducted by various Non-Government Organizations and donors but due to lack of care by the community members, some deep wells and dug wells can be seen in abandoned conditions. Proper sanitation measures at the water are not followed leading to contamination of the water sources.

Moreover, many of the communities stated that there are no water-related diseases encountered due to drinking water, whereas one community at Mbaravule reported an incident of diarrhea in the past. Improper hygiene, solid waste disposal near the water sources, and unavailability of toilets make the water sources prone to contamination thereby increasing the risk of water-borne diseases in the communities. Most of the water sources are very dirty with water not draining properly, stagnant, breeding grounds for mosquito and other microbiological organism growth resulting in malaria.

There is no recording of water borne infections in the annual Guadacanal Health Surveys. The project area lies within the Good Samaritan Health Zone 6 which is part of the annual Guadacanal Health Surveys conducted between 2017and 2019 with Zone 6 accounting for 91 villages and 22,046 population. Other than malaria the incidence of other water borne diseases is not recorded.

The results of the Community Health Survey are summarised in **Figure 6-2** and indicate 9% incidence of diarrhea, 8% skin related illnesses and 30% malaria. Stomach pain accounted for 30% and this may be related to presence of the giardia parasite in the water. According to the survey villagers may boil water used for drinking and cooking which would eradicate coliforms but by doing so, particularly if wood is used as an indoor fuel, increase the risk of respiratory infections.

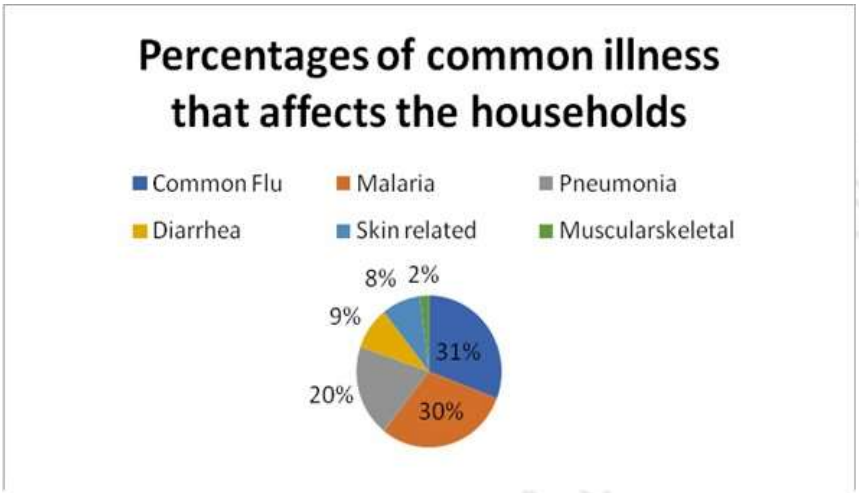


Figure 6-2 Community Health Survey

7 HEC OBLIGATIONS

7.1 During Construction

HEC obligation during construction is to provide a safe and reliable temporary water supply to potentially impacted communities during the period of construction. Intrinsic on this approach is that such temporary supplies can be converted into permanent sustainable supplies by integrating with the CBSP. These are most likely related to sedimentation along the rivers downstream of the damsite. Where existing sources are impaired or damaged during road construction they will need to be reinstated with temporary supplies provided in the interim.

7.2 Long Term

There is no long term obligation by HEC to provide permanent supplies after construction is completed and the TRHDC is operational. To guarantee such would create liabilities for long term operation and maintenance of such supplies which would be a community expectation. In fact once TRHDC is operational the water flows and sedimentation downstream of the Dam will be better managed to the benefit of the communities.

Notwithstanding HEC should liaise very closely with CBSP to ensure compatibility in water source provisions and to avoid any unnecessary overlap or conflict.

8 COMMUNITY BENEFIT SHARING PROJECT (CBSP)

CBSP is a supplementary project running concurrently with the Temporary Water Supply Replacement Plan and will provide permanent water systems for communities within the project region of Bahomea and Malango. Eighteen community-based water packages have been identified in total and will be covered under the CBSP. The area covered by CBSP is shown in **Figure 8-1**.

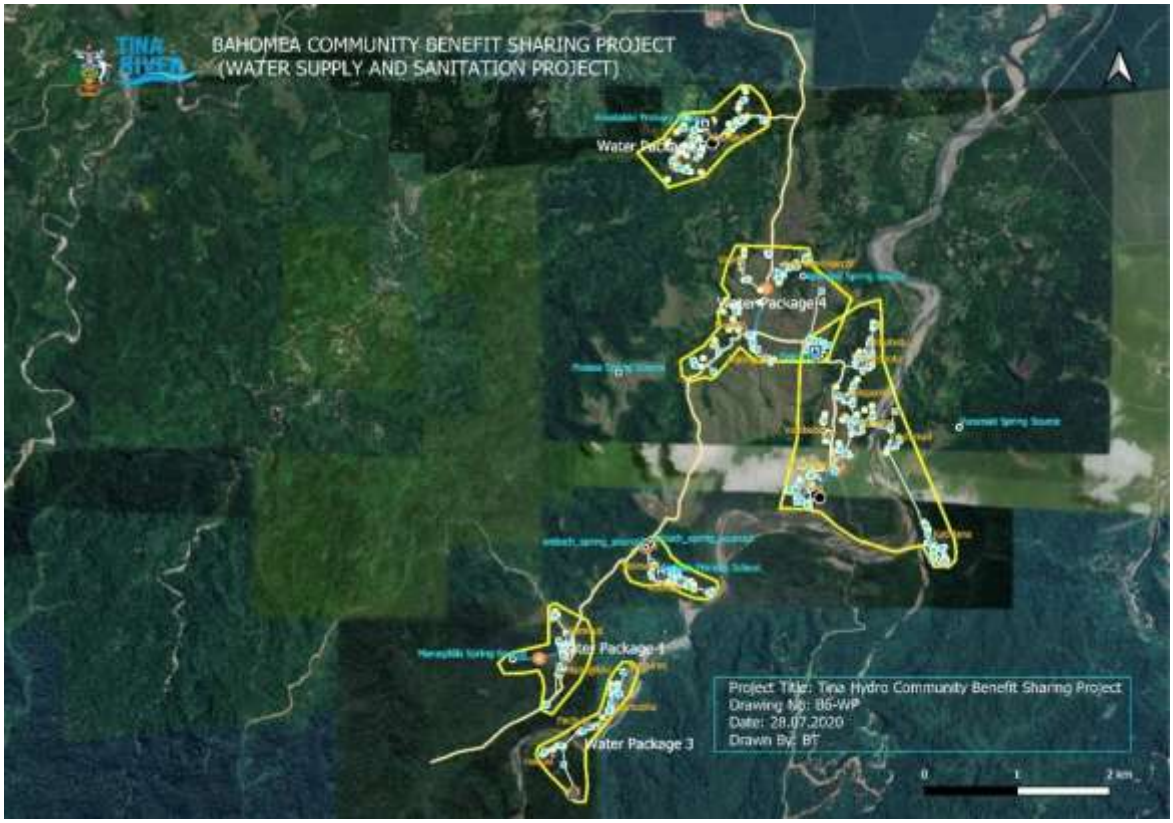


Figure 8-1 Community Coverage by CBSP

A typical source proposed for development under CBSP is the spring at Morava is shown in **Figure 8-2**.

Figure 8-2 Posasa spring at Morava proposed for development by CBSP

9 COMMUNITY WATER SURVEY

9.1 Approach

The desktop survey carried out was mainly focused on validating existing field data collected and analysed, and also used to prepare for the C7 Water Supply Replacement Plan (WSRP). The various types of water sources surveyed include boreholes, streams, wells, river collection points, rain water tanks, and natural springs. The survey assessed the rainwater storage that is attributed to community usage and household rain tanks meant for personal use remains unaccounted. Some of the communities have multiple sources of potable and non-potable water. Potable water refers to water sources used for drinking and cooking and non-potable water usage refers to washing, shower, gardening, and swimming (bathing).

The survey covered 30 communities in and around the TRHDP and the downstream communities that lie along near the banks of the Tina/Ngalimbiu River. 626 households with 3,979 populations were captured in this survey. The survey aims to identify all the available water sources and determine the potential impact due to access road construction and main works or dam construction. It is believed that Hyundai Engineering Company shall provide alternatives to the water sources likely to be impacted due to construction while Community Benefit Share Pilot, another component of this project will build permanent water supplies for the communities. The implementation of both these projects will help to improve the water supply infrastructure in the project area.

9.2 Water Source

The water source survey, detailed in Appendix B, identified numbers of water sources designated as follows:

- Stream STR total of 9
- River Collection point RCP on Tina and Ngalimbui Rivers total of 15
- Springs SP total of 16
- Wells W total of 11, one equipped with solar pump others with hand pumps
- Boreholes BH total of 14, one equipped with above ground solar pump for transmission to support diesel borehole pump
- Rainwater RW more than 11, in some communities larger numbers not listed separately
- Within the communities some of the water sources are privately owned in others they are shared.

Table 9-1 gives a full description of these sources.

Table 9-1 Description of Sources

#	Location	Identification made on the G Earth	Type of Water Source	Current Use	Southing	Easting	Remarks
1	Verande		Borehole	Not working since 2018	9°28'25.50"	160°06'41.09"	
2	Verande		Borehole	Used for drinking, cooking, washing and showering.	9°28'15.60"	160°06'36.7"	Conducted baseline on 10.08.2020 by SPE.
3	Verande	W4	Well		9°28'31.55"	160°06'41.86"	
4	Verande		Borehole		9°28'33.31"	160°06'42.00"	
5	Verande		Borehole with Solar Pump	Used for drinking by all Verande Community Members and other purposes by neigbouring homes.	9°28'38.19"	160°06'41.53"	Conducted baseline on 10.08.2020 by SPE.
6	Verande		Borehole-18 meters deep with Hand Pump	Used for Drinking, cooking and washing.	9°28'49.72"	160°06'39.16"	
7	Verande	W3	Well	Old wooden Well, not used for drinking	9°28'50.51"	160°06'37.10"	
8	Verakabikabi	SP10	Spring	Used for Drinking and cooking	9°29'42.2"	160°06'43.7"	Conducted baseline on 10.08.2020 by SPE.
9	Verakabikabi	SP9	Spring	Used for Drinking	9°29'46.8"	160°06'39.5"	Conducted baseline on 10.08.2020 by SPE.
10	Verakabikabi	W2	Well	Well installed during World War 2, currently in abandoned condition.	9°29'48.07"	160°06'35.88"	
11	Ngongoti	W1	Well	Used only during rain for showering, usually gets dried	9°30'06.56"	160°06'31.55"	
12	Ngongoti	SP7	Spring from Surface Water	Used for drinking and washing but usually dried up.	9°30'12.17"	160°06'33.30"	
13	Marava		Stream at the old road, water crossing	Used for laundry, bathing and washing	9°30'5.25"	160°06'18.42"	
14	Marava	SP6	Spring	Used for drinking and cooking.	9°30'2.61"	160°06'11.52"	Conducted baseline on 10.08.2020 by SPE.
15	Marava		Stream is at the same place of Spring SP6.	Used for bathing and washing.	9°30'2.61"	160°06'11.52"	
16	Marava	SP5	Stream same as no 15	Used for drinking.	9°30'9.61"	160°06'58.99"	
17	Valesala/Antioch		Spring collected from SP3/SP4 through PVC Pipe	Used for drinking, Washing, cooking and shower.	9°31'23.9"	160°05'50.30"	Conducted baseline on 10.08.2020 by SPE.

#	Location	Identification made on the G Earth	Type of Water Source	Current Use	Southing	Easting	Remarks
18	Valesala/Antioch	SP3	Spring	Used for drinking, Washing, cooking and shower.	9°31'20.44"	160°05'47.31"	
19	Valesala/Antioch	SP4	Spring	Used for drinking, Washing, cooking and shower.	9°31'17.94"	160°05'49.89"	
20	Managikiki	SP2	Spring	Used for drinking and washing	9°32'10.41"	160°05'13.10"	Conducted baseline on 10.08.2020 by SPE.
21	Managikiki		Spring Close to Access road, extended by Bamboo	Used for drinking and washing	9°32'8.96"	160°05'20.69"	Conducted baseline on 10.08.2020 by SPE.
22	Managikiki		Stream		9°32'7.76"	160°05'7.15"	
23	Managikiki	SP1	Spring		9°31'58.01"	160°05'1.15"	
24	Verakuji		Stream		9°31'55.50"	160°05'12.66"	
25	Workers Camp		Borehole with Submersible Pump	Used for Washing and Shower	9°28'12.90"	160°06'11.7"	Conducted baseline on 10.08.2020 by SPE.

Sources are described below and photos of typical installations are included in **Appendices D and E.**

- River water catchments along the banks of the Tina and Ngalimbui Rivers. These are shallow pits on the banks of the rivers which effectively filter out sediments from the turbid river waters and are used for drinking water and other purposes. Water is not taken directly from the rivers, but the rivers are commonly used for bathing, swimming and ablutions. During river floods the river becomes dangerous to access and also water sources can be damaged by flood waters.

Figure 9-1 Drinking water from Tina River at Habusi

Figure 9-2 River Collection Point for Namopila and Komoreu

- Streams are also used as water sources, and these are generally of better quality than the river water in terms of sediment but as they are also used for bathing and ablutions the water could be contaminated with coliforms.
- Springs are also commonly used but are often very low supply and some distance from the communities. Observations suggest that the spring water may be of poor quality. In many cases the springs are at lower elevation than the communities and to develop as permanent supplies would require catchment dams, pumps, pipeline and storage tanks. To install these could have land title issues. One system has been installed at Verakai & Managikiki Village for the Managikiki spring to be used for washing and shower only sometimes drinking. There is a pipe here that runs to the top of the hill which the village installed with the intention of pumping water up. The diesel water pump they bought in September 2019 (Kipor Model No. KDP15H) has very low discharge head (26 m) and cannot pump the water from the bottom of the valley to the village, the actually calculated hydraulic discharge

head is 136 m. Also the water quality has an issue with high count of E.coli bacteria in the spring water source.

Figure 9-3 Spring protected with concrete box at Verakabikabi

- Shallow wells are reasonably common on the floodplain along the lower reaches of the river system and generally about 5 m deep. They are equipped with hand pumps, diesel pumps and in one instance a solar powered pump. These wells are not maintained, the water is considered to be contaminated and pump failure is common. Funds for purchase of diesel fuel are limited and the pumps often stand idle.

Figure 9-4 Community Well Matanaso

- Deeper boreholes have also been constructed on the floodplain to depths of up to 20 m. Similar problems with maintenance, pump failure and lack of funds for fuel are also experienced. At Vera'ande, one of the few villages relatively well serviced by a variety of water sources a borehole (depth not recorded) has been equipped with a solar pump and automatic water level controller and provides 20 lpd each to a number of households in the village. Date of installation is not recorded but to appears to be working well. The water quality survey indicated that this is one of the few installations with low total coliform and e-coliform counts.

Figure 9-5 Solar pump on bore at Vera'ande.

- Groundwater. It should be understood that the alluvial plain constitutes an extensive aquifer system with high annual recharge and realistically there are no limits on how much groundwater can be abstracted from this aquifer for community water supply. Total potential demand is a fraction of the volume of groundwater held in storage and annual recharge.
- Rainwater tanks are also reasonably common. They provide a sustainable supply of freshwater suitable for drinking, cooking and washing. Providing the communities have adequate training on maintenance and avoid excessive use of the water during dry season then rainwater provides a sustainable supply of freshwater suitable for drinking, cooking and washing. Examples are given in **Appendix E** and shown in **Section 12**.

10 RISK ASSESSMENT

Each water source examined by Prime Engineers and Builders has been given a risk ranking ranging from non-applicable through low to medium, high and extreme. In general the term extreme is considered to be emotive and the preference would be highest risk. The full risk assessment by Prime is presented as Appendix **C**. Error! Reference source not found. presents the 11 villages considered to be at highest risk and provision of water tanks and trucking of groundwater has already commenced for these priority villages.

Table 10-1 Priority Villages for Temporary Water Supply

No	Community	Water Source	Status	Usage	Threat Sources		Risks	Likelyhood	Consequences	Recommendation	Remarks
					Access Road Construction	Dam Construction					
1	Verakambikambi	SP7	Still in use	Drinking	◎	X	SP7 is at high risk of being contaminated from runoff and sediments deposits being washed down from up stream however it is rarely used due to small quantity.	ALMOST CERTAIN	MAJOR	1. Erosion control measures such as sediment ponds and drainage should be effectively implemented to avoid the sed-imentation and runoff enter-ing the water sources. 2. Provide the total 5KL water tanks to support the water consumption for drinking wa-ter. 3. Due the relative ease of ac-cess, Verakambikambi's water can be supplemented by water trucks and it has been operat-ed by HEC. 4. Posasa water source will be used and developed by CBSP to supply water to Marava, Ngonti and Valele by con-structing water dam, receiving storage tank, Distribution Reservoir tank and the pipe-line and fittings for the pro-ject.	1. HEC has provided a water tank(5KL) on 23.06.2020. 2. HEC has provided a water tank(2KL) on 04.07.2020. 3. HEC has provided rain water collection accessories on 29.03.2021.
2	Valesala (Antioch)	SP9	Still in use	Drinking, Washing, Cooking, Shower	◎	X	SP9 likely would be affected due to its lower elevation compared to the road and which will influence the contamination and deposition of sediments from surface runoff	LIKELY	MAJOR	1. Erosion control measures such as sediment ponds and drainage should be effectively implemented to avoid the sedimentation and runoff entering the water sources. 2. There is a need to protect the two water spring sources at Valesala by constructing a separate concrete wall barrier to prevent runoffs. A new water dam needs to be constructed to protect the water source as well as to capture most of the water coming out from the rock and ground. 3. Since both the water sources are at extreme risk, rain water tanks will be provided to augment the drinking water requirement. 4. Provide the total 9KL water tanks to support the water consumption for drinking water. 5. CBSP plan has been in developing for this community.	1. HEC has provided Water tanks with capacity of 2X5000 liters=10,000 liters with rain water collection accessories on 30.04.2021
		SP10	Still in use		◎	X	SP10 likely would be affected due to having location at a lower elevation compared to the road and which is at high risk of being contaminated from deposition of sediments from surface runoff	LIKELY	MAJOR		
3	Verakuji & Managikiki Villages	SP11	Still in use	Drinking, Washing, Cooking, Shower	◎	X	SP11 is very close to the access road and accordingly would likely be affected by construction activities but used by a small number of community members.	LIKELY	MAJOR	1. Erosion control measures such as sediment ponds and drainage should be effectively implemented to avoid the sedimentation and runoff entering the water sources. 2. Supply communal rain potable water tank for the village for drinking and cooking only while for washing and shower they have to walk down the stream as normally they always did every day 3. There are a few residents who rely on other water for drinking, washing and cleaning with high likelihood and rare	1. HEC has provided water tank(5KL) on 06.07.2020.

No	Community	Water Source	Status	Usage	Threat Sources		Risks	Likelyhood	Consequences	Recommendation	Remarks
					Access Road Construction	Dam Construction					
										usage, during water turbidity high and unusable conditions, alternate water sources SP13 and SP14 shall be used. 4. Provide the total 6KL water tanks to support the water consumption for drinking water. 5. CBSP plan has been in developing for this community.	
4	Habusi	RCP1	Still in use	Drinking, Washing, Cooking, Shower	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	1. Habusi community has an alternative water source about 100 m away from their village. The Habusi water stream will not be affected so the community can use it for swimming, washing, cooking and drinking. Also supply communal rain potable water tank for the older people in village for drinking and cooking only while for washing and swimming they will still need to use the Habusi stream. 2. Provide the total 1KL water tanks to support the water consumption for drinking water.	
5	Pachuki	RCP2	Still in use	Drinking, Washing, Cooking, Shower	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	1. Water Supply replacement shall be provided as no reliable water supply during the Dam Construction. 2. Supply communal rain potable water tank for the village for drinking and cooking only while for the other purpose they will still need to use the river either to dig shallow wells at river bank to collect water or use at source3.Provide the total 1KL water tanks to support the water consumption for drinking water.	
6	Namopila	RCP3	Still in use	Drinking, Washing, Cooking, Shower	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	1. Water Supply replacement shall be provided as no reliable water supply during the Dam Construction. 2. Supply communal rain potable water tank for the village for drinking and cooking only while for the other purpose they will still need to use the river either to dig shallow wells at river bank to collect water or use at source 3. Provide the total 6KL water tanks to support the water consumption for drinking water.	
7	Komureo	RCP4	Still in use	Drinking, Washing, Cooking, Shower	X	◎	This is a very small community and river is the only source of water supply, that will be affected by dam construction.	ALMOST CERTAIN	MAJOR	1. This is a small community and very close to Namopila.. 2.Water Supply replacement shall be provided as no reliable water supply during the Dam Construction. 2. Provide the total 1KL water tanks to support the water consumption for drinking water.	

No	Community	Water Source	Status	Usage	Threat Sources		Risks	Likelyhood	Consequences	Recommendation	Remarks
					Access Road Construction	Dam Construction					
8	Valekocha	RCP5	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	1. Valekocha have an alternate water source to rely on during the event of river water being unusable. Since the alternate water supply stream will be-come turbid during the rainy or flood season, water supply replacement in for of Rain water tank needs to be provid-ed to supplement. 2. Provide the total 2KL water tanks to support the water consumption for drinking wa-ter. 3. At this elevation boreholes may not be considered and not be feasible due to accessi-bility limitations. 4. Valekocha may be able to share the water supplied to Valesala (650 m north) through a gravity fed water supply.	
9	Vatunadi	RCP6	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	1. The villages on the western side of the Tina River. 2. Vatunadi have an alternate water source to rely on during the event of river water being unusable. Since the alternate water supply stream will become turbid during the rainy or flood season, water supply replacement in for of Rain water tank needs to be provided to supplement. 3. Provide the total 1KL water tanks to support the water consumption for drinking water.	
10	Kolanji	RCP7	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	1. This is a small community and the water supply provided to Valesala may also be used to supply Kolanji. However, since the distance to fetch clean water was very far and steep, HEC need to supply rain water tank to the village for only drinking and cooking. 2. Provide the total 1KL water tanks to support the water consumption for drinking wa-ter.	
11	Veramaota	RCP8	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	1. The community will need the communal rain water tank for each community for drink-ing and cooking only. All the tanks that will be supplied need to have tank base frames include the roof catchment with all the gutters and acces-sories to complete the instal-lation. For the other purpose, they can still use the Tina River or can dig a shallow well near the river to access water during dry seasons	

No	Community	Water Source	Status	Usage	Threat Sources		Risks	Likelyhood	Consequences	Recommendation	Remarks
					Access Road Construction	Dam Construction					
12	Taurasa	RCP10	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	2. Water Supply replacement shall be provided during the Dam Construction. 3. Provide the total 1KL water tanks to support the water consumption for drinking wa-ter.	
13	Valebebe 1&2	RCP9	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	1. Water Supply replacement shall be provided as no reliable water supply during the Dam Construction. 2. Provide the total 3KL water tanks to support the water consumption for drinking water.	
14	Tina	RCP9	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	1. Tina community has a reli-able water source recently installed in form of Borehole. And the dependence on the river is decreasing gradually. 2. Since the CBSP also has planned for a robust water supply network for Tina and nearby communities, HEC can support the development of the plan with CBSP.	
15	Kathiana	RCP11	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	1. Water Supply replacement shall be provided during the Dam Construction. 2. Provide the total 5KL water tanks to support the water consumption for drinking water.	
16	Haimane	RCP12	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	1. Haimane have an alternate water source to rely on during the event of river water being unusable. Since the alternate water supply stream will become turbid during the rainy or flood season, water supply replacement in form of Rain water tank needs to be provid-ed to supplement. 2. Provide the total 3KL water tanks to support the water consumption for drinking water.	
17	Vuramali	RCP13	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	1. Vuramali has multiple water sources that can be reliable during dam construction works and flooding events. 2. No, alternate water supply is required for this community.	
18	Valebariki	RCP14	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	1. Valebariki have an alternate water source to rely on during the event of river water being unusable. Since the alternate water supply stream will be-come turbid during the rainy or flood season, water supply replacement in form of Rain water tank needs to be provid-ed to supplement.	

No	Community	Water Source	Status	Usage	Threat Sources		Risks	Likelyhood	Consequences	Recommendation	Remarks
					Access Road Construction	Dam Construction					
										2. Provide the total 1KL water tanks to support the water consumption for drinking wa-ter.	
19	Horohotu 1&2	RCP14	Still in use	Drinking,Cooking, Swimming,Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	1. Horohotu have an alternate water source to rely on during the event of river water being unusable. The alternate water supply stream will become turbid during the rainy or flood season. To cope up dur-ing the above described condi-tions Rain water tank are also available. 2. Hence there is no require-ment of any additional water supply replacement	
20	Abuabili	RCP17	Rarely used	Swimming, Washing	X	◎	Occasionally use the Ngalimbiu River for big washing and swimming, Distance from Abuabili to the river is 700m	ALMOST CERTAIN	MAJOR	1. Similar to the other com-munities located on the downstream flood plains, there are multiple water sup-ply sources rarely use the Ngalimbiu River. 2. During the events of river water becoming turbid, alter-nate water sources in the community can be used. 3. No alternative water supply replacement is required for this community.	1. The deep well was dug and provided by GPPOL company some years ago, It has been installed with a solar pump, 6m high tank frame with 1 x 3Kl storage and a stand pipe 2. The bore hole was drilled by Rural Development Programme and install with a Hand PVC pump
21	Komubeti	RCP18	Rarely used	Swimming, Washing	X	◎	Occasionally use the Ngalimbiu river when the diesel pump has no fuel. Distance from Komleti to the river is approximately 460m	ALMOST CERTAIN	MAJOR	1. This community has installed a Borehole with storage tank and water supplied to each community with standpipes. 2. The water supply ifrastructure is well developed and no replacement shall be required.	1. Borehole drilled and pump supplied by Rural Development Programme. 2. The whole community has 7 standpipes for distribution of water.
22	Taona	RCP17	Rarely used	Swimming, Washing	X	◎	Occasionally, Ngalimbiu river only be used for big household washing and for garden purposes and sometimes swimming. Distance from Taona to the river is approximately 200m	ALMOST CERTAIN	MAJOR	1. Since the Drinking water resource in this community is limited, water supply in form of additional rain water tanks shall be provided.	
23	Matonaso 1,2&3	RCP 16	Still in use	Gardening, Swimming, Washing	X	◎	Occasionally ,Ngalimbiu river only be used for big household washing and for garden purposes and sometimes swimming. Distance from Taona to the river is approximately 200m	ALMOST CERTAIN	MAJOR	1. Matonaso has a number of water sources in the community and rarely depend on the River for their domestic needs. These water sources can be used when the water is unusable from the Ngalimbiu river. 2. No alternative water supply is required to be provided.	
24	Old Selwyn	RCP 21	Rarely used	Swimming, Washing	X	◎	The RCP21 will be affected, but the community would not use it as already the community has sufficient water from the boreholes and rain water tanks	ALMOST CERTAIN	MAJOR	1. Old Selwyn community showcases the best model for community water supply. There are reliable water sources in the community that can be used during the Dam construction works. Further, Ngalimbiu River is hardly used by the community these days	1. Borehole developed by Rural Development Programme and install 6m high with a structural steel tank frame. 2. There is a plan for installation of Solar Pump by Rural Development Programme.

No	Community	Water Source	Status	Usage	Threat Sources		Risks	Likelyhood	Consequences	Recommendation	Remarks
					Access Road Construction	Dam Construction					
25	Mbubulu 1,2&3	RCP15	Still in use	Swimming, Washing	X	◎	1. Occasionally use the Ngalimbiu River for washing and swimming after gardening works.	ALMOST CERTAIN	MAJOR	1. Mbubulu has a number of water sources in the commu-nity and rarely depend on the River for their domestic needs. These water sources can be used when the water is unusable from the Ngalimbiu river. Ngalimbiu River is rare-ly used by the community these days. 2. No alternative water supply is required to be provided.	1. It was drilled at year 2020 at 9m deep supplied with a 5KL storage tank and a stand pipe. It never runs dry through out the year. Also it save 30 people in the community. 2. All the materials were already provided by the Rural Development Programme

11 WATER REQUIREMENT

11.1 Yield

Based on published data (**Table 11-1**) on water consumption in rural areas the preferred supply is 50 lcpd but in some areas this is 20 to 25 lcpd reducing to 10 lcpd where supply is limited. Within the project area the largest demand is for ablutions and gardens where sediment is not an issue and this is generally met from by the rivers. On that basis a supply of 12 lcpd can meet the freshwater demand within the communities.

Table 11-1 Typical rural water use (litres per capita per day)

Drink cook	Dish wash	House wash	Clothes wash	Bath shower	Garden	Toilet	Pool	Max.	Tina River
4	3	1	3	20	18	0	0	49	11

Each household has between 8 and 10 occupants so with suitable restrictions on use a single house roof can provide 120 lpd per household or about 12 lpd per capita. Depending on the number of households in a village, additional tanks can be installed and where there are churches, community halls and/or schools the roof area is larger. The results of the survey indicate that water is carried from source to community by women and children, often along steep slippery paths infested with centipedes and snakes using 1.5 L bottles and 20 L containers, on average about twice per day but where access is difficult only once per day. Some households state that they carry 20 to 25 lpd from individual sources. This equates to between 20 and 50 L per household per day (5 to 6 lcpd) and confirms that the above estimates on water useage are conservative. Other water demands for bathing, ablutions and gardening are likely met from other sources such as wells, streams or the river.

11.2 Water Quality

Appendix D presents an additional survey in August 2020 of a number of sources where water quality testing for total coliform and e-coli was undertaken. Several springs and boreholes met the WHO Guidelines for drinking water but the majority were contaminated. Coliforms and e-coli are invisible to the naked eye, unlike sedimentation, and do not normally cause odour or taste. The communities are generally unaware of the levels of faecal contamination in their water sources and poor sanitation practices around these sources contributes to the contamination. Nevertheless boiling of water before drinking is common and may contribute to the relatively low incidence of diarrhea.

12 RAINWATER HARVESTING

12.1 World Health Organisation

The World Health Organisation (WHO) has addressed rainwater harvesting in its Drinking Water Quality Guideline. WHO recognises that rainwater harvesting is widely practised at a household level but is increasingly being used on a larger community scale and is a proven important source of drinking-water. The development of formal Water Safety Plans (WSPs) at the household level may not always be practical, but promotion of sanitary inspection with simple good practice is important.

Well-designed rainwater harvesting systems with clean catchments, covered cisterns and storage tanks supported by good hygiene at point of use, can offer drinking-water with very low health risk. Rainwater is initially relatively free from impurities, except those picked up by the rain from the atmosphere. However, the quality of rainwater may subsequently deteriorate during harvesting, storage and household use. Wind-blown dirt, leaves, faecal droppings from birds and other animals, insects and litter on the catchment areas, such as roofs and in cisterns, can contaminate rainwater, as can particles from the atmosphere, such as soot from burning materials such as old tyres. Regular cleaning of catchment surfaces and gutters should be undertaken to minimize the accumulation of debris. Wire meshes or inlet filters should be placed over the top of downpipes to prevent leaves and other debris from entering storage containers and cleaned regularly to prevent clogging.

Materials used in the catchment and storage tank should be approved for use in contact with drinking-water and should not leach contaminants or cause taste, odour or discoloration. As rainwater is slightly acidic and very low in dissolved minerals, it can dissolve metals and other impurities from materials of the catchment and storage tank, resulting in unacceptably high concentrations of contaminants in the water.

Most solid roof materials are suitable for collecting rainwater, but roofs with bitumen based coatings are generally not recommended, as they may leach hazardous substances or cause taste problems. Care should be taken to ensure that lead-based paints are not used on roof catchments. Thatched roofs can cause discoloration or deposition of particles in collected water. The preferred roofing material in the context of this study is galvanised iron sheeting.

12.2 Project Specific

There area number of examples of rainwater catchment in Appendix E with several examples shown here. In terms of sustainable yield the minimum monthly rainfall during dry season is 100 mm and a roof catchment of 6 m by 6 m can yield up to 3,600 litres per month during dry season, considerably more during wet season. Each household has between 8 and 10 occupants so with suitable restrictions on use a single house roof can provide 120 lpd per household or about 12 lpd per capita. Depending on the number of households in a village additional tank can be installed and where there are churches, community halls and/or schools the roof area is larger. Indeed the examples shown below appear for the most part to have roof areas larger than 6 m by 6 m.Based on published data on water consumption in rural areas the preferred supply is 50 lcpd but in some areas this is 20 to 25 lcpd reducing to 10 lcpd where supply is limited. Within the project area the largest demand is for ablutions and gardens where sediment is not an issue and this is generally met from by the rivers. On that basis a supply of 12 lcpd can meet the freshwater demand within the communities.

Figure 12-1 Rainwater catchment from church roof, Old Selwyn

Figure 12-2 Community Rainwater Catchment, Old Selwyn

Figure 12-3 Rainwater Catchment on Community Building, Taona

Figure 12-4 Privately owned rainwater harvesting scheme, Abuabili

Figure 12-5 Rainwater tank at Pachuki

13 LIMITATIONS

13.1 Access

The majority of villages in this survey suffer from poor access. Only nine of the 30 villages are accessible by water truck. Walking distance to sources is commonly 200 m and can be as high as 900 m on steep slippery slopes infested by centipedes and snakes. It is the role of women and children to cart the water. Water tanks to be provided by HEC will therefore inevitably have to be placed at the nearest accessible point to the village which may be equal or lesser distance than current sources but in some cases may be greater. Villagers will normally have better access to the road network so even where the distance is greater the ease of access will be better.

13.2 Long Term Viability

The HEC temporary water supply replacement plan, already initiated involves placement of water tanks at or as close as possible to villages. Several have been placed already. These tanks are currently being serviced by groundwater trucked from the 30 m deep well at the Camp. Deeper boreholes are to be constructed at the Camp and the Office and an allowance of 20,000 lpd has been made to continue to service the tanks during the period of construction. There is no risk associated with this scheme. Ultimately the recommendation will be to transfer these tanks across to CBSP for their use within the villages as part of the preferred long term water sustainability programme of rainwater harvesting. There is sufficient rainfall even during dry season to meet the projected drinking and cooking water demand.

13.3 Community Acceptance

Review of the water source installations shows a range of rainwater harvesting schemes. This is not counting collection in buckets and containers which is apparently commonly practised. During the water source survey it appears that the community has a preference for solar pumps on boreholes. The boreholes would have to be correctly, sited and designed to avoid contamination and in that respect would need to be up to 20 m deep. It may be thought that a solar powered system may be a cheap option but the cost of installation, maintenance and replacement is high, much higher than a roofwater collection system with tank storage. Add to that the already common use of rainwater at minimal cost, a sustainable option providing drinking water quality, then rainwater harvesting can be considered the preferred option. There are a few solar

powered systems of recent installation which are performing well and this new technology appears to have influenced community thinking. In the long term there may be problems there is a history of poor maintenance at many of the sources examined. And the history of rural water supply is littered with failed and abandoned schemes which in retrospect were too ambitious.

14 CONCLUSIONS

The downstream village water sources were first surveyed in 2019 and HEC's local water engineer has recently undertaken another survey of water sources which may potentially be impacted by access road construction and main works. INOGEN will use these survey details to revisit and update the preliminary risk and mitigation matrix presented in Appendix C of the main report. The intention will be to provide temporary water supply replacement where required, protect existing water sources and improve water quality. Note that this more recent survey indicates that communities have significantly reduced their dependence on river waters.

After agreement with Lenders and OE an Action Plan will be prepared in which the Works to be undertaken by HEC will be detailed.

The community has expressed a preference for boreholes and solar pumps and clearly this will need to be addressed by CBSP. It is our considered opinion that this is not a preferred solution given the cost and maintenance requirements and very limited experience with these systems to date. Where springs are returning negative coliform counts then these may also be adapted for permanent supply by CBSP.

The CBSP is a supplementary project running concurrently with the Temporary Water Supply Replacement Plan and will provide permanent water systems for communities within the project region of Bahomea and Malango. Eighteen community-based water packages have been identified in total and will be covered under the CBSP. As far as practicable the Temporary Water Replacement Sources to be installed by HEC should be upgraded by CBSP and integrated with their Permanent Water Supply Programme.

APPENDICES

Appendix A Hydrogeological and Hydrological Assessment

Water Sources Catchment Area Hydrology Overview

This technical report describes the methodology and outcomes of the field and remote sensing hydrological survey for the Catchment Area. The main objective of this survey were to establish a hydrological model for the system to assist in the understanding of the flow of ground and surface water that are likely impacted due to the Access Road and Dam construction.

The hydrological survey has been conducted as part of the C7 Water Supply Replacement Plan to address knowledge gaps pertaining to the potential impacts of the construction activities on the existing water resources in the catchment areas.

Catchment Description

Tina catchment area is located 24km east of Honiara in Central Guadalcanal and has an elevation ranging from 8m to 240m above the mean Sea Level (MSL). The Catchment has an Area of about 45.043Km2 and is subject to a complex hydrological setting. The main focus in this hydrological Survey is to understand River Networks, drainage Networks, runoffs, flow accumulation, watersheds and to extract the contour of the existing terrain to better understand the hydrology activities of the Catchment and its impacts. This Survey also focuses on water demand and consumption for the households that are located within/around the project area.

Catchment Delineation

For modeling, the entire catchment was not divided into discrete sub-catchments because from the point of the inlet there is only one network that flows into the entire catchment. Therefore, this catchment can also be referred to as sub-catchment of the Tina River watershed network. This sub-catchment was derived using the QGIS **r.watreshed** function and **r.stream.extract** function based on the 1 second (30m) DEM of the region. The delineation of the catchment was based on the boundary provided by the Prime Engineering & Builder field survey by identifying in-channel catchment areas. Below are the Remote sensing procedures for the catchment delineation.

Note: (Download DEM tiles _Mosiac DEM tiles_Reproject DEM_Calculate the Flow direction_filed sinks/ remove spikes_Subset DEM_Derive strreams_Defind outflow points & Derive catchment)

Data Collection, Analysis, and Processing

Overview of data sources used for the hydrological Model

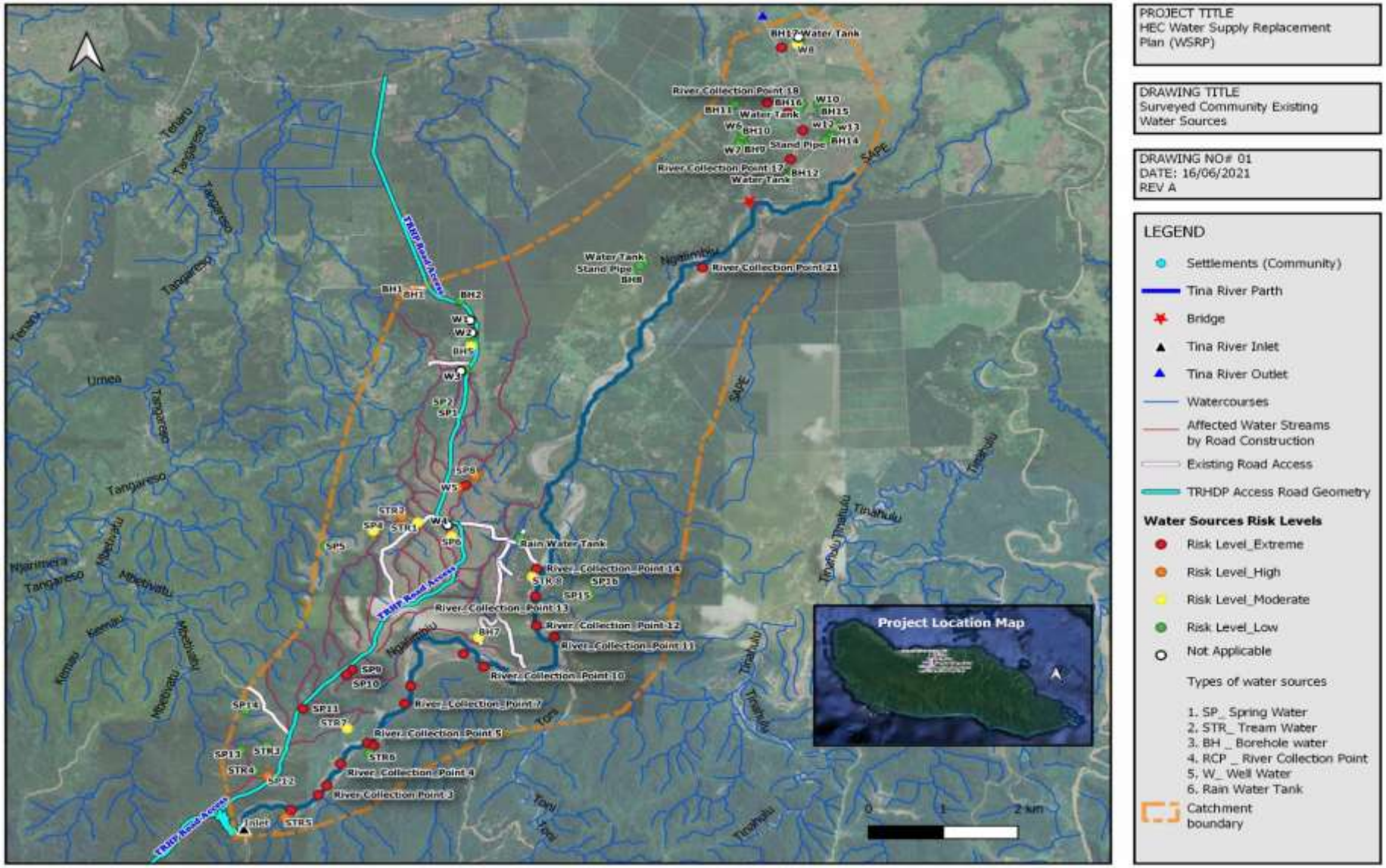
Description	Resolution	Source	Year
Digital Elevation Model	30m	Landsat 8	2020
Stream Network	Polygon (extract from DEM)	DEM	2020
Google Earth Images	Approx. 1-10m	Google Earth	2021
Road	1-10m	Google Earth	2021
Boundary	Polygon extract from Google Earth	Google Earth	2021

Description	Resolution	Source	Year
Settlements	Point 1m	GPS (Field Survey)	2020
Household	Points 1-5m	GPS (Field Survey)	2020
Water Source	Points (1m)	GPS (Field Survey)	2020
Contour	Lines (2m)	30m DEM	2020
Watershed	Lines (30m)	30m DEM	2020
Flow mesh Network	Arrow (3m)	Flow Direction (Accumulation)	2020
Water Mask (5hectare	Polygon (extract from DEM)	Landsat 8 (DEM)	2020
Topographic Wetness Index	Raster (30m)	Landsat 8 (DEM)	2020
Half-Basin	Raster(30m)	Landsat 8 (DEM)	2020
Watershed Basin	Raster(30m)	Landsat 8 (DEM)	2020
Guadalcanal Hill shade	Raster(30m)	Landsat 8 (DEM)	2020

Flow Pathway Analysis

The flow pathway analysis is based on the D8 method (based on 8 deterministic flow directions). This Method looks for the steepest gradient between the current cell in the center and its 8 neighbors and set this direction as the direction where all the water is routed to. In a simple form, each cell has a value of one, in a more precise form, the values that are summed up are the cell area. The sums of the area of cells that drain to a certain cell are the hydrological surface area of this cell. The higher this value, the more water is to be expected to flow at this point. Typically, high values are associated with “downstream” positions along linear depressions such as ditches, gullies, or valleys, and often a threshold can be found, where in reality permanent streams appear. In case of heavy rain events, the network of these high catchment area cells representing the flow pathways give hints where water might accumulate, and substantial water levels and flow velocities might be observed (the latter also depending on slope distribution/steepness of the catchment area). This process of surface water accumulating by confluence is called runoff concentration and this analysis method is, therefore, also named catchment or flow accumulation analysis.

To produce water masking for the Catchment area, a remote sensing technique was employed with SRTM datasets. In this SRTM dataset, the region could be analyzed by using specialized algorithms such as watershed in QGIS application. There are various processes, which are available to achieve this. However, we have chosen Watershed algorithm analysis to determine the five hectare regions for the catchment area. In the SRTM datasets, we merged all the tiles for Guadalcanal and, then we clipped out the region, which needs to be analyzed by the application. After which we have selected the Watershed algorithm with its appropriate parameters for processing. The determinant parameter is the five hectare, which is needed by the Watershed algorithm to create the region of five hector for Tina catchment area. Using this process, we have generated five hector zones along the Tina River Network with their area of water content in square meters per five hectares and as result we produced water Mask shape file used in the model.

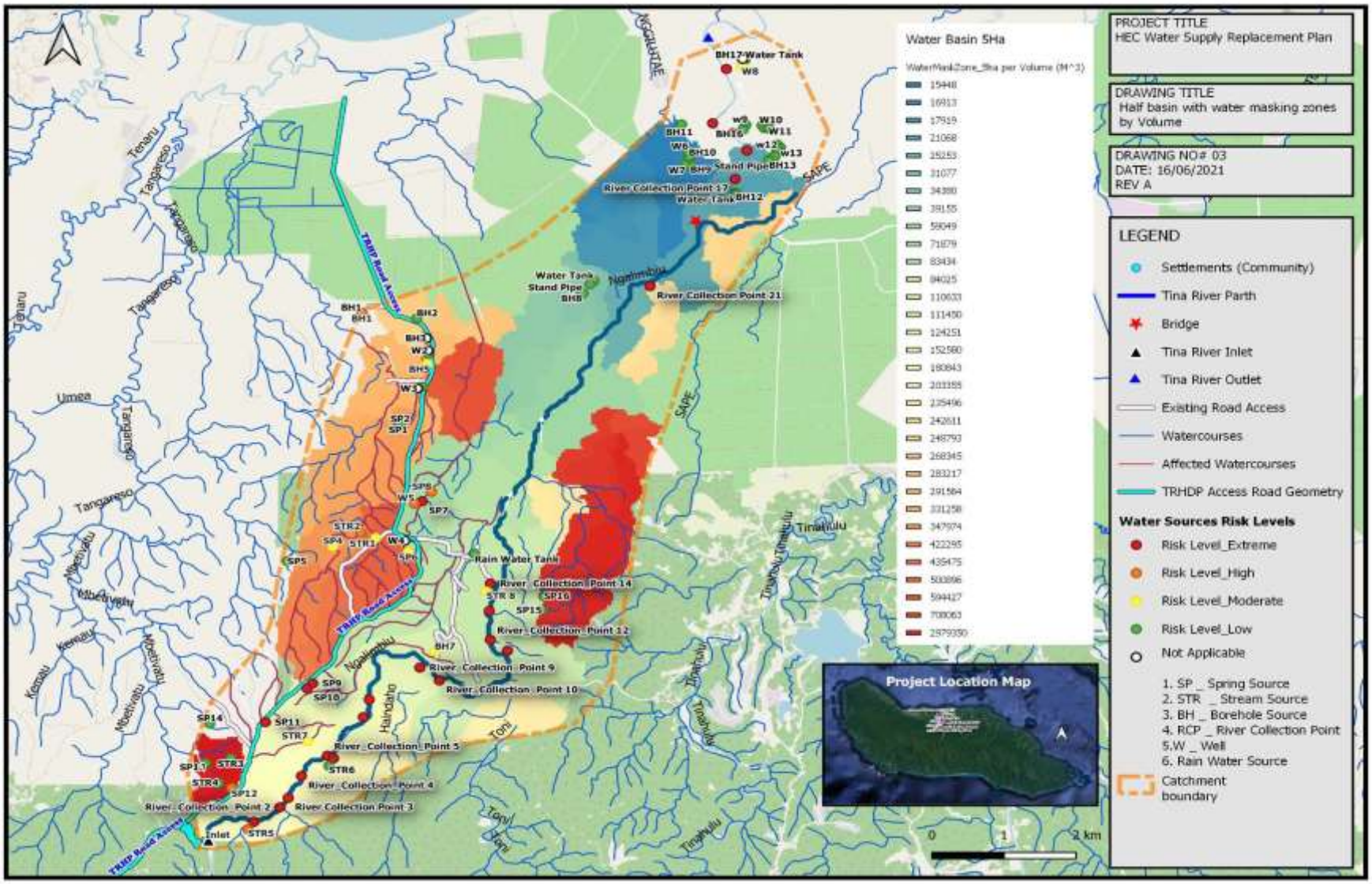


Surveyed Community Existing Water Sources

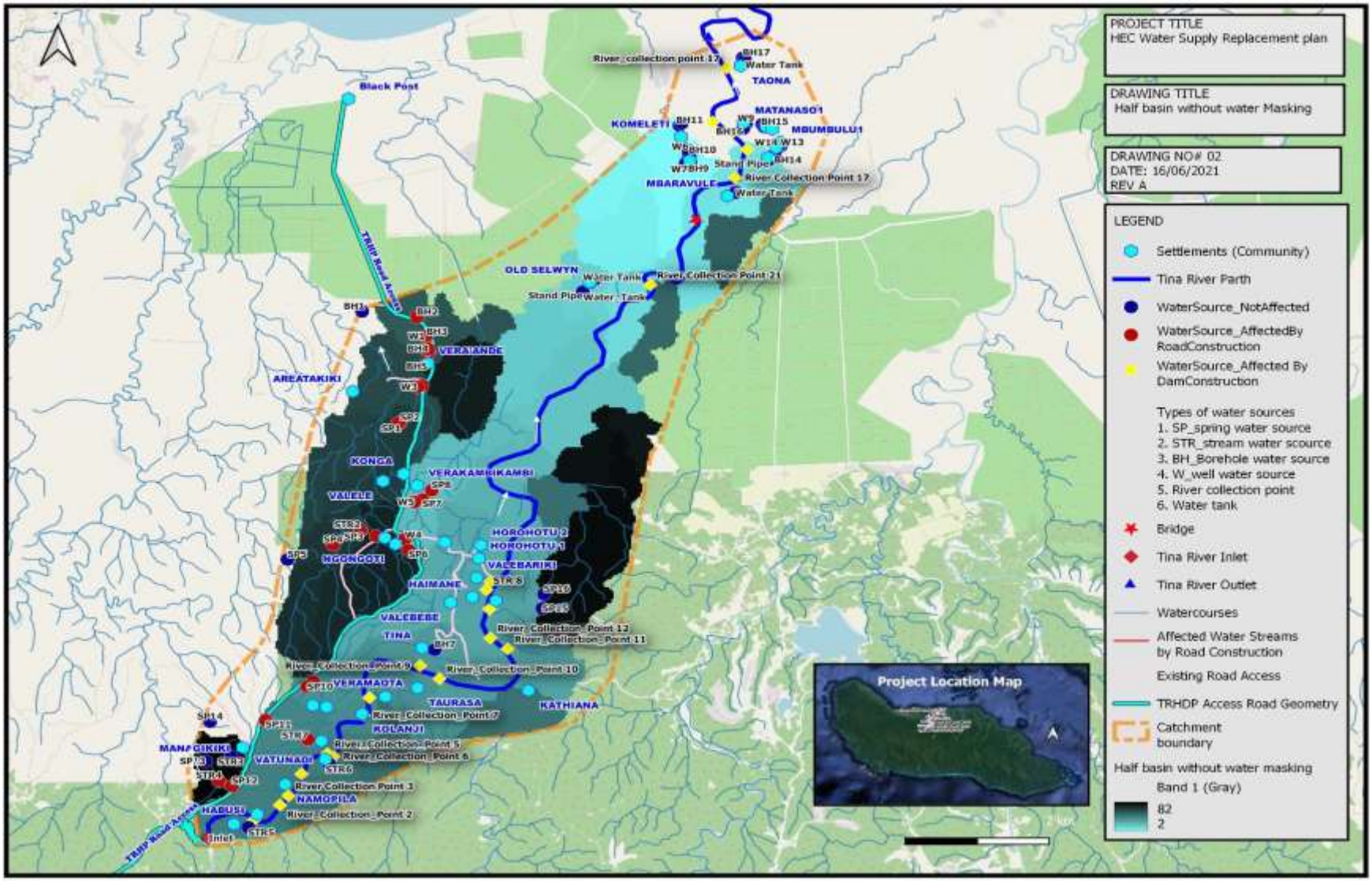
Catchment Watershed Basin Description

The output half basin raster map stores each half-basin and is given a unique value. Watershed basins are divided into left and right sides. The right-hand side cells of the watershed basin (looking upstream) are given even values corresponding to the values in the basin. The left-hand side cells of the watershed basin are given odd values which are one less than the value of the watershed basin.

The watershed basin shows a different portion in the geographical catchment area that collect and store rainwater during precipitation process and gradually drains or seeps to the water body such as stream, groundwater, river. The map in figure below shows watershed areas with an approximate volume of water per 5 hectare areas for the catchment area.



Half Basin with Water Masking



Half Basin without Water Masking

Catchment Area Zones

The catchment area is analyzed and simplified into four zones in order to capture the relevant hydrological effects of the waterbody with respect to the access road and dam construction. However, the impacts to the water sources were identified and categorized into

- water sources that were not affected either by access road or dam construction,
- water sources affected by road construction and
- water sources affected by dam construction works.

Community Zoning

No	Zone 1	Zone 2	Zone 3	Zone 4
1	Valesala	Marava	Verande	Abuabili
2	Manangikiki	Ngongoti	Old Selwyn	Komubeti
3	Habusi	Valele		Taona
4	Pachuki	Verakambikambi		Matonaso 1,2,3
5	Namopila	Tina		Mbaravule
6	Komureo	Valebebe 1&2		Mbubulu 1,2,3
7	Valekocha	Katihana		
8	Vatunadi	Haimane		
9	Kolanji	Valebariki		
10	Veramaota	Horohotu1&2		
11	Taurasa	Vuramali		

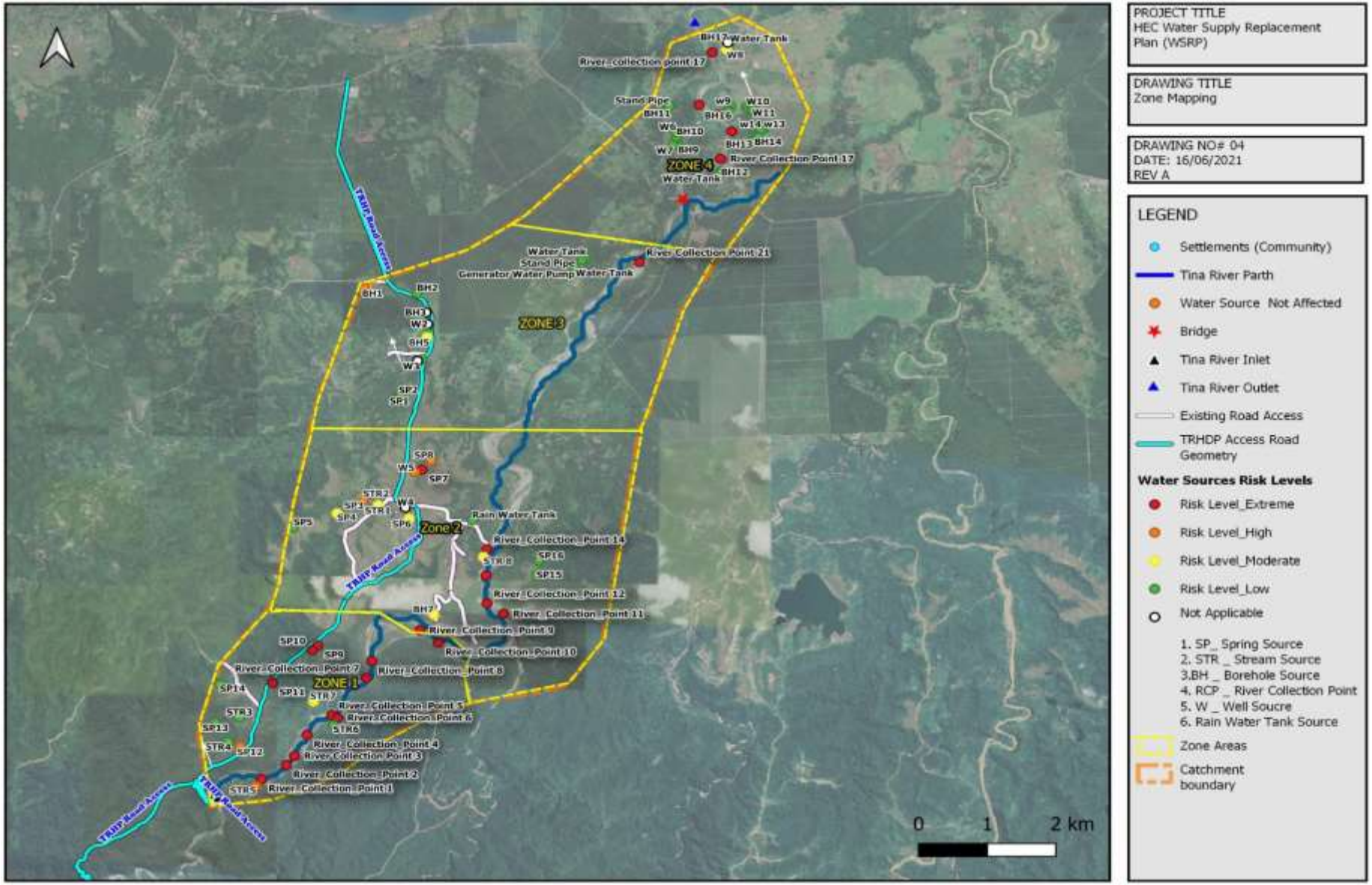
The technical parameters have many influences to predict the outcome and will help in analysis of the associated impacts, some of the parameters are as follows:

- 2m Contour lines
- Watercourses
- Watershed dissolved geometry
- Surface water flow mesh directions
- Slope gradient and
- Catchment area river basins

The contour lines are the distinguishing feature of the catchment area, the shape of the terrain, and connect points of equal elevation (m). It shows the slope gradient of the catchment area directed to the watershed dissolved areas. Most watershed-dissolved areas are directed to the water bodies such as watercourses or streams, underground water, creeks, and lakes. All of the water body dissected, drained, and eventually into the Tina River and surrounding rivers in the catchment area. These water bodies have created water sources for the communities in the catchment area of which some will partly affect by the access road construction and some may later on by the dam construction works. The surface water flow mesh directions interpretation shows possible flow directions of water in the surface area. Therefore, the surface water flow mesh directions pattern has an evident high level of probability to dictate and influences the quantity and quality of water sources in the catchment area caused by the dam and road construction works.

Catchment Zone 1, 2, and 3 have mostly been surveyed several times during the pre-construction and development phase of the project. However, Zone 4 was only surveyed in 2019 by ERM as detailed in the C7

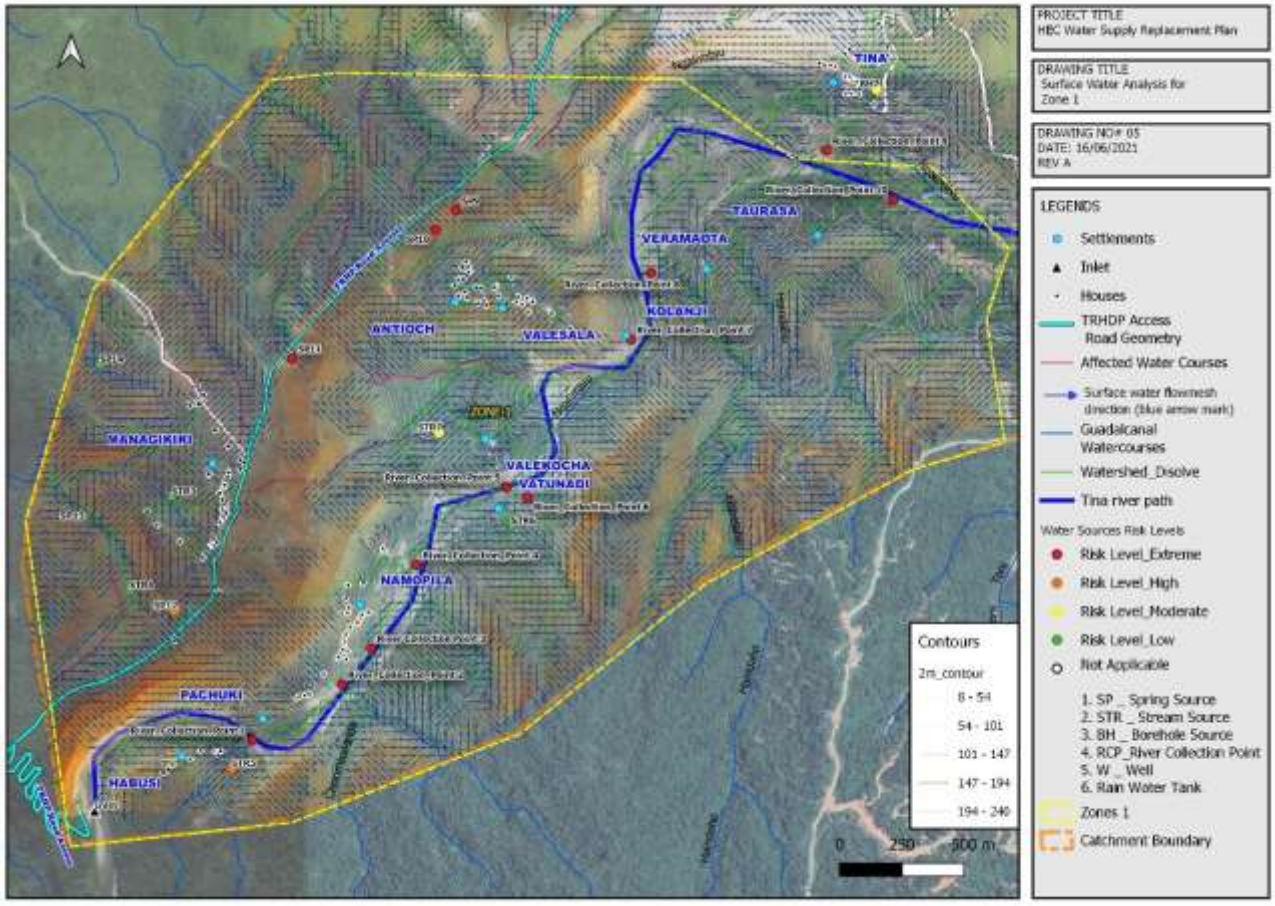
Water Supply Replacement Plan. The scenario of communities and their dependence on rivers for water has significantly changed due to various funded projects by NGOs. Most of the communities have shifted their water sources from river collection points to bore holes and dug wells.



Overview of catchment area zones

Catchment Area Zone 1

Zone 1 contains 11 communities lying along the Access Roads and the Tina River. The water sources(SP9,10,11,12) along the Access Road, which is used by Managikiki and Valesara community are likely to be affected by Access Road construction works. Further, all the River Collection Points (RCP 1 to 8, 10) located along the Tina River, which is used by 9 communities will be affected by the dam construction works. Out of 9 communities, only 2 communities, Habusi and Vatunadi, have the alternative water sources (Stream 6,7) which flows from the east side of the Tina River will not be affected by the dam construction. The 5 communities, Pachuki, Namopila, Komureo, Veramota and Taurasa, only use water from the river with no other alternatives available during the main construction works.

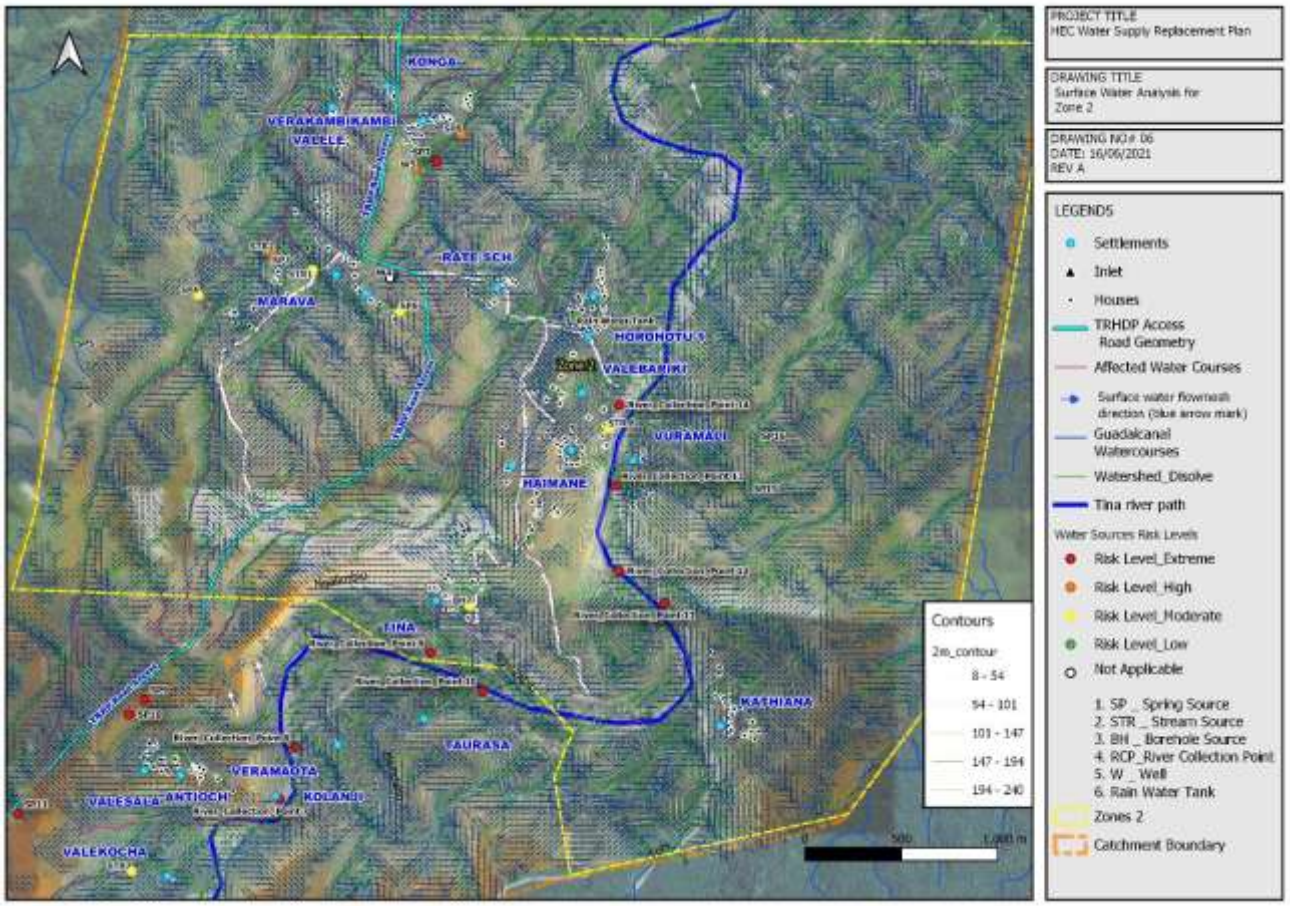


Catchment Area Zone 2

Zone 2 has eleven communities and seven of these, Kathiana, Valebebe, Haimane, Vuramali, Valebariki, Tina and Horohotu, depend on the Tina or Ngalimbiu River as their water source for their living. The other four communities situated close to the existing road which will be upgraded by the project depend on springs and streams to fetch water and these communities include Ngongoti, Marava, Valele and Verakambikambi. It is evident that most of their water sources (STR1, STR2, SP6, SP7, SP8, W4, W5) are likely affected by the Access Road construction works. However, Ngongoti, Marava and Valele have alternative water sources that can be used when the water is turbid due to any kind of construction, while Verakambikambi has no alternatives.

All the River Collection Points (RCP 9, 11, 12, 13,14) used by seven communities which are located along the river are likely to be affected by the Dam construction works. However, all the communities have the

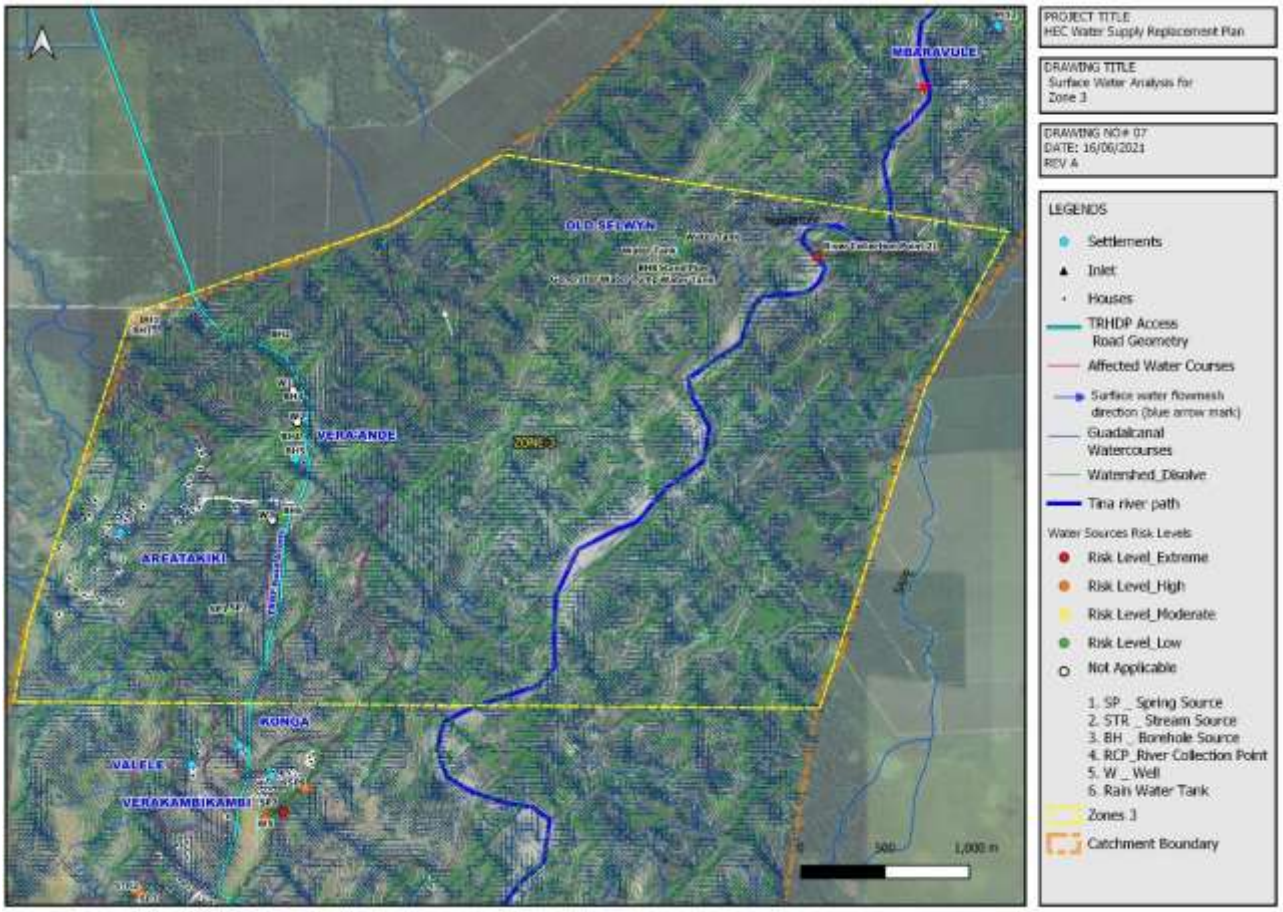
alternative water sources reliable or limited use. Further, in case of RCPs 11 to 14, since they are located along the Ngalimbiu River, which is downstream of the confluence of two rivers, Tina and Toni, there are various risk factors contributing to the water quality degradation apart from the Dam construction.



Catchment Area Zone 3

There are two main communities in zone 3, namely: Vara'ande and Old Selwyn. Vera'ande have multiple water sources since the houses are scattered along the access road. These sources are less likely to be affected by road construction considering the location of the sources and existing drainage along the access road and the upgradation of it. Further, the depth to be excavated is under 0.7m according to the design and most of them are boreholes and wells.

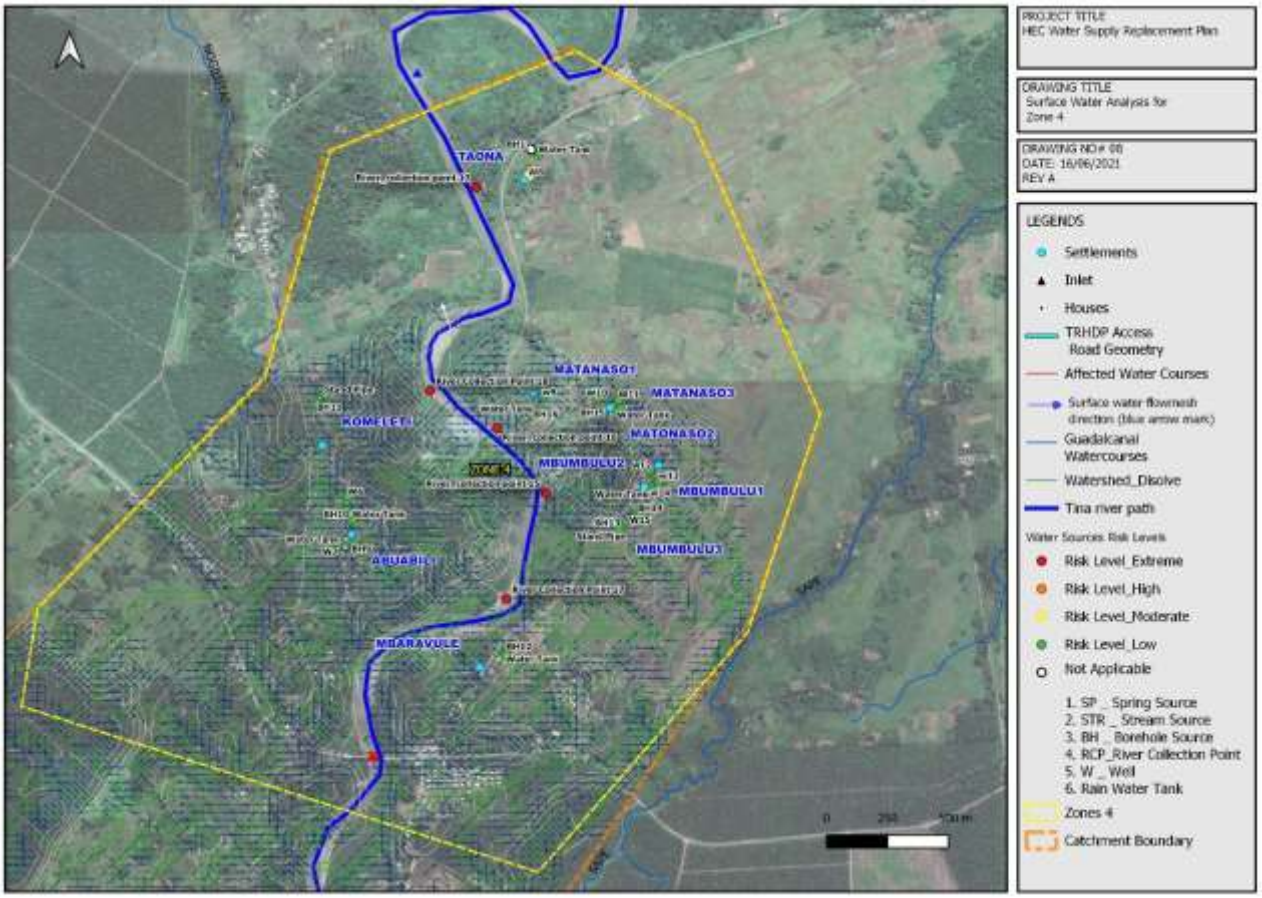
The community, Old Selwyn has a very well established water supply infrastructure and rarely use the river. The water sources that supplies water to Selwyn includes Stand pipes from borehole and water tanks that will not be affected by either by Access Road or Dam construction.



Catchment Area Zone 4

Zone 4, has six communities and all the communities located on the downstream flood plains tend to have greater access to wells and communal taps, and generally don't use the Ngalimbiu River for drinking water. Since they have multiple water supply sources, River Collection Point is rarely used. Further, the other water sources that supplies water for the communities including well and borehole will not be affected by Dam construction. Therefore, the impact on these water sources will be less compared to the upstream communities and considering the distance from the project area, water travelling through this long distance will get diluted resulting in reduced turbidity and suspended solids.

However, due to lower elevations, the wells and boreholes pose a risk of getting contaminated due to floods. This was evident in Taona community, where a recently developed borehole has been abandoned due to flood water entering the borehole. Currently the community has limited water supply in terms of quantity for drinking and cooking.


PROJECT TITLE
HEC Water Supply Replacement Plan
DRAWING TITLE
Surface Water Analysis for Zone 4
DRAWING NO# 00
DATE: 16/06/2021
REV A
LEGENDS
Settlements
Inlet
Houses
TRHDP Access Road Geometry
Affected Water Courses
Surface water flowmesh direction (blue arrow mark)
Guadalcanal Watercourses
Watershed_Dissolve
Tina river path
Water Sources Risk Levels
Risk Level_Extreme
Risk Level_High
Risk Level_Moderate
Risk Level_Low
Not Applicable
1. SP _ Spring Source
2. STR _ Stream Source
3. BH _ Borehole Source
4. RCP_River Collection Point
5. W _ Well
6. Rain Water Tank
Zones 4
Catchment Boundary
TAONA
MATANASO1
MATANASO3
MATANASO2
KOMELETI
MBUMBULU2
MBUMBULU1
MBUMBULU3
ABUABILI
MBARAVULE

Appendix B Water Source Survey Results

No#	Communities	Current Household #	Current Population #	Population Water Capacity Demand per day (L/day)	Daily estimated amount of drinking water in liters (based on 25 L per person, per day)	Water Source		Water Source Specifications				Status	Water Source	Water source descriptions	Method of	Survey Date
						GPS Location		Flow rate (L/s)	Elevation (m)	Distance (m)	Type		usage		Collection	
1	Marava	29	166	166,6	4,15	STR1 (Marava stream)	621303.03, 8949514.01	N/R	39	150	Stream at the old road, water crossing	Not in use due to turbidity	N/A	1. The Marava Stream is located just below the village which the community entirely depend on it for washing and shower. 2. The water sources is located close to the existing access road not included in Lot 1. This road has been used for local purpose	20L bucket for washing once a day	2021.06.01
						STR2 (Betikopo stream)	621085.87, 8949608.30	N/R	51	400	Stream	Still in use	N/A	1. The stream serves the communities of Marava, Valele and Areatakiki 2. Debris and sediments deposit in the stream filled up the pools making it dry.	Use only for shower and washing twice a day	
						SP3 (Marava spring)	621093.12, 8949596.06	0.08	42	400	Natural pool	Still in use	Drinking, Cooking	1. The water collection point is higher than the stream 2. Marava spring is located 875m from the access road so likely it will not be affecting during road construction work and levelling. 3. The route can be difficult to walk due the decline, it is easy to slip and fall. During the raining season it is even more difficult to climb up and down as the ground is wet and slippery. 4. There are snakes and centipedes on the path at night. It is not safe for women to collect water at night as there are customary hunters “Vele” who might be strangers to the community. 5. 15 Liters per day is the drinking and cooking water requirement as answered by one of the users.	Use 1.5L bottles, 20 buckets and 20L containers twice a day	

No#	Communities	Current Household #	Current Population #	Population Water Capacity Demand per day (L/day)	Daily estimated amount of drinking water in liters (based on 25 L per person, per day)	Water Source		Water Source Specifications				Status	Water Source	Water source descriptions	Method of	Survey Date
						GPS Location		Flow rate (L/s)	Elevation (m)	Distance (m)	Type		usage		Collection	
						SP4 (Betikopo spring)	620708.21, 8949383.66	0.025	51	600	Natural pool	Still in use	Drinking, Cooking	1. The spring water source was located beside the stream under the rock, which never runs dry during dry season. It was dugout in the rock and connected with a 50mm pipe to collect water. 2. Flow rate is very low so it causes over crowed in the morning and evening time to collect water in the stream. During flooding season it's hard to collect water due to collection point submersed in water at the Betikopo stream. 3. Water Spring distance was far away from the houses. The route can be difficult to walk due the decline, it is easy to slip and fall. During the raining season it is even more difficult to climb up and down as the ground is wet and slippery. 4. There are snakes and centipedes on the path at night. It is not safe for women to collect water at night as there are customary hunters "Vele" who might be strangers to the community.		
						SP5 (Posasa spring)	620073.88, 8949155.01	0.726	89	2	Indirect gravity Fed Water Source	Limited use due to long distance	Drinking, Shower, Washing, Cooking	1. It was never run dry during dry season because it was located and protected in the virgin forest 2. The issue with the Posasa water source was the location and the distance which will incur high cost to construct water dam, receiving storage tank, Distribution Reservoir tank and the pipeline and fittings for the project. The cost of transporting	Rarely use by the community because of long distance between community and the water source.	

No#	Communities	Current Household #	Current Population #	Population Water Capacity Demand per day (L/day)	Daily estimated amount of drinking water in liters (based on 25 L per person, per day)	Water Source		Water Source Specifications				Status	Water Source	Water source descriptions	Method of	Survey Date
						GPS Location		Flow rate (L/s)	Elevation (m)	Distance (m)	Type		usage		Collection	
														the water to the villages will be expensive.		
2	Valele	10	123	12,3	3,075	STR1 (Marava stream)	621303.03, 8949514.01	N/R	39	300	Shared same source with Marava and Ngongoti	Not in use due to turbidity	N/A	1. The Marava Stream is located just below the village about 300m, which the community entirely depend on it for washing and shower 2. The water sources is located close to the existing access road not included in Lot 3. This road has been used for local purpose	Normally use 20L containers to fetch for washing, kitchen utilities twice a day. Also they use 1.5L bottles, 20L buckets and 20L containers twice a day	17.04.2021
						SP3 (Marava spring)	621093.12, 8949596.06	0.08	42	700	Natural pool	Still in use	Drinking, Cooking	1. The community entirely depend on it for cooking. 2. Marava spring is located 875m from the access road so likely it will not be affecting during road construction work and levelling. 3. The route can be difficult to walk due the decline, it is easy to slip and fall. During the raining season it is even more difficult to climb up and down as the ground is wet and slippery. 4. There are snakes and centipedes on the path at night. It is not safe for women to collect water at night as there are customary hunters “Vele” who might be strangers to the community. 5. 15 Liters per day is the drinking and cooking water requirement as answered by one of the users.		
3	Ngongoti	15	120	12	3	SP3 (Marava spring)	621093.12, 8949596.06	0.08	42	600	Natural pool	Still in use	Cooking	1. The community use this source for cooking.	Normally use 20L containers to fetch for	21.04.18

No#	Communities	Current Household #	Current Population #	Population Water Capacity Demand per day (L/day)	Daily estimated amount of drinking water in liters (based on 25 L per person, per day)	Water Source		Water Source Specifications				Status	Water Source usage	Water source descriptions	Method of Collection	Survey Date
						GPS Location		Flow rate (L/s)	Elevation (m)	Distance (m)	Type					
						SP6 (Ngongoti Spring)	621756.28, 8949299.86	0.589	63	50	Spring	Usually dried up	Washing	1. It runs out dry during dry seasons. When in dry season the community use the marava stream for big household washing and shower 2. Although the stream, water source for Ngongoti Village, is already existed with the current access road, it could be impacted during road construction activities considering 200m distance from the access road. 3. This village is using marava stream and water tanks.	washing, kitchen utilities twice a day. Also they use 1.5L bottles, 20L buckets and 20L containers twice a day	
						W4	621703.62, 8949472.23	N/A	54	100	Dug Well	No longer in use due to lack of maintenance regardless of the construction	N/A	1. Dry up during dry season and sediment deposit in the well and also high turbidity which was not suitable for use		
4	Vera'ande	16	150	15	3,75	SP1	621613.81, 8951255.52	N/R	27	200	Spring near forest village	Still in use	Drinking, Cooking, Washing, Cleaning	1. Two springs are located near forest village and is part of the Vera'ande community 2. The issues affecting the water source was during wet season when there was storm water causing turbidity and not safe to use it.	Normally use 20L containers to fetch for washing, kitchen utilities twice a day	17.04.2021
						SP2	621640.14, 8951257.17	0.02	27	200	Natural pool	Still in use	Drinking, Cooking, Washing, Cleaning	1. The user answered 15 liters per day is the requirement per household. 2. The issues affecting the water source was during wet season when there was storm water causing turbidity and not safe to use it.		
						BH2	621871.32, 8952880.29	0.09	18	10	Electric Pump operated from Diesel Generator	Still in use	Drinking, Cooking, Washing, Cleaning	1. Newly built Family owned. 30 liters per day is the estimated usage.	1,000 liter	

No#	Communities	Current Household #	Current Population #	Population Water Capacity Demand per day (L/day)	Daily estimated amount of drinking water in liters (based on 25 L per person, per day)	Water Source		Water Source Specifications				Status	Water Source	Water source descriptions	Method of	Survey Date
						GPS Location		Flow rate (L/s)	Elevation (m)	Distance (m)	Type		usage		Collection	
						BH3	622004.13, 8952575.87	N/A	18	10	Borehole	Not in use	N/A	1. Borehole has been abandoned since 2018	N/A	
						BH4	622031.16, 8952335.88	N/R	18	10	PVC Hand pump & Borehole	Still in use	Cleaning, Washing	1. Private owned borehole which was used only for washing and cleaning 2. The drinking water is brought from the Borehole with Solar Pump in Verande.	Normally use 20L containers to fetch for washing kitchen utilities twice a day	
						BH5	622016.30, 8952185.97	0.1	21	10	Borehole with Solar Pumping with automatic tank controller	Still in use	Drinking, Cooking, Shower, Washing	1. Used for drinking by all Verande Community Members and other purposes by neighboring homes. 2. Around 20 liters is the drinking and cooking water requirement per household	1,000 liters stainless steel tank	
						BH6	621942.92, 8951832.10	N/R	24	10	Borehole with hand pump	Still in use	Washing, Cleaning	1. Borehole-18 meters deep with Hand Pump	Normally use 20L containers to fetch for washing, kitchen utilities twice a day	
						W1	621988.07, 8952588.63	N/R	18	20	Fitted to a diesel pump	Still in use	Shower, Washing	1. Old well built since 2001 still used 2. The drinking water is brought from the Borehole with Solar Pump in Verande (BH5).	1,000 liters PVC Tank	
						W2	622027.32, 8952390.01	N/A	18	20	PVC well	Not in use	N/A	1. Well is located at Nickson settlement and has been abandoned	N/A	
						W3	621879.98, 8951808.02	N/A	24	20	Wooden well	Not in use	Unsafe to use	1. Old wooden well, no flowing water, looks stagnant. 2. Unsafe to use due to contamination 3. Well has been abandoned	N/A	
5	Verakambikambi	32	324	32,4	8,1	SP7	621946.91, 8950077.15	0.007	36	200	Very small natural pool	Still in use	Drinking	1. This spring is an alternate drinking water source for Verakambikambi community members only.	Normally use 20L containers to fetch for washing, kitchen utilities twice a day. Also they use 1.5L bottles, 20L buckets and 20L containers twice a day	15.04.2021

No#	Communities	Current Household #	Current Population #	Population Water Capacity Demand per day (L/day)	Daily estimated amount of drinking water in liters (based on 25 L per person, per day)	Water Source		Water Source Specifications				Status	Water Source	Water source descriptions	Method of	Survey Date
						GPS Location		Flow rate (L/s)	Elevation (m)	Distance (m)	Type		usage		Collection	
						SP8	622076.19, 8950219.65	0.72	37	200	Concrete Box tank	Still in use	Drinking, Cooking	1. The spring for Verakambikambi, at the bottom of a very steep hill. PVC pipe was installed 6-7 years ago, however the spring has been used for many years. Low turbidity, reliable year-round 2. The estimated use is about 24 liters as said by one of the female users.	Normally use 20L containers to fetch for washing, kitchen utilities twice a day	
						W5	621837.48, 8950040.13	0.008	37	200	Using a steel drum and PVC pipe outlet	Still in use	Cooking, Washing	1. It is usually dirty in the rainy season and not suitable for drinking. 2. Guide said it was installed in WW2 and uses a drum from the war to keep the well in shape.	utilities twice a day	
6	Valesala (Antioch)	46	364	36,4	9,1	SP9	620426.62, 8947282.98	0.283	145	30	Transmission Pipe Length: 1000m, Direct Fed Water Source	Still in	Drinking, Washing, Cooking, Shower	1. Valesala depend on the two springs as a primary source of water, which both are located in close proximity to the access road route(approx.70m). During wet seasons storm water from the road usually comes down into the stream and water dam. 2. The village already have an existing water supply system in the village with a 10KL storage water tanks with 3 stand pipes	Normally use 20L containers to fetch for washing, kitchen utilities twice a day. Also they use 1.5L bottles, 20L buckets and 20L containers twice a day	29.04.2021
						SP10	620347.63, 8947205.64	0.171	146	30	Discharge Head: 13m Transmission Pipe Length: 800m, Direct Fed Water Source					
7	Verakuji &	37	265	26,5	6,625	STR3	619286.90, 8946132.92	N/R	212	280	Stream	Still in use but rarely used	Shower, Washing	1. Occassionally used the stream in the wet season which located below the village 2. Animal waste and human waste could enter into the water source below the village	Visit the source once a day	21.04.14
						STR4	619117.92, 8945757.94	N/R	164	380	Stream	Still in use but rarely used	Swimming	1. Very occasional (seasonally dependent). 2. STR4 is located right next to a steep slope on which lies the proposed road access		
						SP11	619769.84, 8946688.53	0.03	180	700	Extended with a bamboo	Still in use	Drinking, Washing,	1. SP11 is very close to the access road	Normally use 20L containers to fetch for	

No#	Communities	Current Household #	Current Population #	Population Water Capacity Demand per day (L/day)	Daily estimated amount of drinking water in liters (based on 25 L per person, per day)	Water Source		Water Source Specifications				Status	Water Source	Water source descriptions	Method of	Survey Date
						GPS Location		Flow rate (L/s)	Elevation (m)	Distance (m)	Type		usage		Collection	
											from the rock		Cooking, Shower	2. Used for shower, washing and drinking only by a few residents.	washing, kitchen utilities twice a day. Also they use 1.5L bottles, 20L buckets and 20L containers twice a day	
						SP12	619299.03, 8945675.87	0.15	198	290	Natural Pool	Still in use	Washing, Cleaning Only sometimes drinking	1. SP12 is located at a lower elevation compared to the road and is situated about 100m from access road construction boundary	Visit the source once a day	
						SP13	618936.03, 8946057.95	1.26	153	560	Spring	Still in use	Drinking, Washing, Cooking, Shower	1. SP13 is located up gradient of the access road 2. Managikiki spring is for washing and shower only sometimes drinking. 2. There is a pipe here that runs to the top of the hill. The village put it in with the intention of pumping water up. The diesel water pump they have bought (as of September 2019, Kipor Model No. KDP15H) with very low discharge head (26m) is not strong enough to pump the water from the bottom of the valley to the village. The actually calculated hydraulic dischage head is 136 from the stream to the village. 3. Also the water quality has an issue with high count of E.coli bacteria in the spring water source	Normally use 20L containers to fetch for washing, kitchen utilities twice a day. Also they use 1.5L bottles, 20L buckets and 20L containers twice a day	
						SP14	618998.92, 8946663.61	0.08	172	900	Natural pondage	Still in use	Drinking, Washing, Cooking, Shower	1. SP14 is less likely to be affected as it is located at a high elevation compared to the access road and is isolated by a hill. 2. The spring is located below the village and about 716 meters from the Access Road		

No#	Communities	Current Household #	Current Population #	Population Water Capacity Demand per day (L/day)	Daily estimated amount of drinking water in liters (based on 25 L per person, per day)	Water Source		Water Source Specifications				Status	Water Source	Water source descriptions	Method of	Survey Date
						GPS Location		Flow rate (L/s)	Elevation (m)	Distance (m)	Type		usage		Collection	
														3. Animal waste and human waste could enter into the water source below the village		
8	Habusi	6	34	3,4	850	RCP1	619610.99, 8945157.97	N/A	69	100	Tina River	Still in use	Drinking, Washing, Cooking, Shower	1. Mostly use the Tina River bank to dig shallows holes to collect water for drinking and cooking. 2. Use the River for washing and swimming,	Normally use 20L containers to fetch for washing, kitchen utilities twice a day. Also they use 1.5L bottles, 20L buckets and 20L containers twice a day	07.05.2021
						STR5	619528.28, 8945044.08	N/R	68	100	Stream (wet season)	Still in use	Drinking, Washing, Cooking, Shower	1. This streams also called as Habusi stream is used to fetch water as alternative source which was not going to disturb by the Dam Construction		
9	Pachuki	20	30	3	750	RCP2	619971013 8945382.01	N/A	63	100	Tina River	Still in use	Drinking, Washing, Cooking, Shower	1. Mostly use the Tina River bank to dig shallows holes to collect water for drinking and cooking. 2. Use the River for washing and swimming.	Normally use 20L containers to fetch for washing, kitchen utilities twice a day. Also they use 1.5L bottles, 20L buckets and 20L containers twice a day	08.05.2021
10	Namopila	34	250	25	6,25	RCP3	620088.05, 8945526.81	N/A	63	100	Tina River	Still in use	Drinking, Washing, Cooking, Shower	1. RCP3 is located along a stretched section of the river 2. Mostly use the Tina River bank to dig shallows holes to collect water for drinking and cooking. 3. Use the River for washing and swimming.	Normally use 20L containers to fetch for washing, kitchen utilities twice a day. Also they use 1.5L bottles, 20L buckets and 20L containers twice a day	08.05.2021
11	Komureo	3	15	1,5	375	RCP4	620269.99, 8945861.03	N/A	66	10	Tina River	Still in use	Drinking, Washing, Cooking, Shower	1. RCP4 is small dug well in the river bank to fetch water	Normally use 20L containers to fetch for washing, kitchen utilities twice a day. Also they use 1.5L bottles, 20L buckets and 20L containers twice a day	08.05.2021
12	Valekocha	10	60	6	1,5	RCP5	620631.08, 8946173.06	N/A	57	100	Tina River	Still in use	Drinking, Cooking, Swimming, Washing	1. Mostly use the Tina River bank to dig shallows holes to collect water for drinking and cooking. 2. Use the River for washing and swimming,	Normally use 20L containers to fetch for washing, kitchen utilities twice a day. Also	08.05.2021

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						GPS Location		Flow rate (L/s)	Elevation (m)	Distance (m)	Type		usage		Collection	
														3. It could be affected as a result of turbidity due to the accumulated sediments and dirt from upstream activities	they use 1.5L bottles, 20L buckets and 20L containers twice a day	
						STR7	620360.08, 8946392.23	N/R	66	250	Stream (wet season)	Still in use only during wet season	Drinking, Cooking, Swimming, Washing	1. STR7 is an alternative stream that they can fetch water as alternative source which was not going to disturb by the Dam construction. It was located approximately 250m which was just close to the village		
13	Vatunadi	5	30	3	750	RCP6	620715.93, 8946132.02	N/R	57	100	Tina River	Still in use	Drinking, Cooking, Swimming, Washing	1. River Collection Point 6 is just next to Point 5, and would definitely affected once Point 5 is being contaminated as most of the contaminated water will pass by its location 2. Mostly use the Tina River bank to dig shallows holes to collect water for drinking and cooking. 3. Use the River for washing and swimming,	Normally use 20L containers to fetch for washing, kitchen utilities twice a day. Also they use 1.5L bottles, 20L buckets and 20L containers twice a day	08.05.2021
						STR6	620715.93, 8946132.02	N/R	66	50	Stream (wet season)	Still in use only during wet season	Drinking, Cooking, Swimming, Washing	1. STR6 is located higher than the river and an alternative stream that they can fetch water which was not going to disturb by the Dam construction. It was located approximately 50m which just close to the village. During heavy rain, water becomes turbid		

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						GPS Location		Flow rate (L/s)	Elevation (m)	Distance (m)	Type		usage		Collection	
14	Kolanji	3	15	1,5	375	RCP7	621129.99, 8946765.46	N/A	48	15	Tina River	Still in use	Drinking, Cooking, Swimming, Washing	1. Kolanji shared the same two spring water sources with Valesala which was located below the road approximately 70m. During wet seasons storm water from the road usually comes down into the stream and water dam. 2. Walking long distance up to Valesala village to fetch drinking clean water pose danger to steep terranes which affect women and children especially during wet seasons 3. Also they used the Tina River and dug out shallow holes on the river bank to collect water	Normally use 20L containers to fetch for washing, kitchen utilities twice a day. Also they use 1.5L bottles, 20L buckets and 20L containers twice a day	14.04.2021
15	Veramaota	4	15	1,5	375	RCP8	621211.20, 8947033.79	N/A	45	300	Tina River	Still in use	Drinking, Cooking, Swimming, Washing	1. Mostly use the Tina River bank to dig shallows holes to collect water for drinking and cooking. 2. Use the River for washing and swimming	Normally use 20L containers to fetch for washing, kitchen utilities twice a day. Also they use 1.5L bottles, 20L buckets and 20L containers twice a day	08.05.2021
16	Taurasa	6	24	2,4	600	RCP10	622184.99, 8947326.99	N/A	36	300	Tina River	Still in use	Drinking, Cooking, Swimming, Washing	1. Mostly use the Tina River bank to dig shallows holes to collect water for drinking and cooking. 2. Use the River for washing and swimming	Normally use 20L containers to fetch for washing kitchen utilities twice a day. In addition, they use 1.5L bottles, 20 buckets and 20L containers twice a day. They use the river most of their life to access water.	08.05.2021
17	Valebebe 1&2	20	100	10	2,5	RCP9	621914.06, 8947523.96	N/A	39	400	Tina River	Still in use	Drinking, Cooking, Swimming, Washing	1. Use the Tina River bank to dig shallows holes to collect water for drinking, cooking and other household use. 2. The stream at Valebebe area is located just on the river bank which they use for washing only	Normally use 20L containers to fetch for washing, kitchen utilities twice a day. Also they use 1.5L bottles, 20L buckets and 20L containers twice a day	25.05.2021

No#	Communities	Current Household #	Current Population #	Population Water Capacity Demand per day (L/day)	Daily estimated amount of drinking water in liters (based on 25 L per person, per day)	Water Source		Water Source Specifications				Status	Water Source	Water source descriptions	Method of	Survey Date
						GPS Location		Flow rate (L/s)	Elevation (m)	Distance (m)	Type		usage		Collection	
														but during wet season it cannot be used		
18	Tina	114	364	36,4	9,1	RCP9	621914.06, 8947523.96	N/A	39	400	Tina River	Still in use	Drinking, Cooking, Swimming, Washing	1. Mostly use the Tina River bank to dig shallows holes to collect water for drinking and cooking. 2. Use the River for washing and swimming 3. There are many rainwater tanks within these villages, ranging from 5KL "combined" (i.e. communal) tanks, to pots collecting water from roofs. These tanks are seasonally dependent and generally dry up in the dry season. They are also poorly maintained, with some not containing catchment devices, making them redundant.	Normally use 20L containers to fetch for washing, kitchen utilities twice a day. Also they use 1.5L bottles, 20L buckets and 20L containers twice a day	15.04.2021
						BH7	622117.66, 8947769.72	N/R	48	100	4'' Borehole & PVC hand pump (24m depth)	Still in use	Drinking, Cooking, Swimming, Washing	1. New borehole drill this year 2021 with PVC hand pump. 2. Occasionally, used during wet season to fetch water 3. Washing and shower just above the borehole could pose contamination to underground borehole	Normally use 20L containers to fetch for washing, kitchen utilities twice a day. Also they use 1.5L bottles, 20L buckets and 20L containers twice a day	
19	Kathiana	11	175	17,5	4,375	RCP11	623131.01, 8947783.99	N/A	37	400	Ngalimbiu River	Still in use	Drinking, Cooking, Swimming, Washing	1. Mostly use the Tina River bank to dig shallows holes to collect water for drinking, cooking and other household use. 2. Use the River for washing and swimming	Normally use 20L containers to fetch for washing kitchen utilities twice a day. Also they use 1.5L bottles, 20 L buckets and 20L containers twice a day	11.05.2021
20	Haimane	30	100	10	2,5	RCP12	622892.00, 8947952.00	N/A	33	295	Ngalimbiu River	Still in use	Drinking, Cooking, Swimming, Washing	1. It is dangerous to go during the wet season due to flooding, which also makes the water more turbid. 2. Mostly use the Tina River bank to dig shallows holes to collect water for drinking, cooking and other household use.	Normally use 20L containers to fetch for washing kitchen utilities twice a day. Also they use 1.5L bottles, 20L buckets and 20L containers twice a day	15.04.2021

No#	Communities	Current Household #	Current Population #	Population Water Capacity Demand per day (L/day)	Daily estimated amount of drinking water in liters (based on 25 L per person, per day)	Water Source		Water Source Specifications				Status	Water Source	Water source descriptions	Method of	Survey Date
						GPS Location		Flow rate (L/s)	Elevation (m)	Distance (m)	Type		usage		Collection	
														3. Use the River for washing and swimming		
						STR8	622838.16, 8948690.62	N/R	30	220	Stream	Still in use during wet season	Shower, Washing	1. The stream is located just on the river bank which they use for washing only but during wet season flood covered the stream.		
21	Vuramali	26	125	12,5	3,125	RCP13	622877.93, 8948393.85	N/A	27	150	Ngalimbiu River	Still in use	Drinking, Cooking, Swimming, Washing	1. Mostly use the Tina River bank to dig shallows holes to collect water for drinking, cooking and other household use. 2. It's dangerous to go during the wet season due to flooding, which also makes the water more turbid. The village is concerned about the distance and considers the walk to be dangerous, especially for women/girls/children. They often get tired while walking.	Normally use 20L containers to fetch for washing kitchen utilities twice a day. Also they use 1.5L bottles, 20L buckets and 20L containers twice a day	11.05.2021
						STR8	622838.16, 8948690.62	N/R	30	225	Stream	Still in use during wet season	Shower, Washing	1. The stream is located just on the river bank which they use for washing only but during wet season flood covered the stream.		
						SP15	623611.63 8948406.14	N/R	82	600	Spring	Still in use	Drinking, Washing, Cooking, Shower	1. SP15 and SP16 are less likely to be affect since they are both located at a higher elevation to the east side of the river. 2. They are readily available but requires distant walking and used when river floods		
						SP16	623635.32 8948622.68	N/R	92	225	Spring	Still in use	Drinking, Washing, Cooking, Shower			
22	Valebariki	6	40	4	1	RCP14	622893.88, 8948814.11	N/A	33	260	Ngalimbiu River	Still in use	Drinking, Cooking, Swimming, Washing	1. Valebariki community use the Tina River bank to dig shallows holes to collect water for drinking, cooking and other household use. 2. Long distance to the river water source which is steep and can be slippery during the wet seasons. It's not safe for	Normally use 20L containers to fetch for washing kitchen utilities twice a day. Also they use 1.5L bottles, 20L buckets and 20L containers twice a day	15.04.2021

No#	Communities	Current Household #	Current Population #	Population Water Capacity Demand per day (L/day)	Daily estimated amount of drinking water in liters (based on 25 L per person, per day)	Water Source		Water Source Specifications				Status	Water Source	Water source descriptions	Method of	Survey Date
						GPS Location		Flow rate (L/s)	Elevation (m)	Distance (m)	Type		usage		Collection	
														children to access water. Noticed that children have itchiness after shower in the river.		
						STR8	622838.16, 8948690.62	N/R	30	300	Stream	Still in use during wet season.	Shower, Washing	1. The stream is located just on the river bank which they use for washing only but during wet season flood covered the stream.		
23	Horohotu 1&2	33	220	22	5,5	RCP14	622893.88, 8948814.11	N/A	33	600	Ngalimbiu River	Still in use	Drinking, Cooking, Swimming, Washing	1. Mostly use the Tina River bank to dig shallows holes to collect water for drinking and cooking. 2. Use the river for washing and swimming, 3. It's dangerous to go during the wet season due to flooding, which also makes the water more turbid.	Normally use 20L containers to fetch for washing kitchen utilities twice a day. Also they use 1.5L bottles, 20 L buckets and 20L containers twice a day	15.04.2021
						Rain Water Tanks	622676.60, 8949266.5	N/A	40	30	2x3KL rainwater tanks	Used by some families in the community, Installed near church	Drinking	1. 2X3KL rain water tanks are located in the village and used for drinking purpose mainly by some families.		
						STR8	622838.16, 8948690.62	N/R	33	600	Stream	Still in use during wet season	Shower, Washing	1. STR8 is located near the Tina River bank located 600m away from the village. It is used only during wet seasons and dry up during dry weather. It is used only during wet seasons and dry up during dry weather.		
						STR9	622893.88, 8948814.11	N/R	26	400	Stream	Still in use	Drinking, Swimming, Shower, Washing	1. STR9 was affected during flooding due to very close to the river		

No#	Communities	Current Household #	Current Population #	Population Water Capacity Demand per day (L/day)	Daily estimated amount of drinking water in liters (based on 25 L per person, per day)	Water Source		Water Source Specifications				Status	Water Source	Water source descriptions	Method of	Survey Date
						GPS Location		Flow rate (L/s)	Elevation (m)	Distance (m)	Type		usage		Collection	
24	Abuabili	13	120	12	3	W7	625602.64, 8955236.65	N/A	15	30	Solar borehole pump from 5m deep well with 1x3kl tanks(6m)	Still in use	Drinking, Cooking, Shower, Washing	1. The deep well was dug and provided by GPPOL company some years ago, It has been installed with a solar pump, 6m high tank frame with 2 x 3Kl storage and a stand pipe 2. Open dry pit latrine was located 30m away from the well which could contaminate the water source with E. coli or thermotolerant coliform bacteria. The well was unprotected because it has no cover or a lid to protect it. Also the storage tank on the 6m high tank frame never done cleaning so it is possible to have high deposit of mud and dirt in the tank which will affect the health of the community which drinking the water.	Use 1.5L bottles, 20 buckets and 20L containers twice a day. The storage meets 2 to 3 days requirement of the community.	26.04.2021
						BH 9	625670.22, 8955247.88	N/R	15	30	Borehole PVC hand pump with 20m deep	Still in use	Drinking, Cooking, Shower, Washing	1. The bore hole was drilled by Clean Water for Life and install with a Hand PVC pump 2. Washing and shower just above the borehole could pose contamination to underground borehole because there is no waste water discharge pit provided in the system.	Use 1.5L bottles, 20 buckets and 20L containers twice a day	
						BH 10	625647.79, 8955247.88	N/R	15	30	Borehole PVC hand pump with 20m deep	Still in use	Shower, Washing	1. The bore hole was drilled by Clean Water for Life and install with a Hand PVC pump 2. Washing and shower just above the borehole could pose contamination to underground borehole because there is no waste water discharge pit provided in the system. The drilled location selected has high turbidity level underground which cannot be able to drink with it.	Use 4x 20 buckets twice a day per person	

No#	Communities	Current Household #	Current Population #	Population Water Capacity Demand per day (L/day)	Daily estimated amount of drinking water in liters (based on 25 L per person, per day)	Water Source		Water Source Specifications				Status	Water Source	Water source descriptions	Method of	Survey Date
						GPS Location		Flow rate (L/s)	Elevation (m)	Distance (m)	Type		usage		Collection	
						Rain Water Tank	625660.64, 8955346.16	N/A	15	30	3KL Rain Water Tank	Still in use	Drinking, Cooking	1. Private rain water tank already set up with the proper guttering on the roof. 2. The water tank does not have a proper tank frame base so it was not safe, the current tank frame base has timber placed underneath and sitting unbalance position on the ground .	Use 1.5L bottles and 20L containers once a day	
						RCP17	626292.29, 8955020.48	N/A	12	700	Ngalimbiu River	Still in use but rarely used	Swimming, Washing	1. Occasionally use the Tina River bank to dig shallows holes to collect water for drinking and cooking. 2. Use the River for washing and swimming, 3. Not frequently use the Tina river because of long distance to walk and reach the water source.	Not frequently use the river to do their washing,swimming.They only bring their buckets with clothes for washing.	
25	Komubeti	10	60	6	1,5	BH11	625517.54, 8955824.49	N/R	12	30	6''Borehole (20m deep) with Diesel generator water pump & 2X3kL= 6000 liters tank(6m high)	Still in use	Drinking, Cooking, Shower, Washing	1. The Storage tank temporary runs out of water depending on the availability of fuel for the generator pump as each family was responsible for a week as per their schedule. Borehole developed by Rural Development Programme and install 6m high with a structural steel tank frame. High likely to contaminate their borehole because the community does not have proper toilet for waste disposal due to disposal of waste in the bush. Also flies can transport bacteria to their homes which will affect their health and hygiene	Use 1.5L bottles and20L containers twice a day from 7 communal stand pipes distributed in the community.	26.04.2021

No#	Communities	Current Household #	Current Population #	Population Water Capacity Demand per day (L/day)	Daily estimated amount of drinking water in liters (based on 25 L per person, per day)	Water Source		Water Source Specifications				Status	Water Source	Water source descriptions	Method of	Survey Date
						GPS Location		Flow rate (L/s)	Elevation (m)	Distance (m)	Type		usage		Collection	
						RCP18	625980.41, 8955875.78	N/A	5	460	Ngalimbiu River	Still in use but rarely used	Swimming, Washing	1. Not frequently use the Tina river because of long distance to walk and reach the water source. Occasionally use Tina river when the generator water pump has no fuel, Also when visiting food gardens.	Use 20L buckets once a day for household washing	
26	Taona	30	100	10	2,5	BH17	626395.44, 8956863.83	N/R	12	30	4'' borehole with PVC hand Pump	Not in use, damaged due to flood in January	Drinking, Cooking, Shower, Washing	1. BH17 is built by Clean Water for Life in 2020 but after 3 months a flood damaged the borehole PVC hand pump. 2. PVC hand pump cannot be able to move up and down when pumping water with hand because sand and sediments went in to the bore casing during the April flood last year 2020 .	Use 20L buckets once a day for household washing	27.04.2021
						W8	626382.82, 8956754.73	N/A	12	30	Deep well & a private 3KL rain Water Tank	Still in use	Drinking, Cooking, Shower, Washing	1. Deep well water source was currently used and never run dry during dry season 2. Major issue was no proper toilet in the village. They currently used bush as toilets place which it was a main issues, concern and health risk to the community	They have 1x3KL of rainwater tank and the deep well to fetch water then used 1.5 water bottles and buckets to carry water back to their homes.	
						Rain Water Tank	626425.16 8956841.29	N/A	10	30	Rainwater Storage tank of 1000l	Still in use	Drinking, Cooking	1. This is the only good quality drinking water source for the entire community	Collect in water bottles and buckets.	
						RCP17	626170.36, 8956709.62	N/A	9	200	Ngalimbiu River	Still in use but rarely used	Swimming, Washing	1. Ocassionally,Tina river only be used for big household washing and for garden purposes and sometimes swimming before coming back home.	They used the Ngalimbiu river only for swimming, big washing rarely and after gardening.	

No#	Communities	Current Household #	Current Population #	Population Water Capacity Demand per day (L/day)	Daily estimated amount of drinking water in liters (based on 25 L per person, per day)	Water Source		Water Source Specifications				Status	Water Source	Water source descriptions	Method of	Survey Date
						GPS Location		Flow rate (L/s)	Elevation (m)	Distance (m)	Type		usage		Collection	
27	Matonaso 1,2&3	13	40	4	1	W9 (Matanaso 1)	626441.08, 8955852.56	N/R	12	20	Groundwater	Still in use with limited use	Shower, Washing	1. The well is not used for drinking because it has bad odor. It is used for washing and shower and farming 2. It was observed that below 9m (10m-30m) the water quality is poor (bad swampy smell and muddy colour) and experienced water turbidity for several days of heavy rain. 3. During the floods, water becomes turbid	They have 2x5KL of rainwater tanks. All the storage meets 1 week requirement of all the community	26.04.2021
						BH16 (Matanaso 1)	626403.38, 8955793.66	N/R	12	20	Borehole with hand pump	Still in use but restricted to one family	Drinking, Cooking, Shower, Washing	1. Private borehole which was drilled last year 2020 2. It was observed that below 9m (10m-30m) the water quality is poor (bad swampy smell and muddy colour) and experienced water turbidity for several days of heavy rain.		
						W10 (Matanaso 2)	626665.55, 8955842.28	N/R	12	25	Groundwater	Still in use	Drinking, Cooking, Shower, Washing	1. Well was located approximately 25m away from the houses 2. It was observed that below 9m (10m-30m) the water quality is poor (bad swampy smell and muddy colour) and experienced water turbidity for several days of heavy rain. 3. During the floods, water becomes turbid		
						BH15 (Matanaso 2)	626695.98, 8955800.59	N/R	12	20	Borehole with hand pump (private)	Still in use but restricted to one family	Drinking, Cooking, Shower, Washing	1. Community borehole which was located near the church building 2. It was observed that below 9m (10m-30m) the water quality is poor (bad swampy smell and muddy colour) and experienced water turbidity for several days of heavy rain.		

No#	Communities	Current Household #	Current Population #	Population Water Capacity Demand per day (L/day)	Daily estimated amount of drinking water in liters (based on 25 L per person, per day)	Water Source		Water Source Specifications				Status	Water Source	Water source descriptions	Method of	Survey Date
						GPS Location		Flow rate (L/s)	Elevation (m)	Distance (m)	Type		usage		Collection	
						W11 (Matanaso 3)	626754.01, 8955837.78	N/A	12	20	Groundwater	Still in use	Shower, Washing	1. Well is located in the bush where all the trees were surrounded it 2. It was observed that below 9m (10m-30m) the water quality is poor (bad swampy smell and muddy colour) and experienced water turbidity for several days of heavy rain. 3. During the floods, water becomes turbid		
						Rain water Tank (Private)	626402.19, 8955776.85	N/A	12	20	1 rain water tank (private)	Still in use but restricted to one family	Drinking, Cooking	5KL rain water tank was installed at Matanao 1 and privately used		
						Rain water Tank (Comunal)	626746.63, 8955797.23	N/A	12	20	1 communal rain water tank	Still in use	Drinking, Cooking	5KL rain water tank which was installed at the matanaso 3 church building		
						RCP 16	626254.43, 8955721.75	N/A	12	200	Ngalimbiu River	Still in use	Gardening, Swimming, Washing	1. Ocassionally,Tina river only be used for big household washing and for garden purposes and sometimes swimming before coming back home.	They used the Ngalimbiu river only for swimming,big washing and after gardening once a day	
28	Mbaravule	4	50	5	1,25	BH12	626295.25, 8954808.15	N/R	12	50	4'' Borehole C/W Diesel Pump & 10KL tank	Still in use	Cooking, Shower, Washing	1. It was constructed by GPPOL Company some years back and still used today. It never runs dry even during dry season. They never use the Tina River. 2. The community used generator water pump to fill up the storage tank and it can last for a week before they can refill it again. This community does not have any shortage of water issue, which other communities experienced. They also collected water from the GPPOL 1 storage water tank if they needed because they located close to the substation area.	Storage tank	27.04.2021

No#	Communities	Current Household #	Current Population #	Population Water Capacity Demand per day (L/day)	Daily estimated amount of drinking water in liters (based on 25 L per person, per day)	Water Source		Water Source Specifications				Status	Water Source	Water source descriptions	Method of	Survey Date
						GPS Location		Flow rate (L/s)	Elevation (m)	Distance (m)	Type		usage		Collection	
29	Old Selwyn	20	200	20	5	Storage Water Tank	624179.76, 8953267.64	N/A	21	150	3x3KL Rain water tank	Still in use	Drinking, Cooking	1. 3x2KL Rain Water Tanks was installed at 3 different location on the raised platform.	Use 1.5L bottles and 20L containers twice a day	23.04.2021
						BH8	624165.07, 8953272.00	N/R	21	150	1x6'' Bore hole (30m depth) and Petrol Generator pump with 4x3KL rain water tank	Still in use	Drinking, Cooking, Shower, Washing	1. The borehole was developed by Rural Development Programme and installed 6m high with a structural steel tank frame. 2. Water from Borehole is pumped into the storage tanks and further distributed to the individual houses by stand pipes. 3. 4x2KL storage tanks can meet the 3 days demand of the entire community. Storage tanks temporary runs out of water as it depending on availability of fuel for the generator pump. The borehole will not be affected by the dam construction or road construction activities as it located far from the Tina River	4 stand pipes & use 1.5L bottles, 20L buckets and 20L containers twice a day	
						RCP 21	625111.74, 8953376.76	N/A	15	510	Ngalimbiu River	Still in use but rarely used	Swimming, Washing	1. Occasionally use Tina river when the generator water pump has no fuel	Use the Ngalimbiu River only for washing and swimming only at times	
30	Mbubulu 1,2&3	20	300	30	7,5	W12	626878.87, 8955547.47	N/A	12	20	Groundwater	Still in use	Shower, Washing	1. Communal ground water well is located under the fruit tress about 20m from the house funded by US Aid. 2. During the floods, water becomes turbid	Use only for shower and washing twice a day	27.04.2021
						W13	626920.78, 8955504.33	N/A	9	30	Groundwater	Still in use	Shower, Drinking, Washing	1. Communal ground water well is located under the fruit tress about 30m from the house. 2. The well is protected with a Concrete lid 3. Never runs dry throughout a year	Use only for shower, drinking and washing twice a day	

No#	Communities	Current Household #	Current Population #	Population Water Capacity Demand per day (L/day)	Daily estimated amount of drinking water in liters (based on 25 L per person, per day)	Water Source		Water Source Specifications				Status	Water Source	Water source descriptions	Method of	Survey Date
						GPS Location		Flow rate (L/s)	Elevation (m)	Distance (m)	Type		usage		Collection	
						W14	626884.42, 8955477.83	N/A	12	20	Groundwater	Still in use	Shower, Washing	1. Communal ground water well is located in the village and protected 2. During the floods, water becomes turbid	Use only for shower and washing twice a day	
						W15	626842.36, 8955367.52	N/A	12	20	Groundwater	Still in use	Shower, Washing	1. Private ground water well is located near one of the community housing. 2. During the floods, water becomes turbid	Use only for shower and washing twice a day	
						BH13	626759.39, 8955316.37	N/R	12	20	9m deep borehole with solar pump	Still in use	Drinking, Shower, Washing, Cooking	1. It was drilled in 2020 at 9m deep supplied with a 5KL storage tank and a stand pipe. It never runs dry throughout the year. Also it save 30 people in the community	Use 1.5L bottles and 20L containers twice a day	
						BH14	626832.81, 8955377.69	N/R	13	20	9m deep borehole with hand pump	Still in use	Shower, Washing	1. Borehole is located with hand pump and is privately used by 1 household. During the flooding, the water becomes turbid. It never runs dry throughout the year.		
						Rain Water Tank	626874.10, 8955467.20	N/A	13	20	Communal 3KL rain water Tank	Still in use	Drinking	1. The 3KL rain water tank was installed at the church building a solid concrete base and the gutter already installed with it 2. Never carry out tank cleaning regularly to remove debris and dirt inside the tank		
						RCP15	626454.471 8955455.85	N/A	11	400	Ngalimbiu River	Still in use	Swimming, Washing	The community has multiple water supply sources. They rely rarely on the River. They swim in the river after gardening works.	Use the Ngalimbiu River only for washing and swimming only at times	

Appendix C Risk Assessment and Recommendation

No	Community	Water Source	Status	Usage	Threat Sources		Risks	Likelyhood	Consequences	Risk Level	Recommendation	Remarks
					Access Road Construction	Dam Construction						
1	Marava	STR1 (Marava stream)	Not in use	N/A	◎	X	STR1 is at a low lying area in a valley near the village and located close to the existing access road which used for local purpose. In addition to the risk caused by the existing use, it would be affected from surface runoff from the Access Road construction.	LIKELY	INSIGNIFICANT	MODERATE	1. Erosion control measures such as sediment ponds and drainage system should be effectively implemented to avoid the sedimentation and runoff entering the water sources. 2. Provide the total 5KL water tanks to support the water consumption for drinking wa-ter. 3. Due the relative ease of ac-cess, Marava water can be supplemented by water trucks and it has been operated by HEC. 4. Posasa water source will be used and developed by CBSP to supply water to Marava, Ngonti and Valele by con-structing water dam, receiving storage tank, Distribution Reservoir tank and the pipe-line and fittings for the pro-ject.	HEC has provided water tanks with total Capacity of 5X2,100L=10,200L with rain water collection accessories on 06.07.2021
		STR2 (Betikopo stream)	Still in use	N/A	◎	X	STR2 is likely be affected by Access Road consturction that will be conducted from sta. 9+500km to 11km of Lot 1.	LIKELY	INSIGNIFICANT	MODERATE		
		SP3 (Marava spring)	Still in use	Drinking, Cooking	◎	X	SP3 is less likely to be affected by Access Road Construction considering the location and elevation profile of it.	UNLIKELY	MAJOR	HIGH		
		SP4 (Betikopo spring)	Still in use	Drinking, Cooking	◎	X	1. SP4 is less likely to be affected by Access Road Construction considering the location and elevation profile of it. 2. Risk of flooding, where turbid water enters into the collection basin. 3. Flow rate is very low so it causes over crowed in the morning and evening time to collect water in the spring	UNLIKELY	MINOR	MODERATE		
		SP5 (Posasa spring)	Limited use	Drinking, Shower, Washing, Cooking	X	X	1. SP5 will rarely be impacted by any kind of construction due to its location in the virgin forests. 2. It is located far away from community.	RARE	INSIGNIFICANT	LOW		
2	Valele	STR1(Marava stream)	Not in use	N/A	◎	X	STR1 is at a low lying area in a valley near the village and located close to the existing access road which used for local purpose. In addition to the risk caused by the existing use, it would be affected from surface runoff from the Access Road construction.	LIKELY	INSIGNIFICANT	MODERATE	1. Erosion control measures such as sediment ponds and drainage system should be effectively implemented to avoid the sedimentation and	HEC has provided water tanks with total Capacity of 2X2,100L = 4,200L with rain water collection accessories on 06.07.2021

No	Community	Water Source	Status	Usage	Threat Sources		Risks	Likelyhood	Consequences	Risk Level	Recommendation	Remarks
					Access Road Construction	Dam Construction						
		SP3 (Marava spring)	Still in use	Drinking, Cooking	X	X	1. SP3 is less likely to be affected by Access Road Construction considering the location and elevation profile of it. 2. Risk of natural flooding, where turbid water enters into the collection basin	UNLIKELY	MAJOR	HIGH	runoff entering the water sources. 2. Provide the total 5KL water tanks to support the water consumption for drinking water. 3. Due the relative ease of access, Valele's water can be supplemented by water trucks and it has been operated by HEC. 4. Posasa water source will be used and developed by CBSP to supply water to Marava, Ngonti and Valele by constructing water dam, receiving storage tank, Distribution Reservoir tank and the pipeline and fittings for the project.	
3	Ngongoti	SP3 (Marava spring)	Still in use	Cooking	X	X	1. SP3 is less likely to be affected by Access Road Construction considering the location and elevation profile of it. 2. Risk of natural flooding, where turbid water enters into the collection basin	UNLIKELY	MAJOR	HIGH	1. Erosion control measures such as sediment ponds and drainage system should be effectively implemented to avoid the sedimentation and runoff entering the water sources. 2. Provide the total 5KL water tanks to support the water consumption for drinking water. 3. Due the relative ease of access, Ngongoti's water can be supplemented by water trucks and it has been operated by HEC. 4. Posasa water source will be used and developed by CBSP to supply water to Marava, Ngonti and Valele by constructing water dam,	1. HEC has provided a 2,100L water tank on 27.06.2020. 2. HEC has provided rain water collection accessories on 17.03.2021.
		SP6 (Ngongoti Spring)	Usually dried up	Washing	◎	X	1. SP6 is situated below the road access so during rainny times it captures a lot storm water on the excavated roadstrip and produced storm water and sediments that went down to the stream. 2. Unreliable during dry seasons.	LIKELY	INSIGNIFICANT	MODERATE		
		W4	Not in use	N/A	◎	X	1. W4 has been abandondoned so it is not analyzed in the impact assesment. 2. Lack of maintenance by community users has made the source unusable. 3. Drying out in the past.	N/A	N/A	N/A		

No	Community	Water Source	Status	Usage	Threat Sources		Risks	Likelyhood	Consequences	Risk Level	Recommendation	Remarks
					Access Road Construction	Dam Construction						
											receiving storage tank, Distribution Reservoir tank and the pipeline and fittings for the project.	
4	Vera'ande Communities	SP1	Still in use	Drinking, Cooking Washing, Cleaning	X	X	1. SP1 will not be affected considering the existing drainage along the access road and the upgradation of it. Further, the depth to be excavated is under 0.7m according to the design. 2. It is afftected by runoff usually during heavy rain.	UNLIKELY	INSIGNIFICANT	LOW	1. Even it has low risk to road construction works and road level, HEC will need to take precaution measures to install sediment traps along the road as well as keep a close moni-toring schedule to ensure all sediments are well contained within the road	
		SP2	Still in use	Drinking, Cooking Washing, Cleaning	X	X	1. SP2 will not be affected considering the existing drainage along the access road and the upgradation of it. Further, the depth to be excavated is under 0.7m according to the design. 2. It is afftected by runoff usually during heavy rain.	UNLIKELY	INSIGNIFICANT	LOW		
		BH2	Still in use	Drinking, Cooking Washing, Cleaning	X	X	BH2 will not be affected considering the existing drainage along the access road and the upgradation of it. Further, the depth to be excavated is under 0.7m according to the design	RARE	MINOR	LOW		
		BH3	Not in use	N/A	X	X	BH3 will not be affected considering the existing drainage along the access road and the upgradation of it. Further, the depth to be excavated is under 0.7m according to the design.	N/A	N/A	N/A		
		BH4	Still in use	Cleaning, Washing	X	X	BH4 will not be affected considering the existing drainage along the access road and the upgradation of it. Further, the depth to be excavated is under 0.7m according to the design.	RARE	MINOR	LOW		
		BH5	Still in use	Drinking, Cooking Shower, Washing	X	X	1. BH5 will not be affected considering the existing drainage along the access road and the upgradation of it. Further, the depth to be excavated is under 0.7m according to the design. 2. Overpressure from communities due to all the communities using	RARE	MAJOR	MODERATE		

No	Community	Water Source	Status	Usage	Threat Sources		Risks	Likelyhood	Consequences	Risk Level	Recommendation	Remarks
					Access Road Construction	Dam Construction						
							this source for drinking purposes.					
		BH6	Still in use	Washing, Cleaning	X	X	BH6 will not be affected considering the existing drainage along the access road and the upgradation of it. Further, the depth to be excavated is under 0.7m according to the design.	RARE	MINOR	LOW		
		W1	Still in use	Shower, Washing	X	X	1. W1 is at a low lying terrain and is very close to road access, however, considering the existing drainage and the development of it, it will not be affected. Further, the depth to be excavated is under 0.7m according to the design 2. Risk of contamination due to surface runoff during flooding conditions.	UNLIKELY	INSIGNIFICANT	LOW		
		W2	Not in use	N/A	X	X	W2 is not in use.	N/A	N/A	N/A		
		W3	Not in use	N/A	X	X	W3 has been abandondoned so it is not analyzed in the impact assesment.	N/A	N/A	N/A		
5	Verakambikambi	SP7	Still in use	Drinking	◎	X	SP7 is at high risk of being contaminated from runoff and sediments deposits being washed down from up stream however it is rarely used due to small quantity.	ALMOST CERTAIN	MAJOR	EXTREME	1. Erosion control measures such as sediment ponds and drainage should be effectively implemented to avoid the sed-imentation and runoff enter-ing the water sources. 2. Provide the total 5KL water tanks to support the water consumption for drinking wa-ter. 3. Due the relative ease of ac-cess, Verakambikambi's water can be supplemented by water trucks and it has been operat-ed by HEC.	1. HEC has provided a water tank(5KL) on 23.06.2020. 2. HEC has provided a water tank(2KL) on 04.07.2020. 3. HEC has provided rain water collection accessories on 29.03.2021.
		SP8	Still in use	Drinking, Cooking	◎	X	SP8 is at very high risk of being contaminated by surface runoff however it is well concealed by concrete box	UNLIKELY	MAJOR	HIGH		
		W5	Still in use	Cooking, Washing	◎	X	W5 is at very high risk of being contaminated by surface runoffIt that brings down sediments and contaminants from Access Road construction.	POSSIBLE	MODERATE	HIGH		

No	Community	Water Source	Status	Usage	Threat Sources		Risks	Likelyhood	Consequences	Risk Level	Recommendation	Remarks
					Access Road Construction	Dam Construction						
											4. Posasa water source will be used and developed by CBSP to supply water to Marava, Ngonti and Valele by con-structing water dam, receiving storage tank, Distribution Reservoir tank and the pipe-line and fittings for the pro-ject.	
6	Valesala (Antioch)	SP9	Still in use	Drinking, Washing, Cooking, Shower	◎	X	SP9 likely would be affected due to its lower elevation compared to the road and which will influence the contamination and deposition of sediments from surface runoff	LIKELY	MAJOR	EXTREME	1. Erosion control measures such as sediment ponds and drainage should be effectively implemented to avoid the sedimentation and runoff entering the water sources. 2. There is a need to protect the two water spring sources at Valesala by constructing a separate concrete wall barrier to prevent runoffs. A new water dam needs to be constructed to protect the water source as well as to capture most of the water coming out from the rock and ground. 3. Since both the water sources are at extreme risk, rain water tanks will be provided to augment the drinking water requirement. 4. Provide the total 9KL water tanks to support the water consumption for drinking water. 5. CBSP plan has been in developing for this community.	HEC has provided Water tanks with capacity of 2X5000 liters=10,000 liters with rain water collection accessories on 30.04.2021
		SP10	Still in use		◎	X	SP10 likely would be affected due to having location at a lower elevation compared to the road and which is at high risk of being contaminated from deposition of sediments from surface runoff	LIKELY	MAJOR	EXTREME		

No	Community	Water Source	Status	Usage	Threat Sources		Risks	Likelyhood	Consequences	Risk Level	Recommendation	Remarks
					Access Road Construction	Dam Construction						
7	Verakuji & Managikiki Villages	STR3	Still in use	Shower, Washing	◎	X	STR3 will unlikely be affected by Access Road Construction works due to the distance from the road	UNLIKELY	INSIGNIFICANT	LOW	1. Erosion control measures such as sediment ponds and drainage should be effectively implemented to avoid the sedimentation and runoff entering the water sources. 2. Supply communal rain potable water tank for the village for drinking and cooking only while for washing and shower they have to walk down the stream as normally they always did every day 3. There are a few residents who rely on other water for drinking, washing and cleaning with high likelihood and rare usage, during water turbidity high and unusable conditions, alternate water sources SP13 and SP14 shall be used. 4. Provide the total 6KL water tanks to support the water consumption for drinking water. 5. CBSP plan has been in developing for this community.	HEC has provided water tank(5KL) on 06.07.2020.
		STR4	Still in use	Swimming	◎	X	STR4 is located approx.200m from a steep slope on which lies the proposed road access and activities from road construction would result in sediments and runoff.	POSSIBLE	INSIGNIFICANT	LOW		
		SP11	Still in use	Drinking, Washing, Cooking, Shower	◎	X	SP11 is very close to the access road and accordingly would likely be affected by construction activities but used by a small number of community members.	LIKELY	MAJOR	EXTREME		
		SP12	Still in use	Washing, Cleaning Only sometimes drinking	◎	X	SP12 is located at a lower elevation compared to the road and would be affected by erosion of disturbed soils	LIKELY	MINOR	HIGH		
		SP13 (Tapetape Spring)	Still in use	Drinking, Washing, Cooking, Shower	X	X	SP13 is located up gradient of the access road. Hence, the impacts caused by the road leveling and compaction activities are unlikely to occur.	RARE	MODERATE	LOW		
		SP14	Still in use	Drinking, Washing, Cooking, Shower	X	X	SP14 is less likely to be affected as it is located at a high elevation compared to the access road and is isolated by a hill.	RARE	MODERATE	LOW		
8	Habusi	RCP1	Still in use	Drinking, Washing, Cooking, Shower	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	EXTREME	1. Habusi community has an alternative water source about 100 m away from their village. The Habusi water stream will not be affected so the community can use it for swimming, washing, cooking and drinking. Also supply communal rain potable water tank for the older people in village for drinking and	
		STR5 (Habusi Stream)	Still in use	Drinking, Washing, Cooking, Shower	X	X	STR5 is located at an elevation higher than the river and therefore, not affected from the im-pacts from dam construction	RARE	MAJOR	MODERATE		

No	Community	Water Source	Status	Usage	Threat Sources		Risks	Likelyhood	Consequences	Risk Level	Recommendation	Remarks
					Access Road Construction	Dam Construction						
											cooking only while for washing and swimming they will still need to use the Habusi stream. 2. Provide the total 1KL water tanks to support the water consumption for drinking water.	
9	Pachuki	RCP2	Still in use	Drinking, Washing, Cooking, Shower	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	EXTREME	1. Water Supply replacement shall be provided as no reliable water supply during the Dam Construction. 2. Supply communal rain potable water tank for the village for drinking and cooking only while for the other purpose they will still need to use the river either to dig shallow wells at river bank to collect water or use at source 3. Provide the total 1KL water tanks to support the water consumption for drinking water.	
10	Namopila	RCP3	Still in use	Drinking, Washing, Cooking, Shower	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	EXTREME	1. Water Supply replacement shall be provided as no reliable water supply during the Dam Construction. 2. Supply communal rain potable water tank for the village for drinking and cooking only while for the other purpose they will still need to use the river either to dig shallow wells at river bank to collect water or use at source 3. Provide the total 6KL water tanks to support the water consumption for drinking water.	

No	Community	Water Source	Status	Usage	Threat Sources		Risks	Likelyhood	Consequences	Risk Level	Recommendation	Remarks
					Access Road Construction	Dam Construction						
11	Komureo	RCP4	Still in use	Drinking, Washing, Cooking, Shower	X	◎	This is a very small community and river is the only source of water supply, that will be affected by dam construction.	ALMOST CERTAIN	MAJOR	EXTREME	1. This is a small community and very close to Namopila.. 2. Water Supply replacement shall be provided as no reliable water supply during the Dam Construction. 3. Provide the total 1KL water tanks to support the water consumption for drinking water.	
12	Valekocha	RCP5	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	EXTREME	1. Valekocha have an alternate water source to rely on during the event of river water being unusable. Since the alternate water supply stream will be-come turbid during the rainy or flood season, water supply replacement in for of Rain water tank needs to be provid-ed to supplement. 2. Provide the total 2KL water tanks to support the water consumption for drinking wa-ter. 3. At this elevation boreholes may not be considered and not be feasible due to accessi-bility limitations. 4. Valekocha may be able to share the water supplied to Valesala (650 m north) through a gravity fed water supply.	
		STR7	Still in use	Drinking, Cooking, Swimming, Washing			STR7 is likely affected by Access Road Construction.The entrance of the stream is situated near the proposed Access Road alignment.	LIKELY	MODERATE	HIGH		
13	Vatunadi	RCP6	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	EXTREME	1. The villages on the western side of the Tina River. 2. Vatunadi have an alternate water source to rely on during the event of river water being	

No	Community	Water Source	Status	Usage	Threat Sources		Risks	Likelyhood	Consequences	Risk Level	Recommendation	Remarks
					Access Road Construction	Dam Construction						
		STR6	Still in use	Drinking, Cooking, Swimming, Washing	X	X	STR6 is less likely to be affected as it is located higher than the river level elevation therefore surface runoff is towards the river.	RARE	MODERATE	LOW	unusable. Since the alternate water supply stream will become turbid during the rainy or flood season, water supply replacement in for of Rain water tank needs to be provided to supplement. 3. Provide the total 1KL water tanks to support the water consumption for drinking water.	
14	Kolanji	RCP7	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	EXTREME	1. This is a small community and the water supply provided to Valesala may also be used to supply Kolanji. However, since the distance to fetch clean water was very far and steep, HEC need to supply rain water tank to the village for only drinking and cooking. 2. Provide the total 1KL water tanks to support the water consumption for drinking wa-ter.	
15	Veramaota	RCP8	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	EXTREME	1. The community will need the communal rain water tank for each community for drink-ing and cooking only. All the tanks that will be supplied need to have tank base frames include the roof catchment with all the gutters and acces-sories to complete the instal-lation. For the other purpose, they can still use the Tina River or can dig a shallow well near the river to access water during dry seasons 2. Water Supply replacement shall	
16	Taurasa	RCP10	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	EXTREME		

No	Community	Water Source	Status	Usage	Threat Sources		Risks	Likelyhood	Consequences	Risk Level	Recommendation	Remarks
					Access Road Construction	Dam Construction						
											be provided during the Dam Construction. 3. Provide the total 1KL water tanks to support the water consumption for drinking wa-ter.	
17	Valebebe 1&2	RCP9	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	EXTREME	1. Water Supply replacement shall be provided as no reliable water supply during the Dam Construction. 2. Provide the total 3KL water tanks to support the water consumption for drinking water.	
18	Tina	RCP9	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	EXTREME	1. Tina community has a reli-able water source recently installed in form of Borehole. And the dependence on the river is decreasing gradually. 2. Since the CBSP also has planned for a robust water supply network for Tina and nearby communities, HEC can support the development of the plan with CBSP.	
		BH7	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	BH7 is less likely to be affected as it is located above river level and surface runoff as indicated by flow mesh is in the direction towards the river	RARE	MAJOR	MODERATE		
19	Kathiana	RCP11	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	EXTREME	1. Water Supply replacement shall be provided during the Dam Construction. 2. Provide the total 5KL water tanks to support the water consumption for drinking water.	
20	Haimane	RCP12	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	EXTREME	1. Haimane have an alternate water source to rely on during the event of river water being unusable. Since the alternate water supply stream will become turbid during the rainy or	

No	Community	Water Source	Status	Usage	Threat Sources		Risks	Likelyhood	Consequences	Risk Level	Recommendation	Remarks
					Access Road Construction	Dam Construction						
		STR8	Still in use	Shower, Washing	X	X	STR8 is located just on the river bank which they use for washing only but during wet season flood covered the stream. The impact from road construction or dam construction is unlikely.	UNLIKELY	MODERATE	MODERATE	flood season, water supply replacement in form of Rain water tank needs to be provid-ed to supplement. 2. Provide the total 3KL water tanks to support the water consumption for drinking water.	
21	Vuramali	RCP13	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	EXTREME	1. Vuramali has multiple water sources that can be reliable during dam construction works and flooding events. 2. No, alternate water supply is required for this community.	
		STR8	Still in use	Shower, Washing	X	X	STR8 is located just on the river bank which they use for washing only but during wet season flood covered the stream. The impact from road construction or dam construction is unlikely.	UNLIKELY	MODERATE	MODERATE		
		SP15	Still in use	Drinking, Washing, Cooking, Shower	X	X	SP15 is less likely to be affect since they are both located at a higher elevation to the east side of the river, so there is no impacts from dam construction.	RARE	MODERATE	LOW		
		SP16	Still in use	Drinking, Washing, Cooking, Shower	X	X	SP16 is less likely to be affect since they are both located at a higher elevation to the east side of the river, so there is no impacts from dam construction.	RARE	MODERATE	LOW		
22	Valebariki	RCP14	Still in use	Drinking, Cooking, Swimming, Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	EXTREME	1. Valebariki have an alternate water source to rely on during the event of river water being unusable. Since the alternate water supply stream will be-come turbid during the rainy or flood season, water supply replacement in form of Rain water tank needs to be provid-ed to supplement. 2. Provide the total 1KL water tanks to support the water consumption for drinking wa-ter.	
		STR8	Still in use	Shower, Washing	X	X	STR8 is located on the river bank which they use for washing and only flood can affect the water source. The impact from road construction or dam construction is unlikely.	UNLIKELY	MODERATE	MODERATE		

No	Community	Water Source	Status	Usage	Threat Sources		Risks	Likelyhood	Consequences	Risk Level	Recommendation	Remarks
					Access Road Construction	Dam Construction						
23	Horohotu 1&2	RCP14	Still in use	Drinking,Cooking, Swimming,Washing	X	◎	During the dam construction the Tina River will experience high turbidity level in the Tina river and expected a lot of sediments discharge to the river which will affect the water collection points in the river bank.	ALMOST CERTAIN	MAJOR	EXTREME	1. Horohotu have an alternate water source to rely on during the event of river water being unusable. The alternate water supply stream will become turbid during the rainy or flood season. To cope up dur-ing the above described condi-tions Rain water tank are also available. 2. Hence there is no require-ment of any additional water supply replacement	
		STR8	Still in use	Shower, Washing	X	X	STR8 is located on the river bank which they use for washing and only flood can affect the water source. The impact from road construction or dam construction is unlikely.	UNLIKELY	MODERATE	MODERATE		
		STR9	Still in use	Drinking, Swimming, Shower, Washing	X	X	STR9 is located on the river bank which they use for washing and only flood can affect the water source. The impact from road construction or dam construction is unlikely.	UNLIKELY	MODERATE	MODERATE		
24	Abuabili	W7	Still in use	Drinking, Washing, Cooking, Shower	X	X	1. Abuabili is located far from Tina River and all water sources at the village are located at a bit higher elevation from the river. 2. Further, there is a ridge between the river and the water sources, thus, less chance to be affected by the Dam construction. 3. During rainy days face problem for pumping as solar pump cannot be used. They hire Diesel pump during these kind of events.	RARE	INSIGNIFICANT	LOW	1. Similar to the other com-munities located on the downstream flood plains, there are multiple water sup-ply sources rarely use the Ngalimbiu River. 2. During the events of river water becoming turbid, alter-nate water sources in the community can be used. 3. No alternative water supply replacement is required for this community.	1. The deep well was dug and provided by GPPOL company some years ago, It has been installed with a solar pump, 6m high tank frame with 1 x 3Kl storage and a stand pipe 2. The bore hole was drilled by Rural Development Programme and install with a Hand PVC pump
		BH 9	Still in use	Drinking, Washing, Cooking, Shower	X	X		RARE	MINOR	LOW		
		BH 10	Still in use	Shower, Washing	X	X		RARE	INSIGNIFICANT	LOW		
		Rain Water Tank	Still in use	Drinking, Cooking	X	X		RARE	INSIGNIFICANT	LOW		
		RCP17	Rarely used	Swimming, Washing	X	◎	Occasionally use the Ngalimbiu River for big washing and swimming, Distance from Abuabili to the river is 700m	ALMOST CERTAIN	MAJOR	EXTREME		
25	Komubeti	BH11	Still in use	Drinking, Washing, Cooking, Shower	X	X	1. Stand pipe and BH11 at Komeleti is far from Ngalimbiu River, there is rarely any risks identified with any kind of construction. 2. The Storage tank temporary runs out of	RARE	INSIGNIFICANT	LOW	1. This community has installed a Borehole with storage tank and water supplied to each community with standpipes. 2. The water supply ifrastructure is well	1. Borehole drilled and pump supplied by Rural Development Programme. 2. The whole community has 7 standpipes for distribution of water.

No	Community	Water Source	Status	Usage	Threat Sources		Risks	Likelyhood	Consequences	Risk Level	Recommendation	Remarks
					Access Road Construction	Dam Construction						
							water depending on the availbility of fuel for the generator pump.				developed and no replacement shall be required.	
		RCP18	Rarely used	Swimming, Washing	X	◎	Occasionally use the Ngalimbiu river when the diesel pump has no fuel. Distance from Komleti to the river is approximately 460m	ALMOST CERTAIN	MAJOR	EXTREME		
26	Taona	BH17	Not in use	Drinking, Washing, Cooking, Shower	X	X	BH17 has been abandoned	N/A	N/A	N/A	1. Since the Drinking water resource in this community is limited, water supply in form of additional rain water tanks shall be provided.	
		W8	Still in use	Drinking, Washing, Cooking, Shower	X	X	W8 is far from Ngalimbiu River.	RARE	MAJOR	MODERATE		
		Rain Water Tank	Still in use	Drinking, Cooking	X	X	No risks associated with construction identified.	RARE	INSIGNIFICANT	LOW		
		RCP17	Rarely used	Swimming, Washing	X	◎	Occasionally, Ngalimbiu river only be used for big household washing and for garden purposes and sometimes swimming. Distance from Taona to the river is approximately 200m	ALMOST CERTAIN	MAJOR	EXTREME		
27	Matonaso 1,2&3	W9 (Matanaso 1)	Still in use	Shower, Washing	X	X	All water sources in Matanaso is in close range to each other in a location very less likely to be affected since they are all isolated from the impacts from dam construction at an elevation higher than the river. Surface runoff flows in the direction from the sources towards river, therefore won't be a problem.	RARE	INSIGNIFICANT	LOW	1. Matonaso has a number of water sources in the community and rarely depend on the River for their domestic needs. These water sources can be used when the water is unusable from the Ngalimbiu river. 2. No alternative water supply is required to be provided.	
		BH16 (Matanaso 1)	Still in use	Drinking, Washing, Cooking, Shower	X	X		RARE	INSIGNIFICANT	LOW		
		W10 (Matanaso 2)	Still in use	Drinking, Washing, Cooking, Shower	X	X		RARE	INSIGNIFICANT	LOW		
		BH15 (Matanaso 2)	Still in use	Drinking, Washing, Cooking, Shower	X	X		RARE	INSIGNIFICANT	LOW		
		W11 (Matanaso 3)	Still in use	Shower, Washing	X	X		RARE	INSIGNIFICANT	LOW		

No	Community	Water Source	Status	Usage	Threat Sources		Risks	Likelyhood	Consequences	Risk Level	Recommendation	Remarks
					Access Road Construction	Dam Construction						
		Rain water Tank (Private)	Still in use	Drinking, Cooking	X	X		RARE	INSIGNIFICANT	LOW		
		Rain water Tank (Comunal)	Still in use	Drinking, Cooking	X	X		RARE	INSIGNIFICANT	LOW		
		RCP 16	Still in use	Gardening, Swimming, Washing	X	◎	Occasionally ,Ngalimbiu river only be used for big household washing and for garden purposes and sometimes swimming. Distance from Taona to the river is approximately 200m	ALMOST CERTAIN	MAJOR	EXTREME		
28	Mbaravule	BH12	Still in use	Cooking, Shower, Washing	X	X	BH12 in Mbaravule unlikely to be affected due to the location and the direction runoff flows which is towards the river	RARE	INSIGNIFICANT	LOW	1. Mbaravule community do not use the river water for any purposes. 2. Secondly, the GPPOL water supply is nearby that can be used if their regular water source is disturbed due to any reasons.	It was constructed by GPPOL Company some years back and still used today. It never runs dry even during dry season.
29	Old Selwyn	Storage Water Tank	Still in use	Drinking, Cooking	X	X	Existing water sources in Old Selwyn are safe and are unlikely to be affected by dam construction due to its location and a high elevation than the river. The 3x2Kl rain water tanks are loacted on the raised platform.	RARE	INSIGNIFICANT	LOW	1. Old Selwyn community showcases the best model for community water supply. There are reliable water sources in the community that can be used during the Dam construction works. Further, Ngalimbiu River is hardly used by the community these days	1. Borehole developed by Rural Development Programme and install 6m high with a structural steel tank frame. 2. There is a plan for installation of Solar Pump by Rural Development Programme.
		BH8	Still in use	Drinking, Cooking, Shower, Washing	X	X	1. The 4x2Kl storage water tanks and the borehole pump is sufficient for the community to sustain them. 2. Storage tanks temporary runs out of water as it depending on availability of fuel for the generator pump.	RARE	INSIGNIFICANT	LOW		
		RCP 21	Rarely used	Swimming, Washing	X	◎	The RCP21 will be affected, but the community would not use it as already the community has sufficient water from the boreholes and rain water tanks	ALMOST CERTAIN	MAJOR	EXTREME		
30	Mbubulu 1,2&3	W12	Still in use	Shower, Washing	X	X	1. All water sources in Mbubulu are located where it is unlikely to be affected by dam construction and there is ridge between the river and the villages. 2. The pump always runs during the day time, as	RARE	INSIGNIFICANT	LOW	1. Mbubulu has a number of water sources in the commu-nity and rarely depend on the River for their domestic needs. These water sources can be used	1. It was drilled at year 2020 at 9m deep supplied with a 5KL storage tank and a stand pipe. It never runs dry through out the year. Also it save 30 people in the community. 2. All the materials were already provided by the Rural Development Programme
		W13	Still in use	Shower, Drinking, Washing	X	X		RARE	MINOR	LOW		
		W14	Still in use	Shower, Washing	X	X		RARE	INSIGNIFICANT	LOW		

No	Community	Water Source	Status	Usage	Threat Sources		Risks	Likelyhood	Consequences	Risk Level	Recommendation	Remarks
					Access Road Construction	Dam Construction						
		W15	Still in use	Shower, Washing	X	X	the solar pump controller has not been installed. This leads to wastage of water during the day time.	RARE	INSIGNIFICANT	LOW	when the water is unusable from the Ngalimbiu river. Ngalimbiu River is rare-ly used by the community these days. 2. No alternative water supply is required to be provided.	
		BH13	Still in use	Drinking, Shower, Washing, Cooking	X	X		RARE	MINOR	LOW		
		BH14	Still in use	Shower, Washing	X	X		RARE	MINOR	LOW		
		Rain Water Tank	Still in use	Drinking	X	X		RARE	INSIGNIFICANT	LOW		
		RCP15	Still in use	Swimming, Washing	X	◎	1. Occasionally use the Ngalimbiu River for washing and swimming after gardening works.	ALMOST CERTAIN	MAJOR	EXTREME		

Appendix D Water Sources, photos and water quality analyses

#	Location	Type of Water Source (Spring/ Stream/ Well/ Borehole)	Pumping arrangement if available	Storage arrangement and capacity	Distance from the Access Road (Lot1) (m)	Flow rate in lpm	Current Use (Drinking/ Shower/ Washing)	No of dependents (in persons/ households)	Dependent Villages	Water Demand for Drinking and Cooking (Quantity in liters)	Southing	Easting	Remarks	Image	Image	Result (10/08/20) Low Flow Condition	Result (13/08/20)
1	Verande	Borehole in abandoned condition since 2018			52		No more used				9°28'25.50"	160°06'41.09"	Abandoned condition The well with diesel pump is currently being used.				
2	Verande	Well (Ground Water)	Fitted to a diesel pump	1000 liter PVC Tank	60		Used for washing, bathing and cooking(not drinking)				9°28'25.50"	160°06'41.09"	The drinking water is brought from the Borehole with Solar Pump in Verande.		 		
3	Verande	Borehole	Electric Pump operated from Diesel Generator	1000 liter PVC Tank	47	5.5 lpm	Used for drinking, cooking, washing and showering.	4 Houses	Verande local houses only	120	9°28'15.60"	160°06'36.7"	Newly built Family owned. 30 liters per day is the estimated usage. Discharged at the outlet of the tank.			**Microbiological Assessment** 1. **Total Coliform (MPN/100ml)**: >10,000 / 1,778 / 1,778 **(Acceptable Values(WHO):<10)** 2. **E.coli**(MPN/100ml): 1,088 / 262 / 61 **(Acceptable Values(WHO):0)** **Physico-chemical Analyses Results** 3. **Odour Test(Average 5 sniffers):** None / None / None **(Acceptable Values(ANZECC/ADWG): acceptable)** 4. **Turbidity(NTU):** 0.11 / 0.12 / 0.14 **(Acceptable Values(ANZECC/ADWG): <5.0)** 5. **PH(unit):** 7.3 / 7.3 / 7.5 **(Acceptable Values(ANZECC/ADWG): 6.5-8.5)** 6. **TDS(mg/L):** 240 / 240 / 250 **(Acceptable Values(ANZECC/ADWG): >300)** 7. **Sulphate(SO4, mg/L):** 0 / 0 / 0 **(Acceptable**	**Microbiological Assessment** 1. **Total Coliform(MPN/100ml)**: 538 / 49 / <1 **(Acceptable Values(WHO):<10)** 2. **E.coli**(MPN/100ml): <1 / <1 / <1 **(Acceptable Values(WHO):0)** **Physico-chemical Analyses Results** 3. **Odour Test(Average 5 sniffers):** None / None / None **(Acceptable Values(ANZECC/ADWG): acceptable)** 4. **Turbidity(NTU):** 0.08 / 0.10 / 0.35 **(Acceptable Values(ANZECC/ADWG): <5.0)** 5. **PH(unit):** 7.3 / 7.3 / 7.3 **(Acceptable Values(ANZECC/ADWG): 6.5-8.5)** 6. **TDS(mg/L):** 230 / 240 / 240 **(Acceptable Values(ANZECC/ADWG): >300)** 7. **Sulphate(SO4, mg/L): (Acceptable Values(ANZECC/ADWG): <250)**

#	Location	Type of Water Source (Spring/ Stream/ Well/ Borehole)	Pumping arrangement if available	Storage arrangement and capacity	Distance from the Access Road (Lot1) (m)	Flow rate in lpm	Current Use (Drinking/ Shower/ Washing)	No of dependents (in persons/ households)	Dependent Villages	Water Demand for Drinking and Cooking (Quantity in liters)	Southing	Easting	Remarks	Image	Image	Result (10/08/20) Low Flow Condition	Result (13/08/20)
																Values(ANZECC/ADWG): <250) 8. **Nitrate(No3-N, mg/L):** 3.4 / 3.3 / 3.2 **(Acceptable Values(ANZECC/ADWG): <10)**	8. **Nitrate(No3-N, mg/L):** 3.4 / 3.3 / 3.2 **(Acceptable Values(ANZECC/ADWG): <10)**
4	Verande	Well in abandoned condition			55		Not used				9°28'31.55"	160°06'41.86"	The hand pump installed at a distance of 15 meters is used for after the well is abandoned.				
5	Verande	Borehole	Hand Pump	No storage	45		Used for only washing and cleaning				9°28'33.31"	160°06'42.00"	The drinking water is brought from the Borehole with Solar Pump in Verande.				
6	Verande	Borehole with Solar Pump	Solar Pumping with automatic tank controller	1000 liters stainless steel tank	62	5.94lpm	Used for drinking by all Verande Community Members and other purposes by neigbouring homes.	40 Houses	Verande	800	9°28'38.19"	160°06'41.53"	Around 20 liters is the drinking and cooking water requirement per household Th discharge is measured at the consumer tap without any pump.			**Microbiological Assessment** 1. **Total Coliform(MPN/100ml):** 122 / 2,727 / 122 **(Acceptable Values(WHO):<10)** 2. **E.coli**(MPN/100ml): <1 / <1 / <1 **(Acceptable Values(WHO):0)** **Physico-chemical Analyses Results** 3. **Odour Test(Average 5 sniffers):** None / None / None **(Acceptable Values(ANZECC/ADWG): acceptable)** 4. **Turbidity(NTU):** 0.05 / 0.01 / 0.09 **(Acceptable Values(ANZECC/ADWG): <5.0)** 5. **PH(unit):** 6.6 / 6.7 / 6.7 **(Acceptable Values(ANZECC/ADWG): 6.5-8.5)** 6. **TDS(mg/L):** 160 / 160 / 160 **(Acceptable Values(ANZECC/ADWG): >300)** 7. **Sulphate(SO4, mg/L):** 0 / 0 / 1 **(Acceptable Values(ANZECC/ADWG): <250)** 8. **Nitrate(No3-N, mg/L):** 1.0 / 2.0 / 1.0 **(Acceptable Values(ANZECC/ADWG): <10)**	**Microbiological Assessment** 1. **Total Coliform(MPN/100ml):** 15 / <1 / 12 **(Acceptable Values(WHO):<10)** 2. **E.coli**(MPN/100ml): <1 / <1 / <1 **(Acceptable Values(WHO):0)** **Physico-chemical Analyses Results** 3. **Odour Test(Average 5 sniffers):** None / None / None **(Acceptable Values(ANZECC/ADWG): acceptable)** 4. **Turbidity(NTU):** 0.01 / 0.01 / 0.11 **(Acceptable Values(ANZECC/ADWG): <5.0)** 5. **PH(unit):** 6.9 / 7.0 / 6.8 **(Acceptable Values(ANZECC/ADWG): 6.5-8.5)** 6. **TDS(mg/L):** 160 / 160 / 160 **(Acceptable Values(ANZECC/ADWG): >300)** 7. **Sulphate(SO4, mg/L): (Acceptable Values(ANZECC/ADWG): <250)** 8. **Nitrate(No3-N, mg/L):** 3.3 / 3.4 / 2.9 **(Acceptable Values(ANZECC/ADWG): <10)**
7	Verande	Borehole-18 meters deep with Hand Pump			45		Used for washing and cleaning.				9°28'49.72"	160°06'39.16"					

#	Location	Type of Water Source (Spring/ Stream/ Well/ Borehole)	Pumping arrangement if available	Storage arrangement and capacity	Distance from the Access Road (Lot1) (m)	Flow rate in lpm	Current Use (Drinking/ Shower/ Washing)	No of dependents (in persons/ households)	Dependent Villages	Water Demand for Drinking and Cooking (Quantity in liters)	Southing	Easting	Remarks	Image	Image	Result (10/08/20) Low Flow Condition	Result (13/08/20)
8	Verande	Well			103		Not Used				9°28'50.51"	160°06'37.10"					
9	Verakabikabi	Spring (Ground water)	Gravity fed	Concrete Box tank	360	40.2 lpm	Used for Drinking and cooking	60 Houses	Verakabikabi Vatupaua	1440	9°29'42.2"	160°06'43.7"	The user answered the population of village is around 300. The estimated use is about 24 liters as said by one of the female users.			**Microbiological Assessment** 1. **Total Coliform(MPN/100ml)**: 21 / 21 / 8 **(Acceptable Values(WHO):<10)** 2. **E.coli**(MPN/100ml): <1 / <1 / <1 **(Acceptable Values(WHO):0)** **Physico-chemical Analyses Results** 3. **Odour Test(Average 5 sniffers):** None / None / None **(Acceptable Values(ANZECC/ADWG): acceptable)** 4. **Turbidity(NTU):** 0.27 / 0.25 / 0.35 **(Acceptable Values(ANZECC/ADWG): <5.0)** 5. **PH(unit):** 7.0 / 7.1 / 7.1 **(Acceptable Values(ANZECC/ADWG): 6.5-8.5)** 6. **TDS(mg/L):** 150 / 150 / 150 **(Acceptable Values(ANZECC/ADWG): >300)** 7. **Sulphate(SO4, mg/L):** 0 / 0 / 0 **(Acceptable Values(ANZECC/ADWG): <250)** 8. **Nitrate(No3-N, mg/L):** 1.0 / 1.0 / 1.5 **(Acceptable Values(ANZECC/ADWG): <10)**	**Microbiological Assessment** 1. **Total Coliform(MPN/100ml)**: 10 / <1 / 10 **(Acceptable Values(WHO):<10)** 2. **E.coli**(MPN/100ml): <1 / <1 / <1 **(Acceptable Values(WHO):0)** **Physico-chemical Analyses Results** 3. **Odour Test(Average 5 sniffers):** None / None / None **(Acceptable Values(ANZECC/ADWG): acceptable)** 4. **Turbidity(NTU):** 0.05 / 0.06 / 0.03 **(Acceptable Values(ANZECC/ADWG): <5.0)** 5. **PH(unit):** 7.2 / 7.3 / 7.3 **(Acceptable Values(ANZECC/ADWG): 6.5-8.5)** 6. **TDS(mg/L):** 150 / 150 / 150 **(Acceptable Values(ANZECC/ADWG): >300)** 7. **Sulphate(SO4, mg/L):** - / - / - **(Acceptable Values(ANZECC/ADWG): <250)** **Nitrate(No3-N, mg/L):** 3.2 / 2.7 / 3.2 **(Acceptable Values(ANZECC/ADWG): <10)**

#	Location	Type of Water Source (Spring/ Stream/ Well/ Borehole)	Pumping arrangement if available	Storage arrangement and capacity	Distance from the Access Road (Lot1) (m)	Flow rate in lpm	Current Use (Drinking/ Shower/ Washing)	No of dependents (in persons/ households)	Dependent Villages	Water Demand for Drinking and Cooking (Quantity in liters)	Southing	Easting	Remarks	Image	Image	Result (10/08/20) Low Flow Condition	Result (13/08/20)
10	Verakabikabi	Spring (Ground water)	Gravity fed	Very small natural pool	270	0.46 lpm	Used for Drinking	60 Houses	Verakabikabi	1440	9°29'46.8"	160°06'39.5"	This spring is an alternate drinking water source for Verakabi community members only.			**Microbiological Assessment** 1. **Total Coliform(MPN/100ml):** 814 / 1,293 / 1,818 **(Acceptable Values(WHO):<10)** 2. **E.coli**(MPN/100ml): <1 / <1 / 3 **(Acceptable Values(WHO):0)** **Physico-chemical Analyses Results** 3. **Odour Test(Average 5 sniffers):** None / None / None **(Acceptable Values(ANZECC/ADWG): acceptable)** 4. **Turbidity(NTU):** 0.59 / 0.85 / 0.72 **(Acceptable Values(ANZECC/ADWG): <5.0)** 5. **PH(unit):** 6.6 / 6.5 / 6.5 **(Acceptable Values(ANZECC/ADWG): 6.5-8.5)** 6. **TDS(mg/L):** 110 / 110 / 110 **(Acceptable Values(ANZECC/ADWG): >300)** 7. **Sulphate(SO4, mg/L):** 0 / 0 / 0 **(Acceptable Values(ANZECC/ADWG): <250)** 8. **Nitrate(No3-N, mg/L):** 1.5 / 1.0 / 1.0 **(Acceptable Values(ANZECC/ADWG): <10)**	**Microbiological Assessment** 1. **Total Coliform(MPN/100ml):** 925 / 1,378 / 1,724 **(Acceptable Values(WHO):<10)** 2. **E.coli**(MPN/100ml): 31 / 87 / 16 **(Acceptable Values(WHO):0)** **Physico-chemical Analyses Results** 3. **Odour Test(Average 5 sniffers):** None / None / None **(Acceptable Values(ANZECC/ADWG): acceptable)** 4. **Turbidity(NTU):** 0.53 / 0.47 / 0.38 **(Acceptable Values(ANZECC/ADWG): <5.0)** 5. **PH(unit):** 6.7 / 6.7 / 6.7 **(Acceptable Values(ANZECC/ADWG): 6.5-8.5)** 6. **TDS(mg/L):** 100 / 110 / 110 **(Acceptable Values(ANZECC/ADWG): >300)** 7. **Sulphate(SO4, mg/L):** - / - / - **(Acceptable Values(ANZECC/ADWG): <250)** 8. **Nitrate(No3-N, mg/L):** 2.8 / 4.2 / 3.0 **(Acceptable Values(ANZECC/ADWG): <10)**
11	Verakabikabi	Well	Gravity fed	Using a steel drum and PVC pipe outlet	162	0.49lpm	Used for cooking and washing (occasionally for drinking)	60 Houses	Verakabikabi	1440	9°29'48.07"	160°06'35.88"	It is usually dirty in the rainy season and not suitable for drinking.				**Microbiological Assessment** 1. **Total Coliform(MPN/100ml):** >10,000 / >10,000 / 5,056 **(Acceptable Values(WHO):<10)** 2. **E.coli**(MPN/100ml): <1 / <1 / <1 **(Acceptable Values(WHO):0)** **Physico-chemical Analyses Results** 3. **Odour Test(Average 5 sniffers):** None / None / None **(Acceptable Values(ANZECC/ADWG): acceptable)** 4. **Turbidity(NTU):** 0.49 / 0.39 / 0.37 **(Acceptable Values(ANZECC/ADWG): <5.0)** 5. **PH(unit):** 7.5 / 7.3 / 7.4 **(Acceptable Values(ANZECC/ADWG): 6.5-8.5)** 6. **TDS(mg/L):** 120 / 120 / 120 **(Acceptable Values(ANZECC/ADWG): >300)** 7. **Sulphate(SO4, mg/L):** 0 / 0 / - **(Acceptable Values(ANZECC/ADWG): <250)**

#	Location	Type of Water Source (Spring/ Stream/ Well/ Borehole)	Pumping arrangement if available	Storage arrangement and capacity	Distance from the Access Road (Lot1) (m)	Flow rate in lpm	Current Use (Drinking/ Shower/ Washing)	No of dependents (in persons/ households)	Dependent Villages	Water Demand for Drinking and Cooking (Quantity in liters)	Southing	Easting	Remarks	Image	Image	Result (10/08/20) Low Flow Condition	Result (13/08/20)
																	8. **Nitrate(No3-N, mg/L):** 2.8 / 3.6 / 4.4 **(Acceptable Values(ANZECC/ADWG): <10)**
12	Pavu	1. Spring(Ground Water) 2. Stream(Surface Water)	Gravity fed	Natural pool	258	0.9lpm	1. Spring Used for drinking, cooking, 2. Stream used for washing and showering.	8 Houses	Pavu	120	9°29'8.50"	160° 6'29.30"	The user answered 15 liters per day is the requirement per household.				**Microbiological Assessment** 1. **Total Coliform(MPN/100ml)**: 861 / 346 / 444 **(Acceptable Values(WHO):<10)** 2. **E.coli**(MPN/100ml): <1 / <1 / <1 **(Acceptable Values(WHO):0)** **Physico-chemical Analyses Results** 3. **Odour Test(Average 5 sniffers):** None / None / None **(Acceptable Values(ANZECC/ADWG): acceptable)** 4. **Turbidity(NTU):** 0.44 / 0.52 / 0.53 **(Acceptable Values(ANZECC/ADWG): <5.0)** 5. **PH(unit):** 7.4 / 7.3 / 7.3 **(Acceptable Values(ANZECC/ADWG): 6.5-8.5)** 6. **TDS(mg/L):** 170 / 170 / 170 **(Acceptable Values(ANZECC/ADWG): >300)** 7. **Sulphate(SO4, mg/L):** 0 / 0 / - **(Acceptable Values(ANZECC/ADWG): <250)** 8. **Nitrate(No3-N, mg/L):** 3.8 / 3.0 / 3.2 **(Acceptable Values(ANZECC/ADWG): <10)**
13	Ngongoti	Well			62		Used only during rain for showering (At present, dried)				9°30'06.56"	160°06'31.55"					
14	Ngongoti	Spring from Surface Water Runoff			165		Used for washing (usually dried up)				9°30'12.17"	160°06'33.30"					
15	Marava	Stream at the old road, water crossing			302		Used for laundry, bathing and washing				9°30'5.25"	160°06'18.42"					

#	Location	Type of Water Source (Spring/ Stream/ Well/ Borehole)	Pumping arrangement if available	Storage arrangement and capacity	Distance from the Access Road (Lot1) (m)	Flow rate in lpm	Current Use (Drinking/ Shower/ Washing)	No of dependents (in persons/ households)	Dependent Villages	Water Demand for Drinking and Cooking (Quantity in liters)	Southing	Easting	Remarks	Image	Image	Result (10/08/20) Low Flow Condition	Result (13/08/20)
16	Marava	Spring fromGround water	Gravity fed	Natural pool	490	4.62lpm	Used for drinking and cooking throughout the year.	30 Houses	RateNangotiMarava	450	9°30'2.61"	160°06'11.52"	15 Liters per day is the drinking and cooking water requirement as answered by one of the users.			**Microbiological Assessment1. Total Coliform(MPN/100ml)**: 1,293 / 2,616 / 1,717 **(Acceptable Values(WHO):<10)2. E.coli**(MPN/100ml): 19 / 30 / 10 **(Acceptable Values(WHO):0)Physico-chemical Analyses Results3. Odour Test(Average 5 sniffers):** None / None / None **(Acceptable Values(ANZECC/ADWG): acceptable)4. Turbidity(NTU):** 0.08 / 0.06 / 0.35 **(Acceptable Values(ANZECC/ADWG): <5.0)5. PH(unit):** 6.9 / 6.8 / 6.9 **(Acceptable Values(ANZECC/ADWG): 6.5-8.5)6. TDS(mg/L):** 160 / 170 / 170 **(Acceptable Values(ANZECC/ADWG): >300)7. Sulphate(SO4, mg/L):** 0 / 0 / 0 **(Acceptable Values(ANZECC/ADWG): <250)8. Nitrate(No3-N, mg/L):** 1.0 / 1.0 / 1.0 **(Acceptable Values(ANZECC/ADWG): <10)**	**Microbiological Assessment1. Total Coliform(MPN/100ml)**: 4,082 / 2,586 / 3,434 **(Acceptable Values(WHO):<10)2. E.coli**(MPN/100ml): 5 / 10 / 5 **(Acceptable Values(WHO):0)Physico-chemical Analyses Results3. Odour Test(Average 5 sniffers):** None / None / None **(Acceptable Values(ANZECC/ADWG): acceptable)4. Turbidity(NTU):** 0.15 / 0.06 / 0.08 **(Acceptable Values(ANZECC/ADWG): <5.0)5. PH(unit):** 7.3 / 7.3 / 7.1 **(Acceptable Values(ANZECC/ADWG): 6.5-8.5)6. TDS(mg/L):** 160 / 160 / 160 **(Acceptable Values(ANZECC/ADWG): >300)7. Sulphate(SO4, mg/L):** - / - / - **(Acceptable Values(ANZECC/ADWG): <250)8. Nitrate(No3-N, mg/L):** 2.9 / 2.9 / 2.8 **(Acceptable Values(ANZECC/ADWG): <10)**
17	Marava	Stream is at the same place of Spring SP6.			490		Used for bathing and washing.				9°30'2.61"	160°06'11.52"					
18	Marava	Spring (Ground water)	Gravity Fed	Natural pool	875	5.22lpm	Used for drinking and cooking	36 Houses	Rate School Nngoti Wind Ridge(1 house) Marava		9°30'9.80"S	160° 5'59.80"E	Rate and Wind Ridge use it only during Dry Season. Marava and Ngoti is close so they use regularly. The demand provided by one of the users was 12-15 liters per day per household for drinking and cooking.				**Microbiological Assessment** 1. **Total Coliform(MPN/100ml)**: 5,231 / 5,231 / 4,082 **(Acceptable Values(WHO):<10)** 2. **E.coli**(MPN/100ml): 43 / 133 / 248 **(Acceptable Values(WHO):0)** **Physico-chemical Analyses Results** 3. **Odour Test(Average 5 sniffers):** None / None / None **(Acceptable Values(ANZECC/ADWG): acceptable)** 4. **Turbidity(NTU):** 0.11 / 0.09 / 0.02 **(Acceptable Values(ANZECC/ADWG): <5.0)** 5. **PH(unit):** 7.7 / 7.9 / 7.8 **(Acceptable Values(ANZECC/ADWG): 6.5-8.5)** 6. **TDS(mg/L):** 210 / 210 / 210 **(Acceptable Values(ANZECC/ADWG): >300)** 7. **Sulphate(SO4, mg/L):** 3 / - / - **(Acceptable**

#	Location	Type of Water Source (Spring/ Stream/ Well/ Borehole)	Pumping arrangement if available	Storage arrangement and capacity	Distance from the Access Road (Lot1) (m)	Flow rate in lpm	Current Use (Drinking/ Shower/ Washing)	No of dependents (in persons/ households)	Dependent Villages	Water Demand for Drinking and Cooking (Quantity in liters)	Southing	Easting	Remarks	Image	Image	Result (10/08/20) Low Flow Condition	Result (13/08/20)
																	Values(ANZECC/ADWG): <250) 8. **Nitrate(No3-N, mg/L):** 3.0 / 2.9 / 2.9 **(Acceptable Values(ANZECC/ADWG): <10)**
19	Valesala(Antioch)	Spring collected from SP3 through PVC Pipe	Gravity fed	Tank is available but now disconnected from the source and used directly.	222	3.72lpm	Used for drinking, Washing, cooking and shower.	62 Houses	Valesala/Antioch	930	9°31'23.9"	160°05'50.30"	15 liters per day was the estimated volume for drinking and cooking.			**Microbiological Assessment** 1. **Total Coliform(MPN/100ml)**: 4,966 / 2,616 / 2,166 **(Acceptable Values(WHO):<10)** 2. **E.coli**(MPN/100ml): 914 / 1,221 / 769 **(Acceptable Values(WHO):0)** **Physico-chemical Analyses Results** 3. **Odour Test(Average 5 sniffers):** None / None / None **(Acceptable Values(ANZECC/ADWG): acceptable)** 4. **Turbidity(NTU):** 0.48 / 0.68 / 0.83 **(Acceptable Values(ANZECC/ADWG): <5.0)** 5. **PH(unit):** 7.3 / 7.3 / 7.4 **(Acceptable Values(ANZECC/ADWG): 6.5-8.5)** 6. **TDS(mg/L):** 180 / 180 / 180 **(Acceptable Values(ANZECC/ADWG): >300)** 7. **Sulphate(SO4, mg/L):** 0 / 0 / 0 **(Acceptable Values(ANZECC/ADWG): <250)** 8. **Nitrate(No3-N, mg/L):** 1.0 / 1.0 / 1.0 **(Acceptable Values(ANZECC/ADWG): <10)**	**Microbiological Assessment** 1. **Total Coliform(MPN/100ml)**: 1,937 / 1,373 / 2,306 **(Acceptable Values(WHO):<10)** 2. **E.coli**(MPN/100ml): 335 / 356 / 283 **(Acceptable Values(WHO):0)** **Physico-chemical Analyses Results** 3. **Odour Test(Average 5 sniffers):** None / None / None **(Acceptable Values(ANZECC/ADWG): acceptable)** **Turbidity(NTU):** 0.19 / 0.17 / 0.23 4. **(Acceptable Values(ANZECC/ADWG): <5.0)** 5. **PH(unit):** 7.6 / 7.6 / 7.6 **(Acceptable Values(ANZECC/ADWG): 6.5-8.5)** 6. **TDS(mg/L):** 170 / 180 / 180 **(Acceptable Values(ANZECC/ADWG): >300)** 7. **Sulphate(SO4, mg/L): (Acceptable Values(ANZECC/ADWG): <250)** 8. **Nitrate(No3-N, mg/L):** 2.9 / 2.8 / 3.1 **(Acceptable Values(ANZECC/ADWG): <10)**
20	Valesala(Antioch)	Spring (Ground water)			90		Used for drinking, Washing, cooking and shower.				9°31'20.44"	160°05'47.31"					
21	Valesala(Antioch)	Spring (Ground water)			67		Used for drinking, Washing, cooking and shower.				9°31'17.94"	160°05'49.89"					

#	Location	Type of Water Source (Spring/ Stream/ Well/ Borehole)	Pumping arrangement if available	Storage arrangement and capacity	Distance from the Access Road (Lot1) (m)	Flow rate in lpm	Current Use (Drinking/ Shower/ Washing)	No of dependents (in persons/ households)	Dependent Villages	Water Demand for Drinking and Cooking (Quantity in liters)	Southing	Easting	Remarks	Image	Image	Result (10/08/20) Low Flow Condition	Result (13/08/20)
22	Managikiki	Spring (Ground water)	Gravity feed	Natural Pool	72	6.6lpm	Used for drinking and washing	35 Houses	Managikiki		9°32'10.41"	160°05'13.10"	24 liters per day for drinking and cooking			**Microbiological Assessment** 1. **Total Coliform(MPN/100ml)**: 3,249 / 3,249 / 3,883 **(Acceptable Values(WHO):<10)** 2. **E.coli**(MPN/100ml): 21/ 34 / 30 **(Acceptable Values(WHO):0)** **Physico-chemical Analyses Results** 3. **Odour Test(Average 5 sniffers):** None / None / None **(Acceptable Values(ANZECC/ADWG): acceptable)** 4. **Turbidity(NTU):** 1.47 / 1.50 / 1.41 **(Acceptable Values(ANZECC/ADWG): <5.0)** 5. **PH(unit):** 6.4 / 6.6 / 6.5 **(Acceptable Values(ANZECC/ADWG): 6.5-8.5)** 6. **TDS(mg/L):** 150 / 150 / 150 **(Acceptable Values(ANZECC/ADWG): >300)** 7. **Sulphate(SO4, mg/L):** 0 / 1 / 1 **(Acceptable Values(ANZECC/ADWG): <250)** 8. **Nitrate(No3-N, mg/L):** 1.5 / 1.0 / 1.0 **(Acceptable Values(ANZECC/ADWG): <10)**	**Microbiological Assessment** 1. **Total Coliform(MPN/100ml)**: 7,068 / 9,932 / 6,499 **(Acceptable Values(WHO):<10)** 2. **E.coli**(MPN/100ml): 80 / 130 / 65 **(Acceptable Values(WHO):0)** **Physico-chemical Analyses Results** 3. **Odour Test(Average 5 sniffers):** None / None / None **(Acceptable Values(ANZECC/ADWG): acceptable)** 4. **Turbidity(NTU):** 2.42 / 1.18 / 1.87 **(Acceptable Values(ANZECC/ADWG): <5.0)** 5. **PH(unit):** 6.7 / 6.6 / 6.8 **(Acceptable Values(ANZECC/ADWG): 6.5-8.5)** 6. **TDS(mg/L):** 140 / 140 / 140 **(Acceptable Values(ANZECC/ADWG): >300)** 7. **Sulphate(SO4, mg/L): (Acceptable Values(ANZECC/ADWG): <250)** 8. **Nitrate(No3-N, mg/L):** 3.3 / 3.4 / 2.7 **(Acceptable Values(ANZECC/ADWG): <10)**

#	Location	Type of Water Source (Spring/ Stream/ Well/ Borehole)	Pumping arrangement if available	Storage arrangement and capacity	Distance from the Access Road (Lot1) (m)	Flow rate in lpm	Current Use (Drinking/ Shower/ Washing)	No of dependents (in persons/ households)	Dependent Villages	Water Demand for Drinking and Cooking (Quantity in liters)	Southing	Easting	Remarks	Image	Image	Result (10/08/20) Low Flow Condition	Result (13/08/20)
23	Managikiki	Spring Close to Access road, extended by Bamboo	Gravity fed	No storage, extended with a bamboo from the rock	35	1.72lpm	Used for drinking and washing	35 Houses	Managikiki	840	9°31'37.40"	160° 5'28.46"	Used by Managikiki Village 35 houses there are three sources in total	Delete		**Microbiological Assessment** 1. **Total Coliform(MPN/100ml)**: >10,000 / 4,966 / >10,000 **(Acceptable Values(WHO):<10)** 2. **E.coli**(MPN/100ml): 13 / 171 / 10 **(Acceptable Values(WHO):0)** **Physico-chemical Analyses Results** 3. **Odour Test(Average 5 sniffers):** None / None / None **(Acceptable Values(ANZECC/ADWG): acceptable)** 4. **Turbidity(NTU):** 0.22 / 0.42 / 0.24 **(Acceptable Values(ANZECC/ADWG): <5.0)** 5. **PH(unit):** 7.0 / 7.1 / 7.1 **(Acceptable Values(ANZECC/ADWG): 6.5-8.5)** 6. **TDS(mg/L):** 120 / 110 / 120 **(Acceptable Values(ANZECC/ADWG): >300)** 7. **Sulphate(SO4, mg/L):** 0 / 0 / 0 **(Acceptable Values(ANZECC/ADWG): <250)** 8. **Nitrate(No3-N, mg/L):** 1.0 / 1.0 / 1.0 **(Acceptable Values(ANZECC/ADWG): <10)**	**Microbiological Assessment** 1. **Total Coliform(MPN/100ml)**: >10,000 / 4,082 / 3,851 **(Acceptable Values(WHO):<10)** 2. **E.coli**(MPN/100ml): 127 / 76 / 59 **(Acceptable Values(WHO):0)** **Physico-chemical Analyses Results** 3. **Odour Test(Average 5 sniffers):** None / None / None **(Acceptable Values(ANZECC/ADWG): acceptable)** 4. **Turbidity(NTU):** 0.09 / 0.09 / 0.24 **(Acceptable Values(ANZECC/ADWG): <5.0)** 5. **PH(unit):** 7.5 / 7.5 / 7.5 **(Acceptable Values(ANZECC/ADWG): 6.5-8.5)** 6. **TDS(mg/L):** 110 / 110 / 110 **(Acceptable Values(ANZECC/ADWG): >300)** 7. **Sulphate(SO4, mg/L):** **(Acceptable Values(ANZECC/ADWG): <250)** 8. **Nitrate(No3-N, mg/L):** 3.4 / 3.0 / 3.0 **(Acceptable Values(ANZECC/ADWG): <10)**
24	Managikiki	Stream					Not Used				9°32'7.76"	160°05'7.15"	This water source is indicatedin Existing map but we will remover this sources because they are not using this.	Delete			
25	Managikiki	Stream					Not Used				9°31'58.01"	160°05'1.15"	This water source is indicated in Existing map but we will remover this sources because they are not using this.	Delete			

#	Location	Type of Water Source (Spring/ Stream/ Well/ Borehole)	Pumping arrangement if available	Storage arrangement and capacity	Distance from the Access Road (Lot1) (m)	Flow rate in lpm	Current Use (Drinking/ Shower/ Washing)	No of dependents (in persons/ households)	Dependent Villages	Water Demand for Drinking and Cooking (Quantity in liters)	Southing	Easting	Remarks	Image	Image	Result (10/08/20) Low Flow Condition	Result (13/08/20)
26	Managikiki	Spring (Ground water)(Kukurupe)	Gravity feed	Natural pondage	680	4.56lpm	Used for drinking, shower, washing	35 Houses	Managikiki	840	9°31'37.80" S	160° 5'3.60"E	Used by Managikiki Village 35 houses there are three sources in total				**Microbiological Assessment** 1. **Total Coliform(MPN/100ml)**: 1,.032 / 1,180 / 1,049 **(Acceptable Values(WHO):<10)** 2. **E.coli**(MPN/100ml): <1 / 5 / <1 **(Acceptable Values(WHO):0)** **Physico-chemical Analyses Results** 3. **Odour Test(Average 5 sniffers):** None / None / None **(Acceptable Values(ANZECC/ADWG): acceptable)** 4. **Turbidity(NTU):** 0.14 / 0.03 / 0.03 **(Acceptable Values(ANZECC/ADWG): <5.0)** 5. **PH(unit):** 7.1 / 7.2 / 7.3 **(Acceptable Values(ANZECC/ADWG): 6.5-8.5)** 6. **TDS(mg/L):** 300 / 310 / 310 **(Acceptable Values(ANZECC/ADWG): >300)** 7. **Sulphate(SO4, mg/L): (Acceptable Values(ANZECC/ADWG): <250)** 8. **Nitrate(No3-N, mg/L):** 3.1 / 3.0 / 2.9 **(Acceptable Values(ANZECC/ADWG): <10)**
27	Managikiki (Verakuji)	Spring (Ground water)	Gravity feed	Natural pondage	268	0.92lpm	Used for Washing and Shower (only wet season)	35 Houses	Managikiki	840	9°31'55.50"	160°05'12.66"	One person was questioned and the answer was 24 liters per day per household				**Microbiological Assessment** 1. **Total Coliform(MPN/100ml)**: 968 / 1,378 / 1,124 **(Acceptable Values(WHO):<10)** 2. **E.coli**(MPN/100ml): 16 / 30 / 5 **(Acceptable Values(WHO):0)** **Physico-chemical Analyses Results** 3. **Odour Test(Average 5 sniffers):** None / None / None **(Acceptable Values(ANZECC/ADWG): acceptable)** 4. **Turbidity(NTU):** 1.42 / 1.46 / 1.58 **(Acceptable Values(ANZECC/ADWG): <5.0)** 5. **PH(unit):** 6.9 / 7.0 / 6.9 **(Acceptable Values(ANZECC/ADWG): 6.5-8.5)** 6. **TDS(mg/L):** 110 / 110 / 110 **(Acceptable Values(ANZECC/ADWG): >300)** 7. **Sulphate(SO4, mg/L):** 1 / 1 / - **(Acceptable Values(ANZECC/ADWG): <250)**

#	Location	Type of Water Source (Spring/ Stream/ Well/ Borehole)	Pumping arrangement if available	Storage arrangement and capacity	Distance from the Access Road (Lot1) (m)	Flow rate in lpm	Current Use (Drinking/ Shower/ Washing)	No of dependents (in persons/ households)	Dependent Villages	Water Demand for Drinking and Cooking (Quantity in liters)	Southing	Easting	Remarks	Image	Image	Result (10/08/20) Low Flow Condition	Result (13/08/20)
																	8.**Nitrate(No3-N, mg/L):** 3.0 / 3.1 / 3.0 **(Acceptable Values(ANZECC/ADWG): <10)**
28	Workers Camp	Borehole with Submersible Pump			370		Used for Washing and Shower				9°28'12.90"	160°06'11.7"		Not for community use		**Microbiological Assessment** 1. **Total Coliform(MPN/100ml)**: <1 / 3 / <1 **(Acceptable Values(WHO):<10)** 2. **E.coli**(MPN/100ml): <1 / <1 / <1 **(Acceptable Values(WHO):0)** **Physico-chemical Analyses Results** 3. **Odour Test(Average 5 sniffers):** None / None / None **(Acceptable Values(ANZECC/ADWG): acceptable)** 4. **Turbidity(NTU):** 1.27 / 1.30 / 1.64 **(Acceptable Values(ANZECC/ADWG): <5.0)** 5. **PH(unit):** 7.2 / 7.1 / 7.1 **(Acceptable Values(ANZECC/ADWG): 6.5-8.5)** 6. **TDS(mg/L):** 160 / 160 / 160 **(Acceptable Values(ANZECC/ADWG): >300)** 7. **Sulphate(SO4, mg/L):** 1 / 1 / 0 **(Acceptable Values(ANZECC/ADWG): <250)** 8. **Nitrate(No3-N, mg/L):** 1.5 / 1.5 / 2.0 **(Acceptable Values(ANZECC/ADWG): <10)**	-

Appendix E Photo log of Water Sources

Overhead storage tank installed in the community	Location: Old Selwyn community

Community Borehole	Location: Old Selwyn community

Protected building for pump: Pump House	Location: Old Selwyn community

Community standpipes	Location: Old Selwyn community

Overhead Water Storage tank and Pump House	Location: Komubeti

Community Standpipes	Location: Komubeti

Community Borehole	Location: Komubeti

Diesel Pump for pumping water from Borehole	Location: Komubeti

Abandoned borehole due to flood	Location: Taona

Rainwater Tank installed in the community building	Location: Taona

Well used by community for potable and non-potable use	Location: Taona

Dug well with Solar Pump Controller used for potable and non-potable use	Location: Abuabili

Overhead water storage tank fed from dug well	Location: Abuabili

Borehole with hand pump used for community drinking, washing, shower	Location: Abuabili

Borehole with hand pump used for shower and washing but unfit for drinking and cooking	Location Abuabili

Private rain water storage tank for personal use	Location: Abuabili

Community well	Location: Matonaso

Private hand pump for one household	Location: Matonaso

Community Hand Pump	Location: Matonaso

Community well	Location: Matonaso

Water storage tank but Rain water connection and shed to be built	Location: Matonaso

Community Rain water tank installed near the church Building	Location: Matonaso

Well used by community, the surrounding is muddy as people use for shower at source	Location: Matonaso

Community standpipe connected to rainwater tank installed near church	Location: Matonaso

Diesel Pump house and Borehole of Mbaravule community	Location: Mbaravule community

Water Storage tank for community	Location: Mbaravule

Newly installed Borehole with Solar Pump and storage tank	Location: Mbubulu

Private Borehole with hand pump	Location: Mbubulu

Community Rain water tank installed near the church building	Location: Mbubulu

Community dug well	Location: Mbubulu

Community dug well	Location: Mbubulu

Community dug well protected	Location: Mbubulu

Posasa Stream identified by CBSP for alternate water supply	Location: Marava

Spring at Marava (source: CBSP)	Location: Marava

Spring protected with concrete box at Verakabikabi	Location: Verakabikabi

Rain water collection tank installed at Namanu Clinic	Location: Namanu Clinic

Habusi drinking water source Main Tina river	Location: Habusi

Spring	Location: Pachuki

River Collection Point	Location: Namopila and Komoreu

River Collection Point	Location: Vatundi

River Collection Point	Location: Valekocha

River Collection Point	Location: Koleanji

River Collection Point	Location: Veramaota

River Collection Point	Location: Tina

River Collection Point	Location: Taurasa

River Collection Point	Location: Valebebe

River Collection Point	Location: Vuramali

Spring	Location: Vuramali

Rain Water Tank	Location: Pachuki

Rain Water Tank	Location: Pachuki

Borehole	Location: Tina

Borehole	Location: Haimane

Borehole	Location: Horohotu

Water Supply Replacement Plan: Status Report

20.12.2022

Background

As per the ESIA 2017 and subsequently, EIS 2019, which states the following action for the Developer (Project Company and EPC Contractor):

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.

To date, the surveys undertaken by HEC are as below:

1. Initial survey of project affected communities in September 2019 by HEC and the PO
2. Further survey focusing on communities affected by Access Road construction in March 2020 (to gather more data on water consumption/demand and range of uses)
3. Survey to determine baseline water quality in known existing sources, conducted in July/August 2020
4. Hydrological assessment of watersheds in July 2020
5. Additional Water Supply Replacement Survey and risk assessment conducted by local water engineer who has been engaged in CBSP permanent water supply program (April-June 2021)

Role and Responsibility

A water supply is an essential requirement for all people, however, providing enough water to meet everybody's needs may be difficult in the short-term so water can be made available in stages.

Accordingly, HEC will provide the affected communities with a temporary water supply to remedy some of the immediate impacts during the Project construction and CBSP will provide permanent water supplies to the communities to manage longer-term impacts (and/or permanent impacts). While the priority of CBSP is installing permanent water supply for communities with large populations, schools, and clinics, HEC provides temporary water supplies to the communities likely to be affected by construction activities (access road construction and Dam construction).

Status of Water Supply

With reference to the affected communities identified in ESIA 2019, referred to in Annex C-7-I-Affected Communities, some of the communities have received temporary water supply from HEC under C7 Water Supply Replacement Plan(WSRP), while some permanent water supplies have been established under the Community Benefit Share Pilot(CBSP) programme.

According to the recent updates provided by CBSP in December 2022, Some of the water system packages have been addressed and the remaining water packages will be undertaken in CBSP phase 2, to be rolled out towards the beginning of next year.

The table below provides an update on the status of the Water Supply Replacement Plan.

Water Supply Replacement Plan: Status Report

20.12.2022

#	Communities	Village/ Hamlets	Provisioned in CBSP permanent Water Supply	Action Taken by HEC	Action Required by HEC	Remarks
1	Senge Community	Senge Choro Koropa	These communities will be included in the follow-on CBSP 2 project- most will be natural stream sourced to standpipes and tanks. Actual designs not yet done.	None	Considering the population is very low and the availability of sufficient potable water, no further action shall be required.	**Only 2 people** live in Senge, while Choro and Koropa remain uninhabited.
2	Pachuki	Pachuki Habusi	These communities will be included in the follow-on CBSP 2 project- most will be natural stream sourced to standpipes and tanks. Actual designs not yet done.	None	Considering the population of the community and evaluating the available capacity of potable water, no further action shall be required	Habusi has 3 households with a population of 13, a 5000 liter rainwater tank exists. Pachuki has a population of 48 and has a 5000 liter rainwater tank.
3	Namopila	Namopila Komureo Vatunadi Valekocha	Namopila will be included in the follow-on CBSP 2 , tentatively, CBSP will be tapping a natural source to Tanks to community standpipes. Actual design not yet done.	None	HEC proposes to provide Rainwater Catchment system and tanks to supplement the potable water requirement of the quantities for Namopila and Vatunadi communities.	Namopila has a population of 95 with a 5000 liter community rainwater tank. Komureo has a population of 21 from 4 households. A 5000 liter rainwater tank is available in the community. Vatunadi has a population of 20 with no community rainwater tank. Valekocha has 27 members in their community. There exists a 5000-liter community rainwater tank.
4	Antioch Community	Antioch Valesala Kolanji Komeo	These communities will be included in the CBSP2 follow-on project , plan is to tap HEC office bore hole and run piping to the community along with all other roadside communities. Actual Design not yet done.	The Antioch Community was provided with 2 X 5000 liters Water tank On April 30, 2021. The community asked HEC to relocate the water tanks.	Relocation of water tanks is required.	In addition to HEC's Temporary Water Supply, Antioch community will be fully provided with a permanent water supply by CBSP by 06.2023
5	Tina Community	Tina Valebariki Valebebe	CBSP provided a borehole (63m depth) , 4x 10KL tanks, 1 x 5KL tank and 15 standpipes,	None	None, It has been fully covered under the CBSP scheme.	Tina Community has been fully provided with a

Water Supply Replacement Plan: Status Report

20.12.2022

#	Communities	Village/ Hamlets	Provisioned in CBSP permanent Water Supply	Action Taken by HEC	Action Required by HEC	Remarks
		Tahurasa Valemaota	reticulation pipes and solar panels and pumps. Additionally, Veramoata has been provided with 5000 liter Rainwater tank with catchment system.			Permanent Water Supply by CBSP. Valebariki has been provided with a separate system including Haimane.
6	Vuramali Community	Vuramali Haimane Horohotu 2	CBSP is treating these communities as an extension of the Horohotu 3 (Valebariki system), 4 x 10KL tanks, 10-15 standpipes	None	None, It has been fully covered under the CBSP scheme.	Haimane has been covered in Valebariki Water Supply by CBSP. Horohotu 2 is mapped under the Verakabikabi Water Supply System Package of CBSP.
7	Verakuji Community	Verakuji Managikiki	This system is part of the planning for CBSP 2. Actual design has not yet been done.	5000 liters water tank has been installed and used by the community for drinking and cooking purposes. The water tank is refilled by the HEC tanker truck upon request.	None	In addition to HEC's Temporary Water Supply, Managikiki community will be fully provided with a permanent water supply by CBSP by 06.2023

Water Supply Replacement Plan: Status Report

20.12.2022

#	Communities	Village/ Hamlets	Provisioned in CBSP permanent Water Supply	Action Taken by HEC	Action Required by HEC	Remarks
8	Marava Community	Marava Ngongoti Vatupaua Rate School	CBSP has provided 4 x 10KL w/tanks, 6 x solar panel and pump, reticulation pipings and 11 stand pipes. the system is a natural stream sourced system that is pumped to storage tanks and gravity feed down into the communities.	Vatupaua Community water tank (2100 liters) was provided by HEC and is continuously used by the community for cooking and washing. Ngongti Community water tank(2100 liters) was provided by HEC and is in perfect condition. Marava-1, Community water tank (2100 liters) was provided by HEC and is continuously used by the community people. Marava-2, water tank (2100 liters) was provided by HEC and is continuously used by the community people. Marava-3, second water tank(2100 liters) was provided by HEC and is in good condition and functioning. Community people are continuously using it for drinking and cooking.	None	Completed
9	Vera'ande Community	Vera'ande Verakwali New Mahata	Potentially, a borehole and stand pipes can be provided. Verande is not considered at this stage and may be considered formally during CBSP follow-on mission in Feb 2023. Designs need to be done.	Valele Community has 2 X 2100 liters water tanks which were provided by HEC. These tanks are in good condition, and they are continuously used by community people for drinking and cooking. Additionally, Pavu community is provided with potable water upon demand during the dry season.	None	Completed

Water Supply Replacement Plan: Status Report

20.12.2022

#	Communities	Village/ Hamlets	Provisioned in CBSP permanent Water Supply	Action Taken by HEC	Action Required by HEC	Remarks
10	Verakabikabi	Verakabikabi	Borehole has been completed. This will be part of WP#6, with a borehole (60m depth) already completed to be piped to Horohotu 1 & 2 and also Verakabikabi. 4 water tanks (10KL), solar panels and equipment, reticulation pipings and fittings and stand pipes will be supplied	Verakabikabi was provided with a 5000l Water Tank and accessories.	None	Completed

Photographic Evidence

	
Managikiki provided 5000-liter tank	Antioch/Valesala Community water tank of 5000 liters
	
Antioch/Valesala Community water tank of 5000 liters	Vatupaua Community water tank of 2100 liters

	
Verakabikabi community was provided with 5000 liter tank	Marava 3 water tank of 2100 liters
	
Marava 3 water tank of 2100 liters	Marava 2 water tank of 2100 liters

	
Marava-1, Community water tank of 2100 liters	Ngongti Community water tank (2100 liters)
	
Valele-2 2100liters tank	Valele community tank 2100 liters

Challenges in Water Supply Replacement

1. Where pumps are installed on wells and boreholes they break down and are difficult and expensive to repair or replace. Additionally, the cost of fuel is expensive and pumps can be shut down until sufficient funds are available to purchase diesel.
2. Accessibility to Habusi, Pachuki, Namopila, Valekocha, Veramaota, and Taurasa communities is a matter of concern.
3. Scattered housing poses a challenge to providing a centralized Water Supply system for the entire community.

Key indicators

1. At least 7 Lpcd is provided for domestic use (drinking, food preparation, cleanup)
2. The maximum distance from any household to the water point is 500 metres.

HEC Proposition

Option # 1

Looking at the community aspirations for permanent water supply, similar to the water supply systems installed at other communities, HEC proposes to support the CBSP Programme that will be rolling out the early next year by providing Water tanks to the communities that were not attended under the Temporary Water supply initiative by HEC. The tanks provided by HEC can be used to augment the Water storage capacity of the communities downstream.

Option #2

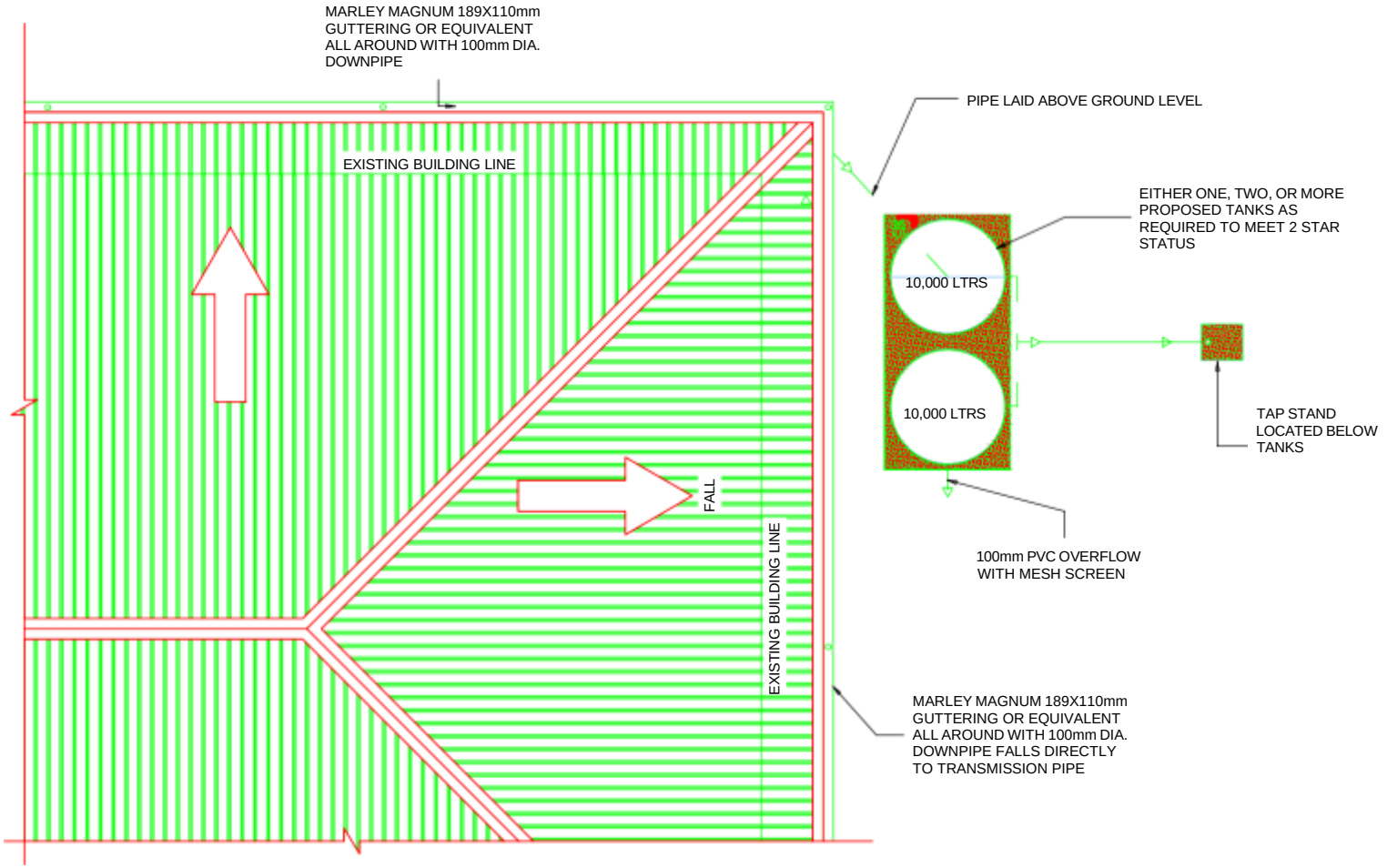
Considering the challenges in water supply replacement, stated above, Rainwater harvesting is easy to install and maintain, a cost-effective method evaluating against various factors. The Rainwater System can supply high water quality suitable for drinking purposes. Considering remote and scattered communities, where water supply is being proposed, the community-based Rainwater system shall be advantageous over other water supply arrangements. Considering the rainfall in these communities, Rainwater systems are conducive however the quality can be improved by using good quality catchment surfaces like corrugated Galvanized metal (iron/steel).

According to the assessments and further evaluations, a few communities downstream do not have sufficient potable water for drinking and cooking. These communities shall be prioritized and provided with potable water through a rainwater catchment system. The improvement work will require the installation of additional rainwater catchment systems, gutters, and water tanks.

#	Community	Population	Available Capacity	Required Capacity	Remarks
1	Pachuki	13	5000	-	Rainwater system was provided by NGO recently.

2	Habusi	3	5000	-	Rainwater system was provided by NGO recently.
3	Namopila	95	5000	5000 liters	Improvement of existing rainwater system.
4	Komureo	21	5000	-	Rainwater system was provided by NGO recently.
5	Vatunadi	20	0	2000 liters	New Rainwater system
6	Valekocha	27	5000	-	Rainwater system was provided by NGO recently.

The design of the Rainwater Catchment System is shown in Annex 1: Rainwater Harvesting with BOQ. The designs have been formulated by Solomon Islands Government through the RWASH programme under the Ministry of Health and Medical Services.

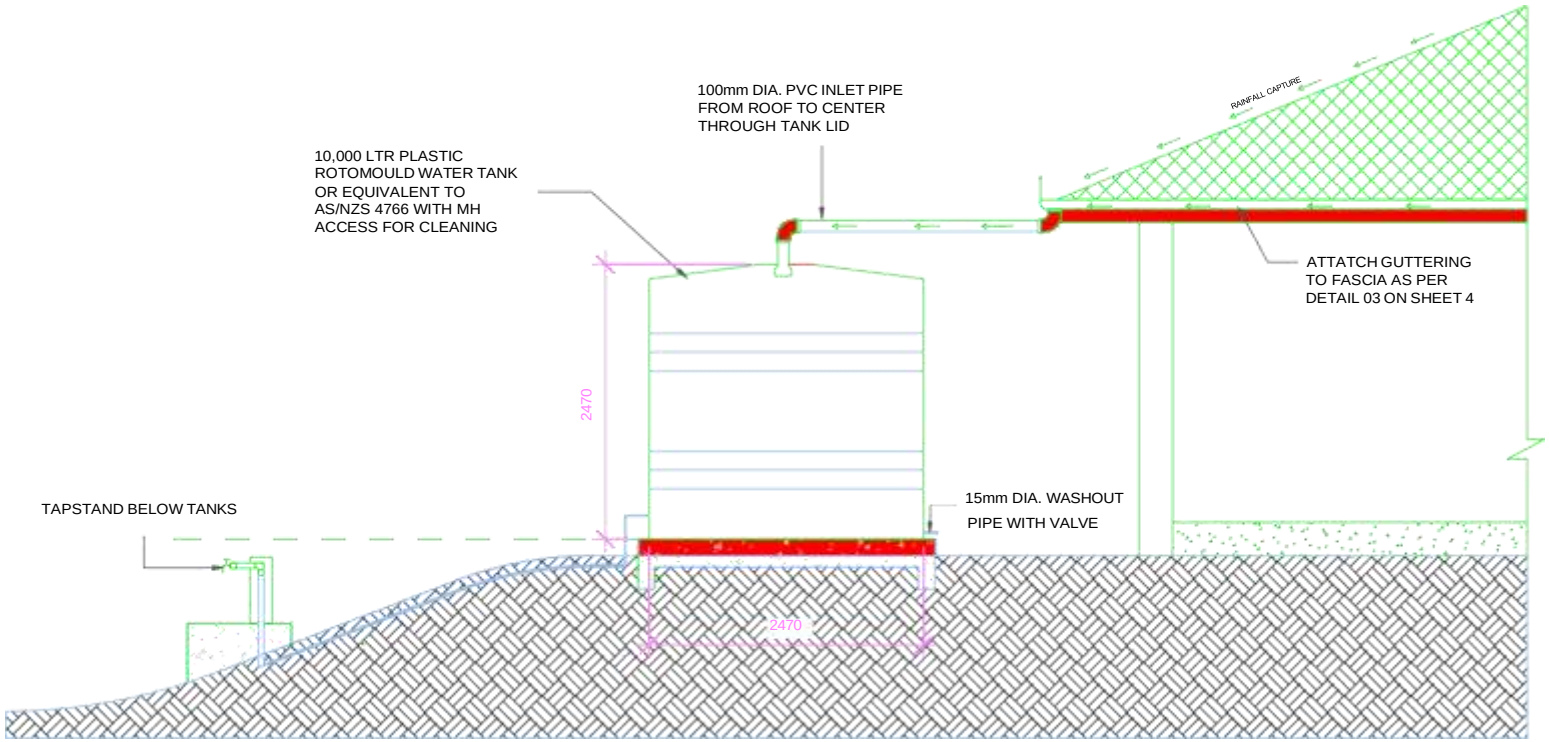


NOTE: DESIGN BASED ON ORIGINAL
DESIGN BY SPC FOR KIRIBATI

1 RAINWATER COLLECTION ROOF PLAN

1 : 100

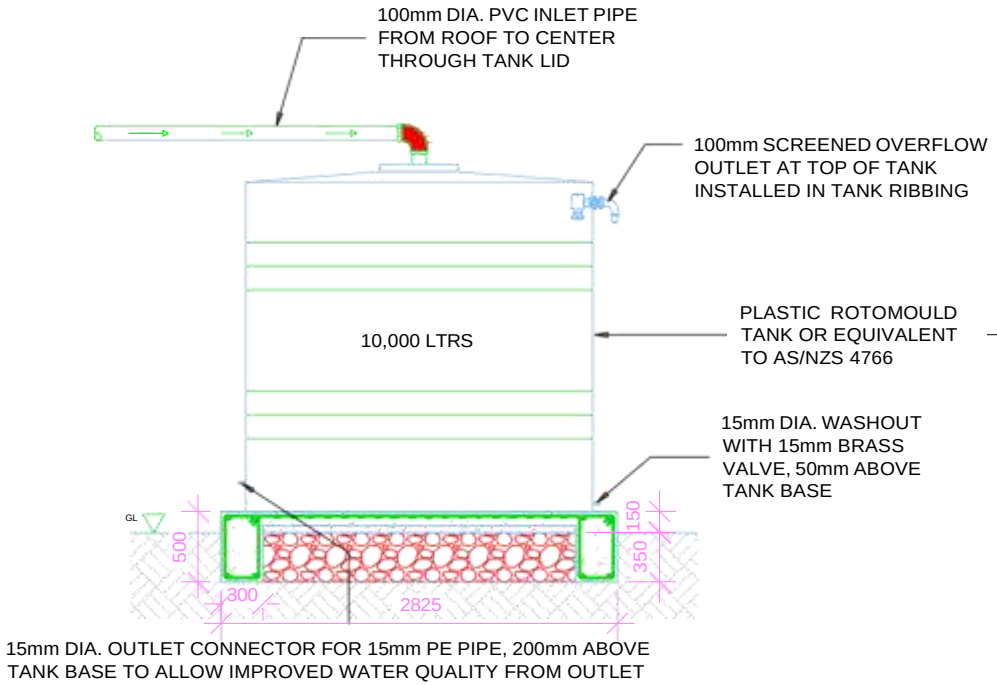
	SOLOMON ISLANDS RURAL WATER SUPPLY AND HYGIENE PROGRAM	TYPE OF STRUCTURE	RAINWATER HARVESTING	DESIGNED BY:	SPC	SCALE: Scale as shown at A4
				DRAWN BY:	D. Williamson, W. Okae'e	SHEET NO: 1 of 4
				CHECKED BY:	V.Fray, P.M.Wopereis	
				REVISION DATE:	17/04/2018	SHEET SIZE: A4

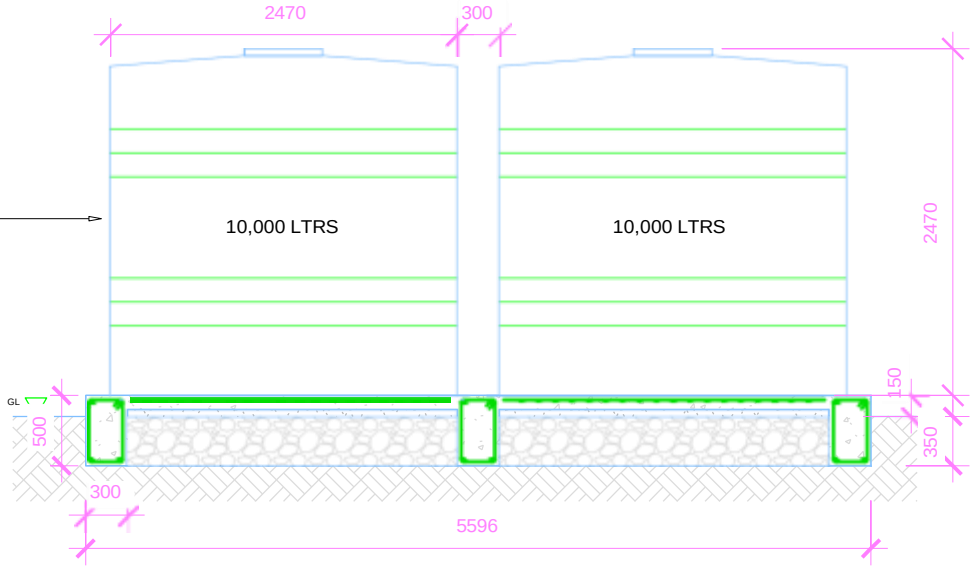


1 SECTIONAL ELEVATION

1 : 50

	SOLOMON ISLANDS RURAL WATER SUPPLY AND HYGIENE PROGRAM	TYPE OF STRUCTURE	ELEVATION/ CORNER DETAIL	DESIGNED BY:	SPC	SCALE: Scale as shown at A4
				DRAWN BY:	D. Williamson, W. Okae'e	SHEET NO: 2 of 4
				CHECKED BY:	V.Fray, P.M.Wopereis	
				REVISION DATE:	17/04/2018	SHEET SIZE: A4





1 TANK STAND SECTION A-A

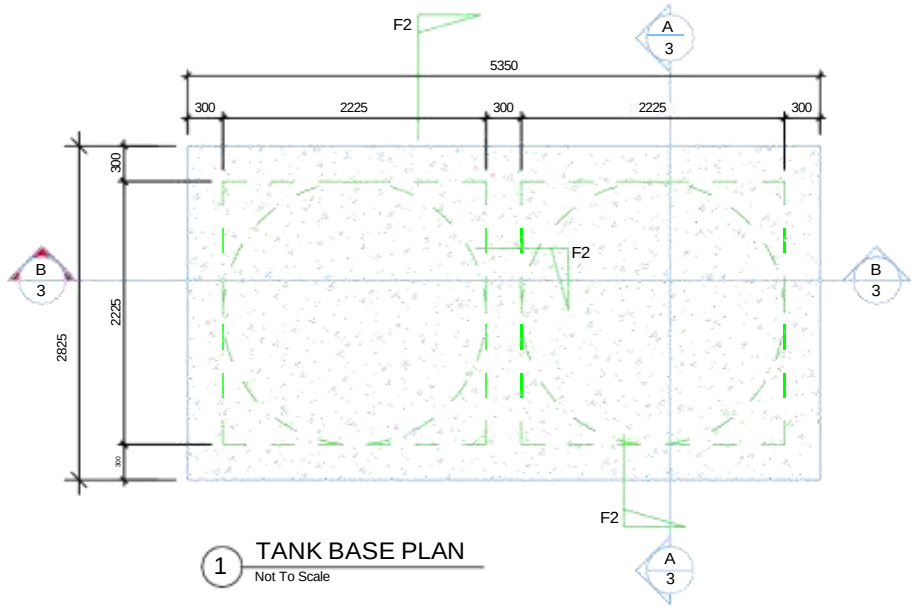
1 : 50

2 TANK STAND SECTION B-B

1 : 50

Tank Storage Requirement		
Number of students plus teachers at school	Minimum storage required to reach 'National Standard' (Litres)	Minimum storage required to reach 2 star status (Litres)
150	45,000	23,000
200	60,000	30,000
300	90,000	46,000

SOLOMON ISLANDS RURAL WATER SUPPLY AND HYGIENE PROGRAM	TYPE OF STRUCTURE	SECTION AA / BB	DESIGNED BY:	SPC	SCALE:	Scale as shown at A4
			DRAWN BY:	D. Williamson, W. Okae'e	SHEET NO:	3 of 4
			CHECKED BY:	V.Fray, P.M.Wopereis		
			REVISION DATE:	17/04/2018	SHEET SIZE:	A4



1 TANK BASE PLAN
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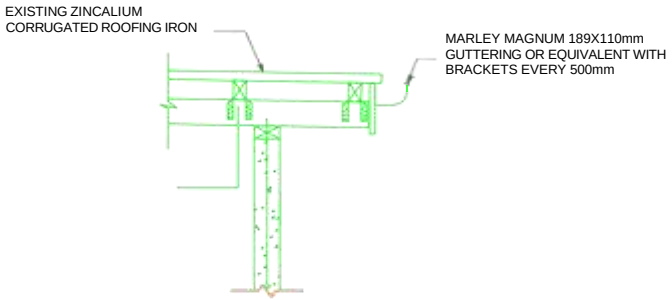

2 DETAIL 02
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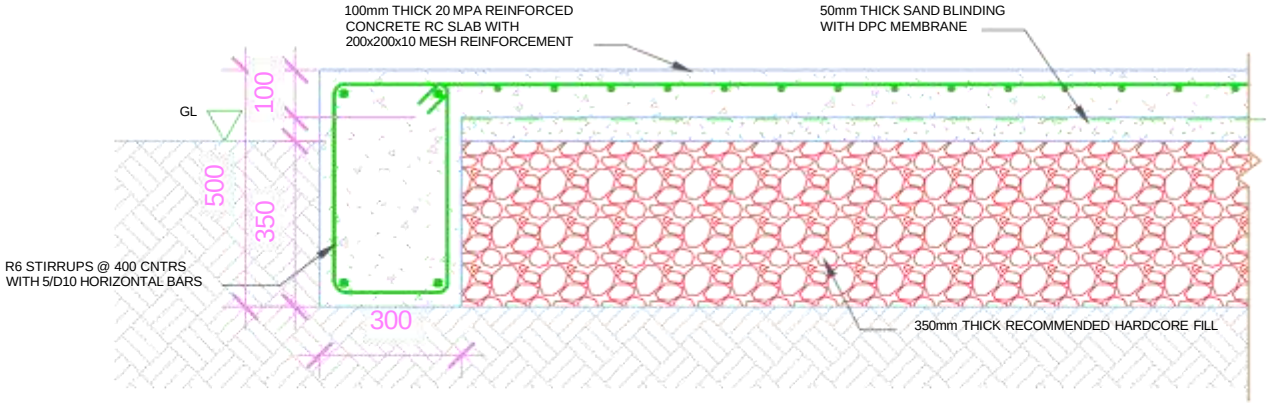


3 DETAIL F2
Not To Scale

	SOLOMON ISLANDS RURAL WATER SUPPLY AND HYGIENE PROGRAM	TYPE OF STRUCTURE	TANK BASE / DETAILS	DESIGNED BY:	SPC	SCALE: Not to scale
				DRAWN BY:	D. Williamson, W. Okae'e	SHEET NO: 4 of 4
				CHECKED BY:	V.Fray, P.M.Wopereis	
				REVISION DATE:	17/04/2018	SHEET SIZE: A4

Rainwater Harvesting System

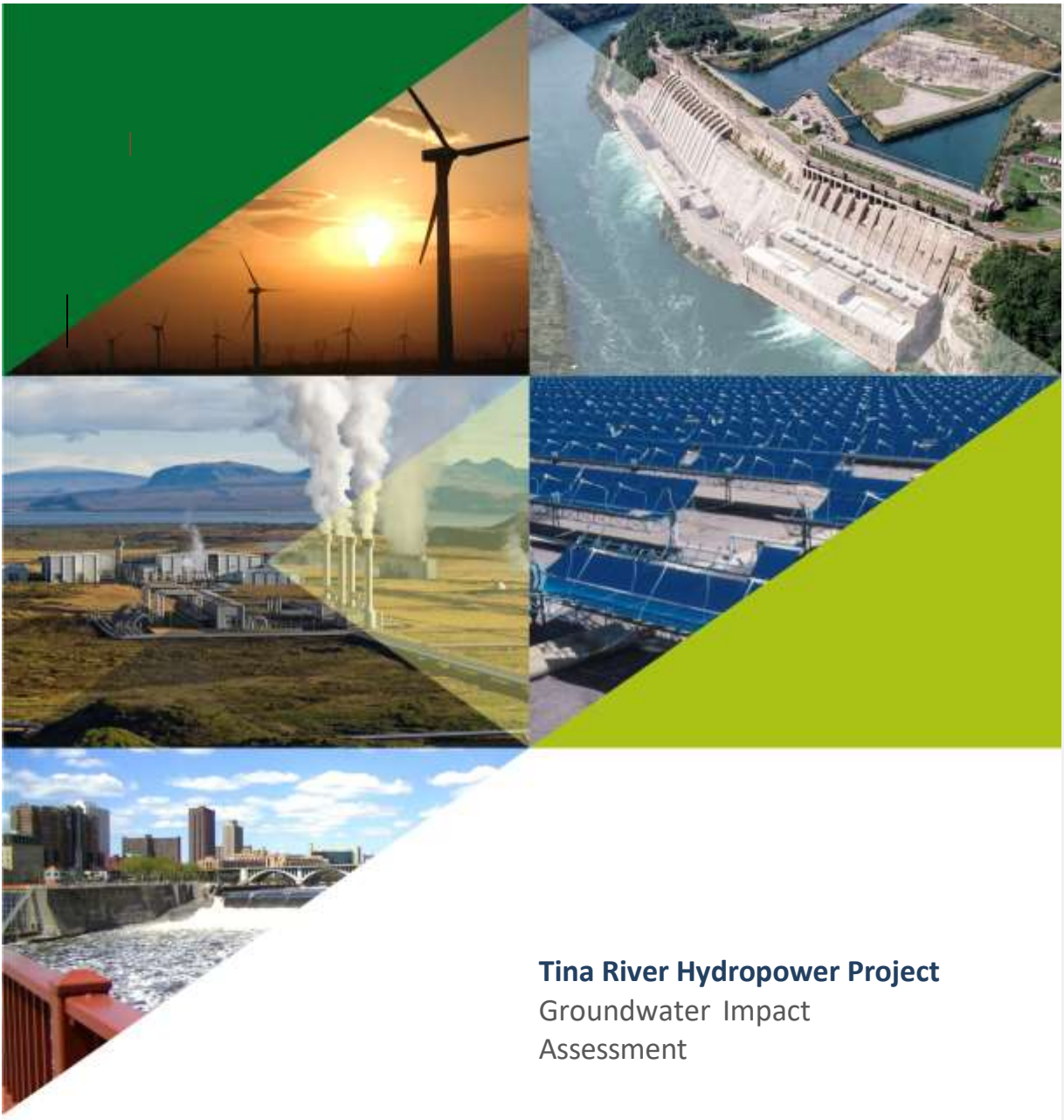
Notes:

1. Refer to attached drawings
2. Price does not include labour and transportation costs

Item	Unit	Quantity	Rate	Total Cost
Guttering/spouting				
189mm PVC Magnum Marley guttering, 3m lengths	m	12	$680	$8,160
Magnum spouting bracket at 600 centres	Ea	7	$36	$252
Magnum universal spouting stopend	Ea	1	$50	$50
Magnum outlet 100mm	Ea	1	$300	$300
100mm dia Magnum PVC downpipes	m	4	$680	$2,720
Magnum 88° socket bend 100mm	Ea	1	$95	$95
20mm galvanized clout nails	kg	0.5	$40	$20
Storage				
D10 deformed reinforcement bars	Length	16	$50	$800
40kg Bag Cement	bag	16	$100	$1,600
300x25 wide timber formwork for tank stand	Length	2	$300	$600
Install 10,000 litre (or equivalent) capacity, adverse weather resistant Poly-tank water storage. Top of tank should be at least 100mm below the base level of the gutter to create enough head. Tanks shall be tested prior to delivery to site. Tanks shall have an entry point which can be easily accessed for cleaning and can be sealed to prevent entry of vermin. Tanks to have inlet/outlet/overflow/washout	Ea	2	$14,000	$28,000
80mm PVC overflow Connected	m	4	$345	$1,380
80mm PVC 90 degree elbow fitting for overflow pipe to direct flow away from tank	Ea	4	$88	$352
15mm Brass gate valve	Ea	2	$90	$180
15mm PVC valve socket	Ea	4	$8	$32
Total				**$44,541**

Date: *28.4.2017*

ANNEX C-7-III GROUNDWATER IMPACT ASSESSMENT



Tina River Hydropower Project

Groundwater Impact Assessment

27.07
2021

INOGEN ALLIANCE

~~Drill and~~ Groundwater Impact Assessment

Person Responsible	HEC HSE Manager

REV.	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
1	08 August 2021	Groundwater Impact Assessment prepared for HEC	HEC and INOGEN	PWOE	
2	04 October 2021	Comments on GIA	OE		
3	11 October 2021	Response to OE comments	HEC and INOGEN	OEPW	
4	16 November 2021	Comments on GIA	OE		
5	17 November 2021	Response to OE comments	HEC and INOGEN	PW	
6					
7					

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SUMMARY

Construction water demand at the TRHDP construction facilities at Camp, Office site including Batcher Plant for Access Road construction and Crusher Plant and Batcher Plant for RCC dam will be met by groundwater ~~by groundwater bores over the five years construction period~~. All drinking water~~potable~~ requirement for workforce will be serviced by water dispensers brought to site. Other potable water use for the workers camp and community will be sourced from groundwater (existing and/or proposed bores).

The Camp sits on the Guadalcanal alluvial plain which forms a relatively shallow and widespread permeable aquifer. It is more than capable of meeting the Camp water demand. Historical records indicate there will be minimal drawdown at greater than 100 m radial distance from the deep aquifer with the closest private community borehole (BH) 110 m distant in the intermediate aquifer. There are no BHs in the deep aquifer in this area.

In the more elevated areas at the Office site and Batch Plant (120) site, the aquifer is fractured sandstone and conglomerate which although as yet unproven in terms of bore yield and drawdown is also projected to be capable of meeting the required demand. Drilling depths down to 150 m are planned. The communities here rely on river water and springs, there are no BHs. The Tina River is probably a losing rather than a gaining stream in relation to this deep aquifer nevertheless the groundwater demand is more than 1,000 times less than river flow and in the unlikely event there is a connection any associated reduction in streamflow would be indiscernible.

At all three sites a groundwater monitoring program is to be implemented and there are allocations for community supply should grievances occur. The groundwater demand has been reduced by more than 20% by recycling/reusing of treated wastewater and groundwater thereby meeting international best practice for efficiency of water use. The total demand is small, only 20 m3/hr. It is also noted that the project is actively supporting and working with the Community Benefit Share Pilot and has appointed a water engineer to assist with the Water Supply Replacement Survey for villages requiring temporary supply.

The drilling and testing program is likely to occupy 3 to 4 months and is a critical component of the construction schedule. Considering the insignificant impact demonstrated by Feasibility Study, drilling works shall be commenced to get more clear information on the quantity and quality.

Location	Provisional Depth (m)	Demand (m3/d)	Water Efficiency	Comment
120 Batch Plant	150	240	All groundwater used, no recycling possible	Bedrock supply as yet unproven
Office ~~and 60 Crusher Plant~~premises	150	1540	A large percentage of crusher plant water to be recycled and a portion of vehicle wash.	Bedrock supply as yet unproven. 180 employees at Office average consumption 50 litres per day (WC only) 7 litres per day (Basin) 32 litres per day (Shower), (Standard for the construction, installation and operation of septic tank systems in south Australia)
Camp premises	70	100	Approximately ~~6~~50 m3/d of treated sewage effluent to be recycled.	Adjacent to 30 m deep existing camp bore. 240 employees at Camp average

Commented [GJ2]: Please insert a revision history/ page indicating:
Prepared by
Checked by
Reviewed / approved by
Date / version of this document

Suggest you also indicate that this report was prepared for HEC

These details are required on all TRHDP documents

Commented [PW3R2]: done

Commented [GJ4]: General comment to authors (no action required) – I have used the IFC EHS Guidelines for Water & Sanitation as a basic guideline for bare minimum aspects that need to be assessed regarding groundwater and potential impacts (and use of groundwater for potable or non-potable supply).

Link to guidance doc:
https://www.ifc.org/wps/wcm/connect/0d8cb86a-9120-4e37-98f7-cfb1a941f235/Final%2B-%2BWater%2Band%2BSanitation.pdf?MOD=AJPERES&CVID=jkD216C

Commented [PW5R4]: We are of course very familiar with these guidelines and have acted for IFC on a number of groundwater studies. this particular study is relatively simple, three BHs at widely separate locations, all with low groundwater demand, to be used only during construction no competing users, no nearby ... [1]

Commented [GJ6]: Why entirely by groundwater, when HEC are allowed to take a certain amount from Tina River, and this wa ... [2]

Commented [PW7R6]: not sure why this question is being raised now after a Groundwater Feasibily Study and Groundwa t ... [3]

Commented [Shin8R6]: During Access Road Construction, If we use Tina River, we have to use the road laying on out of pro j ... [4]

Commented [GJ9]: Please indicate in the table below what volume will be required (based on per person, per day ... [5]

Commented [GJ10]: HEC have stated in the past that they want to avoid the expense of shipping in commercially supplied drink n g [6]

Commented [WW11R10]:

Commented [Shin12R10]: Total 10 water dispensers were brought in and Water is being supplied from "Blue Water Comp a n [7]

Commented [Shin13R10]:

Commented [HK14R10]: Noted that there will be drinking water supplied. For cooking, showering etc. it is assumed that t h e [8]

Commented [Shin15R10]: Drinking water for all the workforce will be supplied from local supplier.

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Commented [DJ16]: 180 people at 50L/d equals 9m3/d. Demand 150m3/d? Extra water for other uses?

Commented [HK17R16]: 140 m3/day for the crusher plant + 10 m3/day for office = 150 m3/day

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				consumption 180 litres per day (IFC Guideline)

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

1.1 Overview

In the ESIA of 20197 the ~~total~~ water demand for construction at the Tina River Hydroelectric Development Project (TRHDP) was estimated to be 30,000 m³ over the~~a~~ three years construction period and was "most likely be pumped from the Tina River, at a location adjacent to the dam site and RCC batch plant, immediately upstream of the cofferdam". A total of 3,000,000m³ of water was also required for concrete production. This proposal has been superseded and groundwater is now proposed. Consequently, this groundwater impact assessment has been prepared.

A total of three new production boreholes (BHs) are proposed, one at the Camp site which sits on the Guadalcanal alluvial flood plain ~~(0 to 20 m asl, 8953047N)~~ and two at higher elevation in the foothills at office/crusher/batch plant and a second batch plant close to the dam. A fourth very low capacity BH to be installed later at the powerhouse will only be used for operations phase. The bores except for powerhouse site are provisionally planned to be used for 5 years for operation of the ancillary construction facilities after which they will become redundant.

Summary details provided in this report are from the Groundwater Feasibility Study prepared for HEC in June 2021 by Earth Water People, an Australia based hydrogeological consultancy ~~working for~~which also provides professional services to Solomon Islands Water Authority (SIWA). ~~Limited data from the ESIA is also included.~~

Table 1-1 Summary of Proposed Water Supply for Each TRHDP Construction Facility

Facility	Easting	Northing	Ground Elevation	Proposed Use	Average Maximum Demand
Camp	621123	8953047	~ 15 m asl	Sanitation & washing	100 m³/day
Office, Batch and Crusher Plant (BP 60)	618106	8944902	~ 300 m asl	Sanitation & operation water	150 m³/day
Batch Plant (BP 120)	616090	8943282	~ 250 m asl	Operation water	240 m³/day

These groundwater demands are relatively low ranging between 2.5 ~~lps~~ litres per second (L/s) at the Camp to 3 L/s at the RCC Batch Plant (BP120). Office and BP120 are adjacent to the Tina River. A very low capacity BH (7 m3/day) will also be installed at Powerhouse in 5 years time and used for the full period of operation. It will be much shallower than Camp BH. The impacts from this BH will be minimal and similar but on a much lesser scale than nominated for the Camp BH. All BHs will produce drinking water quality.When expressed as cumecs (m³/sec) the unit used for river flow the water demands at ~~Office and BP120 are equivalent to about 0.002 and 0.003 cumecs respectively which is insignificant compared to flow in the Tina River where minimum monthly flow is about 3 cumecs (refer ESIA).~~

1.2 Topography and Drainage

The Ngalimbiu River drains northerly from some of the highest peaks on the island of Guadalcanal. It has two main tributaries the Tina and Toni rivers. The Tina River is comprised of three rivers: The

Commented [GJ18]: Has this changed? Do estimates need to be revised given project delays?
PW. Construction period is now 5 years. When this first draft was prepared STPs were planned at Camp and Office. Now onl a larger capacity STP is planned for Camp. The demand and recycling slightl modified.

Commented [Shin19R18]: This is the just statement of ESIA. We quoted the sentence. Thus, we don't need to justify and revise this sentence.

Commented [HK20R18]: This question is relevant as there has been no update on the volume of water required.
This section has been updated with information from the 2019 ESIA however actual figures will help to formally resolve the issue.

Commented [PW21R18]: The water volumes now presented are best estimate. Likely to be slightly modified when BHs are installed and demand at Camp and Office confirmed.

Commented [GJ22]: Why? See my comment in summary above, 1st para
PW. The BHs are a better proposition than a weir above the dam. Given the steepness of the valley and regular high volume floods the weir construction would have to be of the highest engineering integrity, high sediment and possibly e coli needing treatment and fish impacts.

Commented [Shin23R22]: During Access Road Construction, If we use Tina River, we have to use the road laying on out of project area. Accordingly, additional traffic management plan and stakeholders engagement activities shall be considered.

Commented [GJ25]: Please state how long the powerhouse bore could be used for.
Operation phase is 30 years due to this project's BOOT contract. Also - The Powerhouse must have a potable supply and this is in the Employer's Requirements with the required treatment (UV). HE...C [9]

Commented [HK26R25]: All 4 bores required for the project need to be assessed..... [10]

Commented [PW27R25]: 7 m3 is a very low demand and probably the BH will be shallower than at Office. That can onl y b [11]

Commented [GJ28]: This statement is inappropriate and not relevant..... [12]

Commented [GJ29]: Where? In this report, or in EWP report? What information is this referring to? ... [13]

Commented [GJ30]: Please describe/demonstrate how these daily averages have been estimated. E.g. occupancy rates, ... [14]

Commented [GJ31]: Please define what 'sanitation' would include ..... [15]

Commented [WW32R31]: The cold and hot water at the camp bore is most likely plumbed to all showers and basin for all p... [16]

Commented [Shin33R31]: HEC will use the commercial drinking water in this country. MBR water will not be recycled... [17]

Commented [HK34R31]: The original comment is valid but relates to water quality and testing. Both the camp and office b... [18]

Commented [PW35R31]: The BH groundwater will be drinking water quality. The only potential contaminant of concern wo ... [19]

Commented [GJ36]: Why is this relevant when we are talking about groundwater use here, not a water take from Tina River?

Commented [HK37R36]: Relevance is potential loss in groundwater recharge to the river which is not discussed in th... [20]

Mbeambea, the Voraha and the Njarimbisu rivers. The Tina River's catchment area is delineated by: Chupu Karma to the East; Mount Mbutohaina (1649m) to the West; and a chain of mountains to the South, including Mount Tambunanguu (1902m), Mount Popohanatungga (1,877m), and Mount Turipukumahi (1,636m). Mount Popomanaseu (2,310m), the highest mountain of the Solomon Islands, is located just outside of the Tina River catchment. The Tina River catchment is more than three times larger than the Toni River. The catchment area of the Tina River is about 150 km^2 compared to 45 km^2 for the Toni River. The catchment area above the planned dam on the Tina River is 125 km^2. The proposed Office and BP 120 bores are located in the Tina River catchment close to the river and upstream of the confluence with the Toni River. It can be seen on **Figure 1-1** that the Camp is some distance from the nearest river.

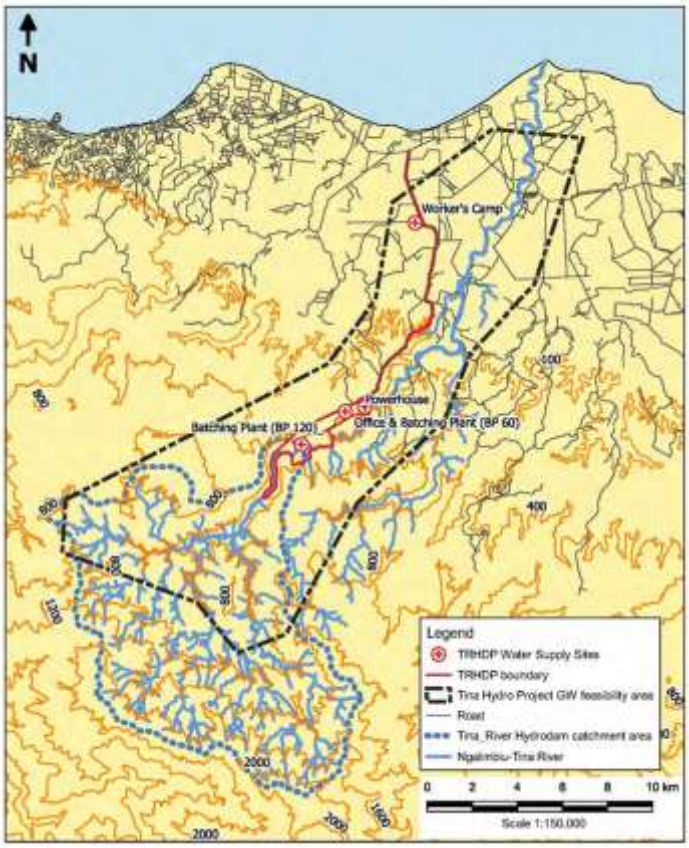


Figure 1-1 TRHDP Facilities and Groundwater Study Area.

1.3 Rainfall

~~There~~ Historically there was a rainfall gauge at Chupu Karma (no longer operational), at ~~approx~~2pprox.. 1,400 m asl, along the eastern catchment boundary of the Tina River. Daily records were taken between June 2010 to February 2013 and from March to July 2017. The average annual rainfall at this elevated station over that period was 5,630 mm. It can be seen from Error! Reference

Commented [GJ38]: Local villages should also be on this map. They are significant downgradient/downstream water users and will be potentially sharing the supply via streams, springs and village bores.
Villages included should match those presented in the Water Supply Replacement Plan

Commented [PW39R38]: They are shown on other maps. No villages will be impacted from the three proposed BHs.

source not found.~~Table 1-2~~ that annual rainfall increases with elevation from about 2,000 mm on the floodplain to about 2,700 mm at the Office and RCC Batch Plant (BP120). Annual rainfall at the camp will be about 2,000 mm similar to that at Honiara and Henderson airport, Error! Reference source not found.~~Figure 1-2~~ and represents a high groundwater recharge potential.

Table 1-2 Modelled aAverage annual rainfall within the Tina River catchment

Altitude (masl)	Annual Average Rainfall (mm)	Rainfall Station
0-100	2,000	Honiara/Henderson
100-500	2,700	Mbumulake
1,400	5,630	Chupu Karma
1,600	6,400	Mt. Chanapaho

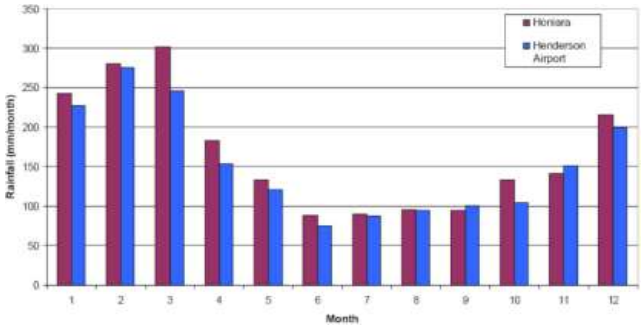


Figure 1-2 Annual Rainfall at Honiara and Henderson Airport (THL, 2019)

1.4 Streamflow

Streamflow was recorded at a gauging station upstream of the planned damsite from 15 June 2010 to 21 September 2013 as reported and analysed in the ESIA (THL, 2019). The average monthly flow over the period Error! Reference source not found.~~Table 1-3~~ ranged between 9 and 22 cumecs with an absolute minimum of 2.85 cumecs. The mean flow at the planned Dam site as recorded in the ESIA ~~2017~~ 2019 is 19.4 cumecs wet season and 12.7 cumecs dry season.

Table 1-3 Average monthly flow in Tina River upstream of Damsite (THL, 2019)

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

Commented [HK41R40]: Please add the source for this figure if known

Commented [PW42R40]: its from the Groundwater Feasibility Study. But the point is, the rainfall is high, whether its 2000 or 3000 mm with a "dry "season and a wet season. Groundwater recharge will be high as a result. Seasonal water level changes can be up to 2 m.

Commented [GJ43]: Please reference correct ESIA versions. There are two – 2017, and then a revised one in 2019.

These numbers didn't change for 2019 ESIA; best to reference the latest version.

Also, as per the 2019 ESIA, I believe is better to report the wet and dry season average flows separately, to recognise the seasonal variation (and manage water takes accordingly to reduce risk of shortages/over-extraction).
Average flow during wet season = 19.4 m^3/s
Average flow during dry season = 12.72 m^3/s
Compared to these numbers, the average monthly flow of 11.5 m^3/s is on the low side.

Commented [PW44R43]: Changed to average wet and dry season flows. But no water is planned to be taken from Tina River.

Months	Average monthly flow at	Minimum recorded (m^3/s)	Maximum recorded (m^3/s)
November	17.12	3.26	445.62
December	20.46	4.83	298.33

1.5 Aquifers

Error! Reference source not found.~~Figure 1-3~~ shows detail from the 1:50,000 scale geological map. There are three aquifers of interest, from south to north the Toni Conglomerate (Tpnc), the Mbetivatu Sandstone (Tpe) and the Guadalcanal floodplain alluvium (Qa). The two Tertiary formations dip northwestwards at 5 – 15^0 beneath the alluvial plain and are both fissured and faulted. It is not known at what depth the Toni Conglomerate lies beneath the Mbetivatu Sandstone at the Office site.

Toni Conglomerates are essentially cemented gravels and conglomerates (> 30% clasts) with the material being mostly volcanic in origin. Clasts are typically up to 300 mm size, but isolated boulders can exceed 10 m in diameter. Mbetivatu Sandstone comprises crudely stratified brownish yellow sandstones with lenses of conglomerate. Both are fractured and faulted.

Both these Tertiary aquifers are consolidated with secondary porosity and are expected to stand up open hole which facilitates Down The Hole Hammer Drilling using air.

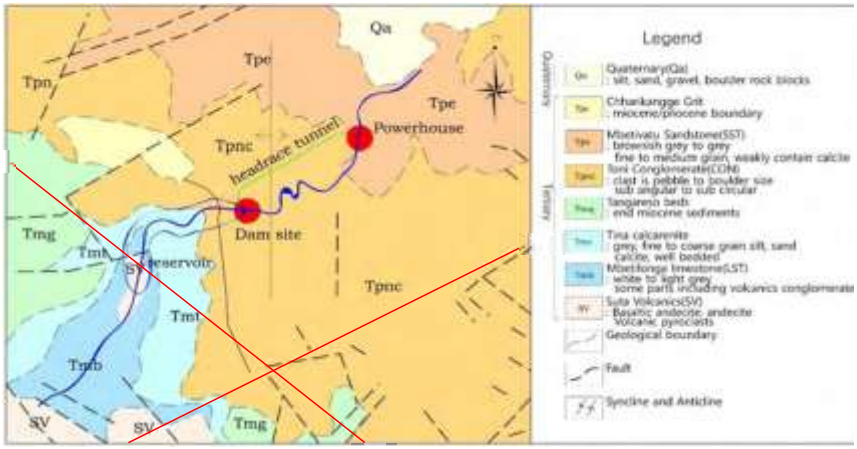


Figure 1-3 Regional 1:50,000 scale geological map.

Geotechnical drilling at the dam, powerhouse and access roads did not differentiate between the formations but it is noted that unconsolidated sediments, either alluvium and/or weathered bedrock can extend down to more than 20 m depth. If intercepted they will need to be cased before drilling into the consolidated bedrock. Some descriptions from the geotechnical drilling are shown below in **Table 1-4.**

Table 1-4 Thickness of Alluvial Gravels at Powerhouse

BH	Coordinates	Location	BH Depth(m)	Gravel Depth and Thickness (m)	Description

Commented [GJ45]: This should go into your Impacts table in Section 4 as a mitigation action

Commented [PW46R45]: Casing isnt an impact. Its the need to use drilling mud which is already covered.

TRD1	619044	8944476	Powerhouse upstream	70	-	-	26.8	24	Alluvial gravels 0-24 m bgl (assumed) but no indication of water level
TRD2	619029	8944474	Powerhouse upstream	70	-	-	10.3	9.2	Alluvial gravels 0-9 m bgl (assumed) but no indication of water level
TRD3	619022	8944414	Powerhouse upstream	70	-	-	27.1	19.2	Alluvial gravels 0-19 m bgl (assumed) but no indication of water level

Thickness (m)

1.6 Existing groundwater use

Honiara, 27 km to the north of the Camp, is supplied predominantly from the deep confined fractured rock aquifer with borefields spread across the city. Four out of six borefields are producing less than 65% of their target yields which can attributed to a combination of well interference and screen clogging.

The semi-confined alluvial aquifer has not been developed extensively for Honiara's water supply but is used by many privately owned bores for which some census data is available at Grass Hill where reference numbers 8911 to 8913 and 9007, 9009 and 9110 (Error! Reference source not found.~~Figure 1-4~~) are recorded as generally between about 15 and 35 m deep with water level 2.5 to 4 metres below ground level (mbgl). These bores are located within 2 km of the Camp site with the closest being 800 m distant. The deepest bore encountered two water bearing zones, a shallow sand and gravel layer down to 18 mbgl and a deeper weathered sandstone layer from 27 mbgl. Further inland at Kangga Village BHs 8103 and 9212 are 35 to 45 m deep and water level is 15 mbgl, reflecting the higher elevation. There has been no systematic measurement of seasonal changes in water level only occasional observations suggesting it may be as much as 2 m. It is probably more in the range 1 to 1.5 m. Water levels peak about one month after end of wet season and then slowly decline because of evapotranspiration until start of the next wet season.

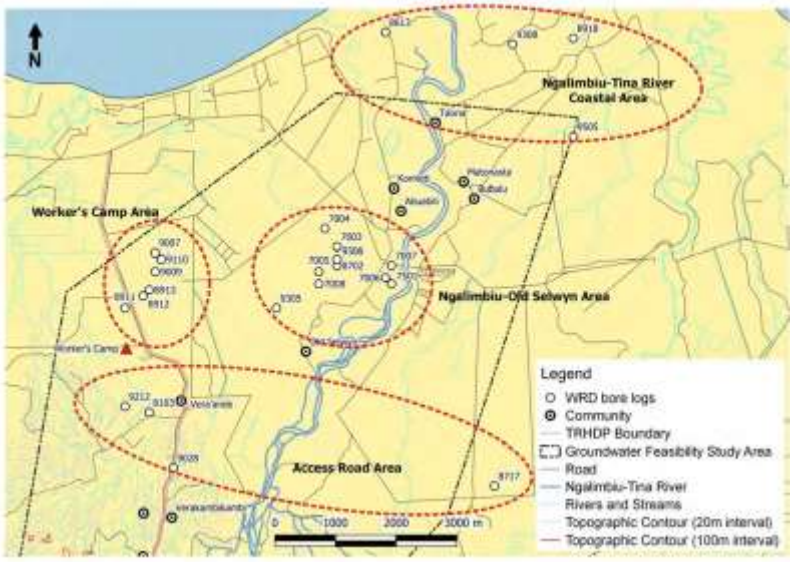


Figure 1-4 WRD boreholes.

Commented [GJ47]: Headings for this table please?

Commented [PW48R47]: done

Commented [HK49R47]: Jess' comment relates to the absence of headings for each column. It is not clear what each column means.

Commented [GJ50]: Please state distance between Honiara and project site.

Commented [PW51R50]: done.

Commented [GJ52]: Another potential impact for your table in Section 4. Please add, and include actions to mitigate (e.g. selection of suitable experienced/qualified contractors with good track record and/or recommendations; careful monitoring of drilling progress by an experienced driller and geologist or hydrogeologist on site; bore integrity inspections….bore casing specifications…etc etc (please add more)).

Commented [PW53R52]: Done

Commented [HK54R52]: Noted the addition of "hydrogeology and drilling expert from Inogen to provide oversight" in table in Section 4

Commented [GJ55]: Increase or decrease, and in which season? Or net change?
Please explain statements like this with more detail – this report will be reviewed by a wide range of people in SIG and lender organisations, so good explanations and context are required.

Commented [PW56R55]:

Commented [PW57R55]: I have added some text but really its back to basics.

Communities access water for everyday needs from a combination of sources (drilled bores, shallow hand dug wells, rainwater catchment and others such as springs and streams) as shown on Error! Reference source not found.~~Figure 1-5~~. At higher elevations springs are also used for drinking water and communities adjacent to the Tina River use the river and springs for washing and ablutions based on water supply replacement survey conducted as part of C7 Water Supply Replacement Plan by HEC with local water engineer.

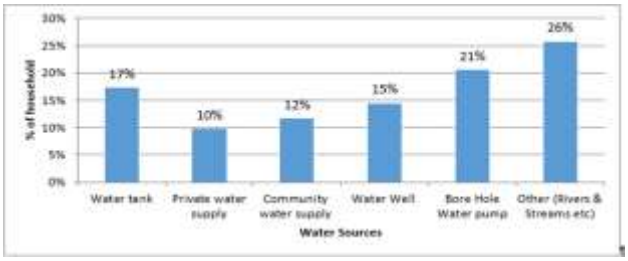


Figure 1-5 Community Water Sources

Typical installations are shown on Error! Reference source not found.~~Figure 1-6~~ (source A. Van Schlkwyk, 1996) and communities within the Project Area on Error! Reference source not found.~~Figure 1-7~~.

Figure 1-6 River bed water hole near Tina Village (left) and well at Vera'ande Village (right)

Commented [GJ58]: This is a very broad generalisation, and not quite correct. A number of villages already had their own rain tanks before this project. They just used them as a secondary/back up supply (or in some cases it is the main drinking supply, because the river water can be bad at certain times of year).
Please review the WSRP and revise this statement to match the actual usage trends.

Commented [PW59R58]:

Commented [PW60R58]:

Commented [PW61R58]: We can only quote the numbers shown in Figure 1-4. But I agree rainwater catchments are more widespread with their use increasing during wet season. We are recommending much more widespread use of roof catchments in our TWSRP.

Commented [GJ62]: Use what? Springs or River? Both are used...

Commented [PW63R62]: Text amended

Commented [GJ64]: Please include source for this data, including date the survey was completed (and cross-reference to the WSRP, where this has been taken from)

Commented [HK65R64]: No source added. Could not find reference to this graph in C7 WSRP

Commented [PW66R64]: The source is Guideline for the estimation of domestic water demand of developing communities in the Northern Transvaal for Water Resources Commission)

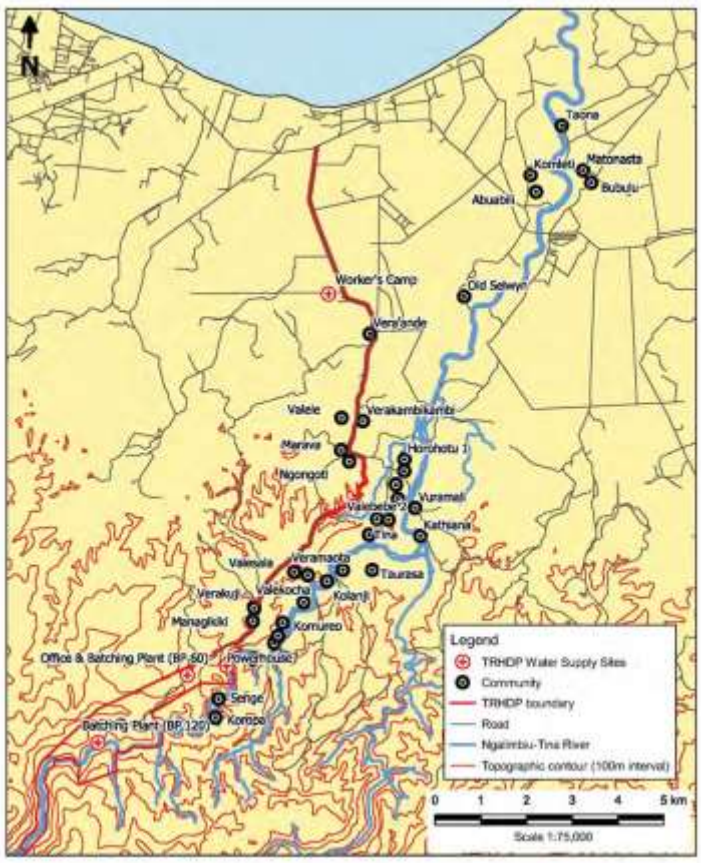


Figure 1-7 TRHDP Facilities and Communities.

There is a bore log for one of the Water Resource Department BHs drilled at Votahombu Village in 1986 (Error! Reference source not found.~~Figure 1-8~~) which gives a description of the shallow aquifer, a coarse sand gravel beneath surface clay which appeared to collapse during drilling. This site is on the Guadacanal Plain and representative of the alluvial aquifer.

Commented [GJ67]: Please define this acronym in full

Commented [PW68R67]: Done

Commented [GJ69]: Where is this in relation to the project? It is not mapped on Figure 1-7

Commented [PW70R69]: Don't have that information. We know its on the Guadacanal Plain and representative of the alluvial aquifer.

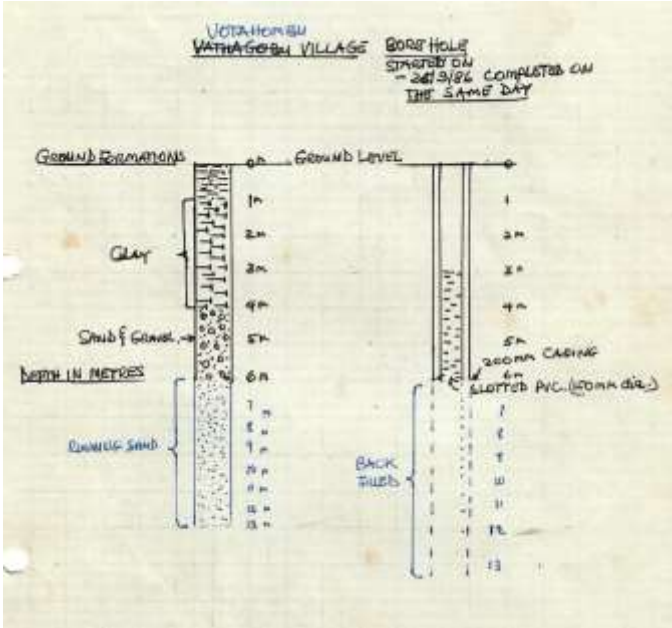


Figure 1-8 WRD BH log.

This BH was equipped with 150 mm PVC casing perforated over a 3 m interval and tested for one hour at 3 lps with drawdown stabilising after only 6 minutes, from 3.4 metres below ground level (mbgl) initial level to 5 mbgl. Other historical BHs described in the Groundwater Feasibility Study Attachment 2 WRD Historical Bore Logs returned similar lithologies and pumping test results.

HEC has undertaken a survey of water sources on 10th and 13th of August 2021~~0~~ ~~(10-13/08/2020)~~ as shown on Error! Reference source not found.~~**Figure 1-9**~~. On the Tina River upstream of the confluence with the Toni River no BHs or dug wells (W) are indicated, only springs (SP). Details and descriptions of all these sources are presented in the *Hydrogeological Assessment Report,* ***Error! Reference source not found.*** ~~*Table 4-1*~~*, Community water source monitoring summary.*

Those springs at higher elevations (SP7 - SP13) were measured to have low flow rates. Given that geotechnical bore logs (such as TBH-8 and TBH-7) measured groundwater levels at approximately 200 masl, there is potential that these higher elevation springs are expressions of the fractured rock groundwater table. However, the fact that flow rates are very low suggests that they are more likely to be shallow groundwater seeps from perched water tables rather than expressions of the deeper groundwater system.

Commented [GJ71]: Which ones? Where were they in relation to the four proposed locations for TRHDP? Need this information to show that these results are relevant, and within the zone of influence for the 4 TRHDP bores (therefore, likely to have similar underlying aquifer characteristics?)

Commented [PW72R71]: They are all in the WRD historical borehole logs, Attachment 2 of the Groundwater Feasibility report.

Commented [GJ73]: Correct? Please make sure full dates are used.

Commented [GJ74]: This report should be attached as an appendix. Lenders will want to read it. Is it the Earth Water People report? Or something attached to WSRP?

Commented [PW75R74]: Its the Earth Water People Report. I am not sure I agree Lenders would want to read it, not in my experience. Its mostly covered in this GIA and it would be a very bulky attachment.

Figure 1-9 Groundwater Sources near Proposed Boreholes.

Commented [GJ76]: The proposed boreholes are not clearly indicated on this map. Neither is the DIA boundary, which should be shown on all project maps for context.

Commented [PW77R76]: The three BH Location now included. Many of the maps are from GFS which dont show DIA. Obviously the three BHs are in DIA..

1.7 HEC Camp Borehole

There is a BH at the HEC camp which was installed by Clean Water for Life (subcontractor) in May and pump tested in August 2020~~2020~~. The BH is 30 m deep, PVC cased to total depth with water level 4.35 m below the surface. There is another BH of the landowner, Garivera 1, which is 110 m to the northeast also 30 m deep with water level 2.47 mbgl.

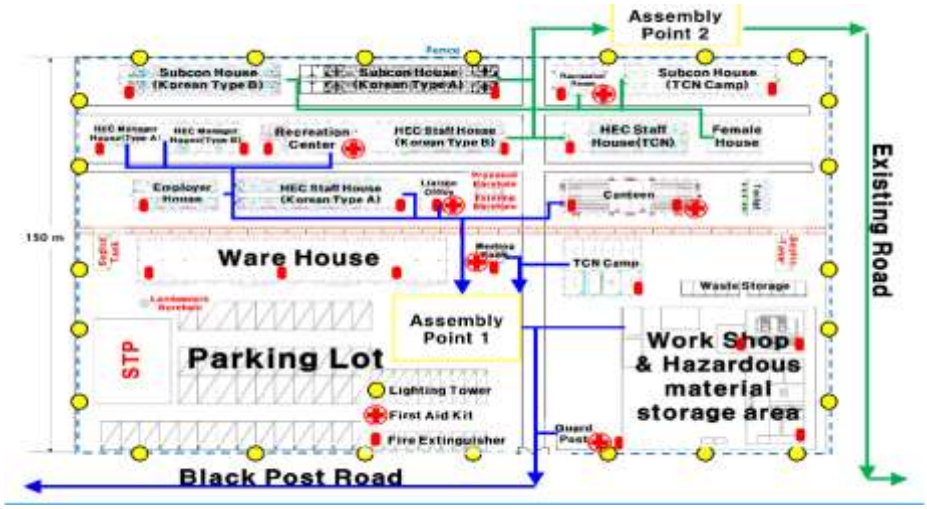
Commented [HK78]: Please include an aerial photograph map and/or design plans showing existing boreholes and proposed borehole location. There are three existing boreholes at or near the camp:
- Existing camp bore
- Garivera PUB bore (110m north-east)
- Borehole 2 (800m east)

Please also provide evidence of no impacts to these existing bores (here or in section 4).
Please also add the location of the existing septic system and proposed sewage treatment plant (STP) including any impacts to the existing or proposed BHs (here or section 4).

Commented [GJ79]: Please include date installed and current status – is it operational? Same for Garivera 1 BH

Commented [PW80R79]: No idea when Garivera was installed, If its important we could enquire. The Camp BH was completed in May 2020 as shown below.

Commented [Shin81R79]: From 13th May,2020 to 27th May,2020, Drilling works has been carried out and currently, it is used for dust suppression and community water supply. Mr Shin, this is the existing Camp BH, not Garivera.



The Camp BH is being used for temporary community water supply at a rate of 10 m3/day to be used only until the deep BH is installed after which it will be reserved for back up supply and water level monitoring, In August 2020 groundwater samples were collected for analysis and a short (2.5 hour) constant rate pump test was undertaken by the Water Resources Division (WRD), Ministry of Mines, Energy and Rural Electrification. The main details of the pump test are summarised in Table 1-5~~Table 1-5~~. The full pump test report produced by WRD is given in Attachment 1 of the Hydrogeological Assessment Report and includes arithmetic drawdown and recovery curves for both the Production BH and Garivera BH1 which was used for drawdown observation. No drawdown was observed in the

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Commented [HK82]: Please check. According to the GW Feasibility Study, the existing camp BH is to be used to replace the existing landowner's bore, that will be closed

Commented [PW83R82]: Not really. The Camp BH was installed to provide water to the camp. The landowners BH is within the camp area near the septic and was never planned to be used and cannot be accessed by the landowner. He will be supplied from the existing BH and later from the new deeper BH.

Commented [Shin84R82]: Currently, he is still using his borehole since the camp was not occupied. However, after occupancy, he will be supplied from the existing BH and later from the new deeper BH.

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Commented [GJ85]: Is this the one by EWP? If so, suggest it is added as an appendix to this document to avoid any confusion.

Commented [PW86R85]: It is. I have already summarised the details don't see the need to attach.

observation bore during the 150 minutes duration of the test which is normal for a well test and in this particular case fit for purpose for the intended use.

Table 1-5 Camp BH, Pump Test Summary (Inogen, 2021)

Pump Rate	Duration of Test	SWL	Drawdown	Bore Depth
100L/min	150 mins	4.85 mbgl	3.15 m	30 m

No mathematical analysis of the pump test data was undertaken but for a test which exceeds three log cycles (0.1, 10 and 100 minutes) in an alluvial aquifer it is reasonable to calculate aquifer parameters and long term drawdown from the results presented. The observed drawdown per log cycle was approximately 0.2 m. If 100 L/min was to be maintained continuously for five years, which is not its intended use, the final drawdown would be only about 5 m for a final drawdown of about 10 m below surface. The flow rate achieved in this pump test was limited by the capacity of the pump used. The drawdown for the proposed replacement BH, to be drilled adjacent to the existing BH, can be estimated after a longer term pumping test at the required abstraction rate of 2 lps using this existing adjacent BH, and the Garivera BH (neighbours BH to the south) for observation. The neighbour, owner of the now closed night club has agreed to discontinue using his BH in return for supply of water from the camp (10 m^3/day). The Camp and Garivera BHs are both in alluvium and in a different aquifer to the proposed 60 m deep BH which will be in weathered sandstone.

1.8 Groundwater Quality

Groundwater quality parameters from the existing camp bore were measured by HEC in August 2020 and returned TDS ranging from 110 to 310 mg/L and averaging about 150 mg/L. Low nitrate, sulphate and turbidity with high total coliform and elevated e-coli were recorded at the springs (SP7 – SP13) with pH ranging from 6.5 to 7.8.

Three groundwater samples were collected from the Camp BH in during the pump test of August 2020 (Table 1-6). Total Dissolved Solids (TDS) was measured at 160 mg/L which is well within the 500 mg/L WHO drinking water standard and is similar to previous TDS measurements in WRD BHs drilled in the area between 1965-1999. A second groundwater sample for ~~The~~ microbiological content in the Camp BH also met WHO standards (**Table 1-7**).

Table 1-6 Chemical and Microbiological Analyses Camp Borehole (August, 2020)

No	Parameter	Result	Acceptable Values
Microbiological Assessment			
1	Total Coliform(MPN/100ml)	<1 / 3 / <1	WHO:<10
2	E.coli(MPN/100ml)	<1 / <1 / <1	WHO:0
Physico-chemical Analyses Results			
3	Odour Test(Average 5 sniffers)	None / None / None	ANZECC/ADWG: acceptable
4	Turbidity(NTU)	1.27 / 1.30 / 1.64	ANZECC/ADWG: <5.0
5	PH(unit)	7.2 / 7.1 / 7.1	WHO/ANZECC/ADWG: 6.5-8.5
6	TDS(mg/L)	160 / 160 / 160	ANZECC/ADWG: <>300
7	Sulphate(SO4, mg/L)	1/1/2	WHO/ANZECC/ADWG: <250
8	Nitrate(No3-N, mg/L)	1.5 / 1.5 / 2.0	ANZECC/ADWG: <10

Commented [GJ87]: Please confirm when a further test will be done (provide a date, and confirm who will do it), and outline the requirements that need to be met regarding pump capacity, duration of tests, information collected etc.

As previously advised to HEC, OE requires that a qualified hydrogeologist supervises the testing given the past issues.

Commented [PW88R87]: We see no reason to do another test.

Commented [DJ89R87]: I don't think you need another test either. Bore appears to have quite a lot of available drawdown. However, you could take a couple of flow and water levels measurements while the bore is in use to confirm.

Commented [GJ90]: I'm a bit curious about this. If it was a private bore that the neighbour installed themselves on their own land (and not for camp use), why do they have to stop using it? HEC doesn't have control over that?

Commented [PW91R90]: His BH is actually within the Camp area. The owner is happy to be supplied with 10 m3/d. HEC want to use it for water level monitoring

Commented [Shin92R90]: His borehole is located within camp premises and near the septic tank. So HEC suggested him to discontinue the borehole and he agreed on HEC's approach.

Commented [HK93R90]: The location of this bore needs to be mapped.
Pleas ensure that a written agreement is kept on file (or ideally added to an appendix here) to avoid potential issues

Commented [PW94R90]: The Garivera BH is 100 m from existing Camp BH near the septic. The other is 800 m to east-northeast. Do not have map or air photo. We can provide aft e... [th2e1]

Commented [Shin95R90]: We already have a written agreement on this matter with Landowner. Please refer to the ..a pro2v2e] ...

Commented [HK96]: Check. Is this from the bore or from springs in another location? Where are sites SP7-13?

Commented [Shin97R96]: Can we use the cross-referencing? Annex D of C7 include all the details.

Commented [GJ98]: Was there any vertical variation? i.e. from surface to depth? ... [23]

Commented [PW99R98]: No vertical measurments were made, unlikely to show much variation over these shallow dep...h ... [24]

Commented [HK100]: Table 1-6 appears to have 3 samples. Were there 3 replicate samples taken? Or were they at differe...n t[25]

Commented [PW101R100]: Inserted and sulphate concentration corrected.

Commented [Shin102R100]: 3 replicate samples taken

Commented [GJ103]: This section is seriously lacking in detail, given the potential risks (for potable use in kitchens, health cl...in...ic ... [26]

Commented [WW104R103]: If testing fails then does HEC propose treatment? ... [27]

Commented [HK105R103]: Water quality monitoring addressed later in the document

Commented [HK106]: ~~Please explain this elevated result which~~ is significantly more than guideline

Commented [PW107R106]: corrected

Commented [Shin108R106]: Typo. Revised in line with Annex D of C7

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Table 1-7 Microbiology Test Report for Camp Borehole (02 June 2020)

Sample No	Date/time collected	Sample description	Analysis	Result	Units	Method
20-347	02/06/20 10:15 am	Little Bottle TINA	Total coliforms	<1	MPN/100 mL	Colilert-18: APHA (online) 9223 B
			E.coli	<1	MPN/100 mL	

Source: National Public Health Laboratory (NPHL) Analysis Results, 3rd June,2020

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It has been suggested that the groundwater may be contaminated with heavy metals and cyanide which are usually associated with gold mining and lower pH groundwaters. There is no gold mining in the Tina River catchment and no possibility of contamination by these analytes. Also a suggestion of pesticides contamination from palm oil plantations which are prevalent in the Lowlands. There are none within the vicinity of the Office or BP120 but there are at the Camp. A preliminary Source – Pathway – Receptor analysis suggests it is highly unlikely there will be pesticide contamination in the deeper aquifers at the Camp. However one-off water quality testing for pesticides will be undertaken at the existing and proposed Camp bores to confirm this. The main risk here is if the community ~~become aware that these analyses are being conducted and then assume they may be present, irrespective of the analytical results. They may demand pesticide analysis of groundwater from their shallow wells and BHs and if these are within or very close to palm oil plantations the risk of contamination increases and if revealed would result in enormous liabilities for the palm oil industry~~ with potential abandonment of community supplies.

Commented [HK109]: Deleted as irrelevant. THL has to ensure the safety of water that it is supplying to workers and the community

1.9 Community Water Supply Initiatives

There are several community water supply initiatives underway. HEC is working closely with the Community Benefit Share Pilot (CSBP) to finalize temporary supply for all villages identified in the C7 Water Supply Replacement Plan (WSRP) and appointed a water engineer to assist CSBP with this program. Potable water supply tanks have already been installed at Ngongoti, Verakambilkambi and Valesala/Antioch prior to start of road construction, Error! Reference source not found.~~**Figure 1-10**~~. These community water sources were identified to be impacted during the access road construction works. Furthermore, water supply alternatives shall be delivered to the downstream communities of the Tina/Ngalimbiu River that are likely to be impacted during the main works (river diversion).

Community water supplies are being transferred by tanker from the existing camp bore and will continue to be delivered from the existing and/or proposed camp bore once established.

Figure 1-10 Water Tank Provided by HEC

2 STAKEHOLDERS CONSULTATION

There is an extensive consultation process in place regarding safeguarding community water supplies. Further detail, including the timeframe for the installation of alternative supplies, is provided in the Water Supply Replacement Plan. ~~into which will be incorporated this groundwater programme. It is an important part of the agenda and overlaps with the larger community water supply agenda of the SECP and in the context of community water provisions already committed. Water supply is always a contentious issue and subject concerns which mostly cannot be justified on technical grounds. For that reason provision has been made for provision of temporary supplies resulting from community grievance, whether justified or not.6~~

~~Table 2-1 Stakeholder Consultation on Groundwater~~

~~Date~~	~~Activities~~	~~Participants~~	~~Actions~~
~~xxx~~	~~Describe the proposed groundwater programme~~	~~Communities, NGOs, Government Agencies, Religious groups……..~~	~~Document attendees with signatures and minutes of meeting including any action items arising~~.
~~yyy~~	~~Progress and results of BH construction and testing and close out action items.~~		
~~zzz~~	~~Regular follow up meetings at 6 monthly intervals~~		

Commented [GJ110]: Please refer to the SECP. Otherwise to the uninitiated, it is not clear what the "larger agenda" will involve.

Commented [PW111R110]: done

Commented [GJ112]: The activities are good – just need more detail in other 2 columns.
At the least, it needs to detail when consultation must occur, with which parties (name specific villages and groups please), who will initiate the engagement, communications and ongoing reporting required to keep people informed, etc. This is especially important when HEC are saying that they will be supplying water to people outside of the workforce (e.g. at Garivera).

Commented [PW113R112]: I think its already part of the SEP.

Commented [HK114R112]: Deleted as incomplete.

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3 PROPOSED GROUNDWATER SUPPLY

3.1 Provisional Groundwater Demand

Error! Reference source not found.~~Table 3-1~~ summarises the groundwater demand and expected sewage treatment at each facility and indicates where reuse and recycling will be adopted to reduce groundwater demand. ~~In~~ In accordance with international best practice on efficient use of resources, the nominated groundwater demand at Camp and Office reflects the reuse and recycling of high quality treated wastewater effluent and the recycling of groundwater at the Crusher Plant.

Further detail on reuse and recycling is given in Error! Reference source not found.~~Table 3-2~~.

Table 3-1 Groundwater Demand and Sewage Treatment

Classification		Maximum demand (Peak time) (m^3/day)	Sewage Treatment (m^3/day)	Remarks
Camp Site	Camp	80	~~52.2~~60	43.2 m3/d for camp + 14.8 m3/day for the office employees, remainder for any contingency. All wastewater effluent reused as dust suppression water during construction
	Adjacent Landowner	10		Replacement for closing Landowners bore
	~~Contingency for~~ Community Water Supply	10		~~Provisional in the event of community grievances~~Replacement water supplies
	Total	100	60	
Office Site~~+~~	Office	40	14.8*	9 m3/d(W/C only), 4.1 m3/d(Basin and Shower) for employees, medical facility, remainder for vehicle washing ~~and~~ , dust suppression and any contingency.
	Crusher Plant (C/P) (Replenishment Water)	70		Initially 200~250 m^3/hr will be filled in water tank of C/P and it will be circulated within C/P system and loss of 50~70 m^3/day will be replenished by groundwater.~~or~~
	Batch Plant 60	3~~2~~0		No recycling
	Contingency for Community Water Supply	10		Provisional for the replacement of community water supplies~~in the event of community grievances~~
	Total	1450	-	
BP 120 (Dam Site)	Total	240	-	For concrete works. No reuse or recycling required~~possible~~

*To be transported to the Camp for treatment

Table 3-2 Recycling/Reuse of Wastewater Effluent and Groundwater at Camp and Office

Classification	Category	Reuse and recycle (m3/day)
Dust Control (Camp Compound)	Wastewater Effluent	5
Dust Control (Access Road Lot 1)	Wastewater Effluent	20
Total Camp		**25**
Dust Control (Access Road Lot 2&3)	Wastewater Effluent	20

Commented [GJ115]: This section needs to contain information about how the water will be distributed.
Will it be instantaneous supply, or use some kind of storage to hold water for later use?
How will peak demand periods (e.g. morning/evening showers) be managed to avoid putting the bores under too much pressure?
PW. Water tanks will be installed at Camp and Office

Commented [GJ116]: Yes, in principle this is great to see, and thank you for considering reuse options seriously.
However, we do still need those usage estimates to be checked and reconciled, as at the moment they seem conflicting/not considering the whole picture. See comments especially for Table 3-1 and 3-2 above.
PW. Done

Commented [HK117R116]: Statement moved to here as more relevant to this section.

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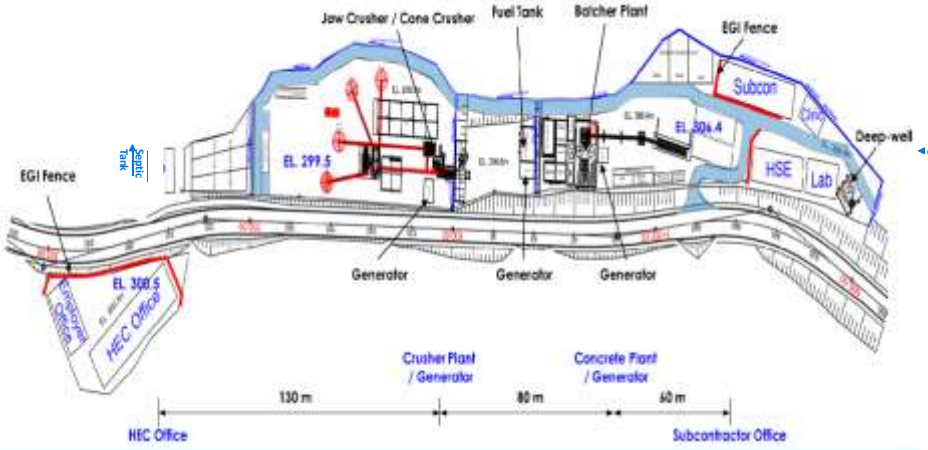
Classification	Category	Reuse and recycle (m3/day)
Dust Control (C/P&B/P compound)	Wastewater Effluent	20
~~C/P Replenishment Water~~	~~Groundwater~~	~~50~~
Car Wash (Mixer Truck)	Groundwater or Wastewater Effluent	20
Total Office		760

3.2 Proposed Groundwater Boreholes

It is proposed to use groundwater for water supply at the three TRHDP temporary ancillary facilities premises – Camp, Office including concrete Batch Plant and Crusher Plant and RCC Batch Plant (BP120). Water will be tested and (if required) treated to drinking water quality standard at the Camp and Office bore.

Groundwater is already a common source of safe water on the alluvial plain and there are no real limitations for its development at the Camp, the aquifer is permeable, sustainable yields can be achieved and initial testing indicates that water quality is high standard. Existing data which has been reviewed in detail supports the development of a second BH to 60 m depth at the Camp.

In the proposed BHs at higher elevation the target aquifers are fractured sandstone and conglomerate bedrock where permeability is related to secondary porosity in fractures and faults. Similar aquifers are developed for the Honiara water supply but there are no reference BHs in the immediate area of the TRHDP facilities. There is a high probability that groundwater in sufficient supply and of good quality can be intersected down to a depth of 100 to 150 m at the Camp and RCC Batch Plant (BP120) with the option of continuing deeper if necessary or installing second BHs, in which case a separate assessment would be prepared. This remains to be determined during drilling and testing.



The BH construction at the camp will require a rotary drilling method using bentonite mud. Bentonite and mud additives are non-toxic and are normally stored, recycled and disposed in pits at the drill site. On completion of the BH these drilling muds will need to be excavated and disposed to landfill. Down the Hole Hammer (DTH) is suitable for drilling the bedrock BHs using air or water but if alluvial or weathered bedrock is present, possibly down to 25 m depth, provision should be made for use of

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Commented [HK130]: Not suitable for use as vehicle washing where human contact will occur

Commented [Shin131R130]: Mixer Truck will be washed by pump car so it doesn't need human contact. However, we can remove this item just in case.

Commented [GJ132]: This doesn't match with what is in Table 3-1, which states that only 14.8 m^3/day treated wastewater will be available for the office site.
Please correct and reconcile these two tables, addressing my comments.

Commented [PW133R132]: No STP at Office. Demand figures modified. Employee demand now 50 ratherr than 180l lcpd.

Commented [Shin134R132]: Approximately total 60 m^3/day treated wastewater will be generated. It will be used for dust control and groundwater will be used for the insufficient amount.

Commented [HK135]: Please provide site maps or design drawings showing the location of the BHs (Figure 3-1 is ok but more detail is needed).
Please confirm that the bores will not be located or impacted by localized contaminant sources e.g. STP, septic tanks, offal pits, waste dumps etc.

Commented [GJ136]: Specify whether non-potable or potable at each facility please (matching with the rest of the report – see my comments in Section 1).
PW. Already answered. BH locations at Camp and Office shown on STP ESIA.

Commented [HK137R136]: Additional text added for clarity

Commented [GJ138]: How? There is no direct evidence for this yet because reliable pumping tests have not been completed. Sustainable yields are not mentioned any where else in this report. We need to see more commentary and evidence on this please (or a plan to obtain that information and confirm before commissioning the bores); it has been raised to HEC on multiple occasions.
PW. We will conduct longer term pump tests on the the three new BHs once they are installed. As for sustainability this is based on the low demand, very limited other use near the BHs and high recharge.

Commented [HK139]: Please discuss the existing septic system and proposed STP in relation to the shallow and deep bores

Commented [HK140]: Please discuss the existing septic system in relation to the proposed Office bore

Commented [PW141R140]: Its in the STP ESIA

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Commented [HK142]: Landfill and/or spoil disposal sites?

Commented [Shin143R142]: Only Landfill

bentonite in the upper section of the hole and its disposal. A total of approximately X m3 of drilling mud is expected to be generated from the camp borehole and X m3 from each of the Office and RCC BP boreholes.

~~In accordance with international best practice on efficient use of resources,~~ the nominated groundwater demand at Camp and Office reflects the reuse and recycling ~~of high quality treated wastewater effluent and the recycling of groundwater at the Crusher Plant.~~

Figure 3-1 Proposed Groundwater Drilling Location

Commented [HK144]: Refer above comment

Commented [HK145]: Check

Commented [HK146]: Check

Commented [Shin147R146]: Camp slime volume of drilled soil and rock fragments would be about 2.5m3.
Office & 60BP and 120BP slime volume would be about 4.7m3 and 3.2m3, respectively.
These slime produced in boreholes will be embedded in two sedimentation basins(36m3) after pumping test.

※ Note : one sedimentation basin volume is 18m3(3m long x 3m width x 2m depth)

Commented [GJ148]: Yes, in principle this is great to see, and thank you for considering reuse options seriously.
However, we do still need those usage estimates to be checked and reconciled, as at the moment they seem conflicting/not considering the whole picture. See comments especially for Table 3-1 and 3-2 above.
PW. Done

4 IMPACT ASSESSMENT

Most~~All~~ potential impacts of the installation and operation of the groundwater bores are ~~rather~~ insignificant or minor. T~~ with t~~he possible exception is~~of~~ community grievances which could be significant if there is a perceived or actual impact on community water supplies, and replacement water sources are not provided.

Siting of the boreholes shall account for localized contaminant sources e.g. the proposed Camp sewage treatment plant, septic tanks, offal pits, waste dumps etc. Any bores used for community water supply, as well as the camp and office bores shall comply with drinking water standards.

During construction, t~~T~~he duration of the potential impacts is short term of the order of three to four weeks ~~during construction of~~ for each of the three BHs. Potential impacts include discharges of sediment-laden water, drilling muds, as well as noise and vibration. No additional vegetation or habitat clearance will occur as a result of the bores, which will be constructed at modified parts of the site (the Camp, Office and RCC Batch Plant respectively).

The operation of the BHs will continue through the five years of construction but again the potential impacts are insignificant or minor. It is noted that the groundwater demands for these bores are relatively low ranging between 2.5 litres per second (L/s) at the Camp to 3 L/s at the RCC Batch Plant (BP120). The Office and BP120 bore are adjacent to the Tina River. When expressed as cumecs (m^3/sec), the unit used for river flow, the water demands at Office and BP120 are equivalent to about 0.002 and 0.003 cumecs respectively which is insignificant compared to flow in the Tina River, where minimum monthly flow is about 3 cumecs (refer ESIA). Therefore no adverse impacts on the river are anticipated.

As the BHs will be decommissioned after construction, there are no long- term impacts. Groundw~~W~~ater levels will recover to their pre-existing level within two to three months of decommissioning.

Table 4-1 Impact Assessment

Activity	Impact	Potential Impact	Management	Monitoring	Responsibility
BHs constructi on.	Minor and very short duration.	Worker and community health and safety (construction)	Implement Worker's Health and Safety Plan, Community Health and Disease Vector Management Plan and Traffic Management Plan	Monitoring as per relevant CESMPs	HEC E&S Manager
		Bentonite, mud additives and foam are non-toxic and are stored, recycled and disposed in pits at the drill site.	m3 of dDrilling muds will need to be held in pit at the BH site and disposed to landfill after BH completed. MSDS will be provided for mud materials and foam.	Visual observations during drilling and close out report for BH. Manifest for disposal of all drilling muds.	HEC E&S Manager
		Noise and vibration during drilling disturbing communities and wildlife.	Daytime drilling only Adhere to Project noise limits as per the Noise and Vibration Management Plan	Monitor and record noise level daily during BH construction. Address community grievances.	HEC E&S Manager

Commented [GJ149]: I'm confused as to why the bullet points here have not been integrated into Table 4-1?
Please add impacts to Table 4-1 (along with suitable mitigation measures, monitoring, responsibilities):
- Damage to project reputation; reduction in trust between communities and the Project (e.g. perceived drawdown/impacts on community water sources such as springs due to groundwater use by the project)
- Use of bentonite and mud additives (please specify materials where possible)
- Use of high pressure equipment (e.g. DTH) – risks to safety; noise/vibration
- Abstraction of groundwater during bore development (unknown water quality – until tested)
- Potential change in groundwater level due to abstraction for Project activities
- Community demand to take over use of boreholes on project completion (this is actually a complex issue – needs to be handled in conjunction with CBSP team at PO)
- Bore reinstatement? Minimising long term impact…

And others I have flagged in comments for Table 4-1
PW.. Done

Commented [HK151R150]: Relevance is potential loss in groundwater recharge to the river which is not discussed in this section. Therefore resolved.

Commented [GJ152]: Please use rows in this table to clearly line up activities/impacts/management etc. They seem to be misaligned and this makes it harder to read.

Commented [HK154R153]: HEC to ensure management actions and monitoring are reflected in relevant CESMPs

Commented [GJ155]: How has significance been assessed? I.e. likelihood and consequence as has been done for all the ESMPs? PW.

Commented [HK156R155]: Appears to have been assessed with mitigation (not standard practice) but not considered consequential

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Commented [HK159]: TBC

Commented [GJ160]: How often, and who has the responsibility for this?

Commented [HK161R160]: Implicit that this is during construction

Commented [GJ158]: What about other impacts during the drilling process?
Noise - mitigate as much as possible; dirlling only during day time?
Drilling will only be done during daytime. The BHs will take ab…d [335]

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Activity	Impact	Potential Impact	Management	Monitoring	Responsibility
			Stakeholders and sensitive receptors to be informed in writing one month prior and again one week prior to construction.		
		After BH construction they will be airlifted, developed and pump tested. Drilling muds and silty groundwater will be discharged.	During development and testing the groundwater should be directed into a sediment settling ponds before discharge ~~to the Tina River~~. Adhere to Project TSS limit of 50 mg/L at discharge point (IFC EHS Guidelines) Implement Water Quality Monitoring Plan (WQMP).	Visual monitoring of silty water, foam and mud discharge. Water quality monitoring of TSS and other parameters as per the WQMP.	HEC E&S Manager
Supervision	Significant if boreholes incorrectly installed	Short term for duration of drilling and testing programme.	Appoint qualified personnel to be on site during drilling, bore construction and testing. Two engineers appointed by HEC (c.v.'s available).	Hydrogeology and ~~Drilling expert from~~ INOGEN to provide oversight and guidance. All BH will be completed in sandstones which are easily recognizable by drilling engineers. Pump testing supervision only requires water level measurements and monitoring of discharge rate. ~~Hydrogeology and Drilling expert from INOGEN to provide oversight and guidance/~~	HEC Site Manager and Inogen
BHs Operation	Minor for 5 years ~~construction reversible~~	Reduction of streamflow	~~T~~No discernible impact on streamflow. No additional management effort required	No monitoring required	HEC E&S Manager
		Drawdown in water level in community water sources	Drawdown will be negligible because community bores ~~they~~ are shallow depth (i.e. different aquifer) and large distances from the three deep BHs.	Monitor water levels in the existing Camp BH and the landholders BH at monthly intervals to establish variations due to abstraction and seasonal variation. There are no other BHs within 800m. Water levels will be plotted monthly.	HEC E&S Manager

Commented [GJ155]: How has significance been assessed? I.e. likelihood and consequence as has been done for all the ESMPs? PW.

Commented [HK156R155]: Appears to have been assessed with mitigation (not standard practice) but not considered consequential

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Commented [GJ162]: Delete, as long as wording I've put is accepted.
I agree that monitoring for impacts on streamflow will be far too onerous and out of proportion to the risk.
OK to not have this, as long as the observation bores are monitored for drawdown effects (as described elsewhere in this table).

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Commented [GJ165]: For the duration of bore production? Please specify.
Will a permanent water level sensor be installed, or will HEC manually measure water level?
How will HEC report on water level data (i.e. monthly report to THL?) How often will seasonal trends be evaluated?
PW. Manually measure. All water levels plotted monthly.

Commented [GJ166]: Is this possible, if they are on private land?
HEC will need to negotiate access in advance. Please describe the process for this to inform the management plan.

Also preferably would be monthly checks, to match with monthly monitoring of other observation bores (as described above)

Commented [HK167]: The GW Feasibility Study says that there are 3 bores: existing camp, bore 110 metres away, bore 800m away.

Commented [GJ163]: Is there any reasoning behind this number? I agree it is necessary (and good that is has been included), but would be good to understand how this distance was arrived at. Is it the estimated edge of a zone of influence for each bore? Does the distance need to be varied between the four locations depending on aquifer characteristics in each area? Zone of influence is unimportant. The 3 BHs are tapping deep aquifers and there are no other BHs within km into these aquifers.

Commented [GJ164]: This approach seems very reactive, although I can understand HEC's nervousness given grievance history to date.
I think HEC have missed the point here. If the WSRP was implemented properly (which is hasn't always been, to date), then grievances should be minor and infrequent. It is up to HEC to improve their reputation and gain the trust of communities. If this is achieved, you shouldn't need to have this contingency.
I would recommend removing this and instead focusing on how HEC can improve their implementation of temporary water supply obligations under the WSRP. Such as properly installing and maintaining rain tanks (not just dropping them off and expecting communities to install the collection system themselves); ... [36]

Activity	Impact	Potential Impact	Management	Monitoring	Responsibility
Groundwater Quality and Potential Contamination	Potentially significant long term and irreversible.	Contamination of BHs from Project landuse	Siting of the BHs shall account for contaminant sources e.g. STP, septic tanks, offal pits, waste dumps.	Hydrogeology and Drilling expert from INOGEN to provide oversight and guidance	HEC Site Manager and Inogen
		Contamination of groundwater by CN, heavy metals and pesticides.	There will be no CN or heavy metals because no gold mining in Tina River catchment. Also very unlikely there will be pesticide contamination in deeper aquifers at Camp. ~~The biggest risk is if community hears that these analyses are being undertaken and may assume the worse despite evidence otherwise~~.	Groundwater quality at existing Camp BH meets WHO drinking water quality guidelines for all standard chemical and microbiological parameters. These will be analysed during pump testing of new BHs, monthly for the first year and 3-monthly thereafter at the Office and 2 x Camp bores. HEC shall also~~is also prepared to~~ undertake a one-off analysis of pesticides and heavy metals at the existing and proposed Camp bores~~if requested~~.	HEC E&S Manager
		Worker and community health and safety (sanitation)	Need to ensure drinking water quality of bores that supply the community, Camp and Office	The Camp and Office bores, as well as Community water supplies from the Project, shall be monitored at source monthly for the first year and 3-monthly thereafter to ensure compliance with WHO drinking water quality guidelines.	HEC E&S Manager
Community Grievances relating to disruption or contamination of water supplies	Potentially significant ~~through the 5-year construction period~~. Can be mitigated~~Reversible~~	Communities may consider their water supply is impacted by the Project and operation of BHs.	~~If springs dry up naturally during dry season provide clean water to impacted community~~. ~~Similarly with BHs and wells if they fail~~.The Project shall provide alternative water supplies to all affected communities as per the Water Supply Replacement Plan	~~Select one spring~~, ~~closest to each of the BHs at Office/Crusher and Batch Plant for visual observation of flow and seasonal variations.~~ Verification that alternative water supplies have been installed as per the Water Supply Replacement Plan	HEC E&S Manager
Bore decommissioning	None, if bores are correctly decommissioned	Risk to community health and safety from abandoned bores	All bores shall be capped and no above ground infrastructure shall remain.	HEC shall ensure bores are decommissioned at the completion of construction	HEC Site Manager

Commented [GJ155]: How has significance been assessed? I.e. likelihood and consequence as has been done for all the ESMPs? PW.

Commented [HK156R155]: Appears to have been assessed with mitigation (not standard practice) but not considered consequential

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Commented [GJ168]: This is not optional, and also should not wait until an impact is seen/already happened. Please refer to WSRP.
Request that this wording is changed please to be more definitive – "HEC will provide equivalent water supply" or similar.

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5 CONCLUSION

The residual risk associated with the lowering of ~~ground water~~ ground water level through abstraction for project construction is very unlikely considering the hydrogeological environment, and the implementation of mitigation measures and monitoring described in Section 4 above. There are no BHs or wells in the neighbouring communities which would experience increased drawdown. In summing up the Groundwater Impact Assessment, ~~it can be readily claimed that~~ the drilling of boreholes and extraction of groundwater ~~will~~ are expected to have potential impacts that are minimal and ~~in the construction phase which is~~ temporary.

Commented [GJ170]: Could be adversely impacted by?

Are you talking here about impact of the project abstraction on neighbouring bore, or vice versa? Please clarify in this text.

Commented [GJ171]: Ideally, remove this word. Suggests there is still a possibility for longer term impacts outside the construction phase, which is possibly not what you mean?
PW. The BHs will not be used after construction phase. The Office and BP 120 BHs will be decommissioned. Normally so would the Camp but may be retained for community use.

Page i: [1] Commented [PW5R4] Paul Whincup 10/3/2021 9:22:00 AM

We are of course very familiar with these guidelines and have acted for IFC on a number of groundwater studies. this particular study is relatively simple, three BHs at widely separate locations, all with low groundwater demand, to be used only during construction no competing users, no nearby groundwater sources, no impacts. But lacking on some information which can only be obtained by drilling and testing. There should be no reason to delay the drilling.

Page i: [2] Commented [GJ6] Grinter, Jessica 9/27/2021 8:00:00 PM

Why entirely by groundwater, when HEC are allowed to take a certain amount from Tina River, and this was already detailed in the ESIA?

The big question from us and lenders has always been why this is necessary (especially for the crusher and batch plant) when there is so much surface water available. Is it an accessibility issue? Please provide detailed justification with evidence to support.

Page i: [3] Commented [PW7R6] Paul Whincup 10/3/2021 9:33:00 AM

not sure why this question is being raised now after a Groundwater Feasibily Study and Groundwater Impact Assessment have been commissioned. And not sure why groundwater was not considered in ESIA. However as a comment a weir across the Tina River upstream of dam would be difficult to engineer safely given the frequency of high volume floods and water treatment would be required for sediment and possibly coli. Possible impacts to fish.

Page i: [4] Commented [Shin8R6] Shin 10/12/2021 8:28:00 PM

During Access Road Construction, If we use Tina River, we have to use the road laying on out of project area. Accordingly, additional traffic management plan and stakeholders engagement activities shall be considered.

Page i: [5] Commented [GJ9] Grinter, Jessica 9/28/2021 5:49:00 PM

Please indicate in the table below what volume will be required (based on per person, per day requirements, and then assuming maximum occupancy of facilities to be conservative)

Done. Conservatively uses peak occupancy figures. The litres per day are standard for all camps and offices.

Page i: [6] Commented [GJ10] Grinter, Jessica 9/27/2021 8:01:00 PM

HEC have stated in the past that they want to avoid the expense of shipping in commercially supplied drinking water.

Please provide details on where the "dispensers" will be filled/obtained from, and how much volume will be required from that source. How will this potable water be transported? What guarantees will HEC have regarding its quality?

PW. This should not be discussed under Groundwater Impact Assessment but in Camp and Office documents

Will water only be used for process/industrial use?

Will groundwater be used for non-potable supply? If so, please detail exactly which activities it will be used for, andwhich will be excluded.

PW. The existing camp bore is being used for temporary community water supply. The three BHs to beconstructed will be used for non-potable supply, ablutions, vehicle wash, aggregate washing etc. It is anticipated that all, as with existing Camp BH will be potable quality, otherwise it will be treated.

Page i: [7] Commented [Shin12R10] Shin 10/12/2021 8:32:00 PM

Total 10 water dispensers were brought in and Water is being supplied from "Blue Water Company" via local suppliers.

Page i: [8] Commented [HK14R10] Harrison, Kristy 11/15/2021 8:22:00 AM

Noted that there will be drinking water supplied. For cooking, showering etc. it is assumed that the existing camp bore will be used. The Water Supply Replacement Plan says that the existing bore will be used for drinking water and will be replaced by the new bore water.

Page 1: [9] Commented [GJ25] Grinter, Jessica 9/27/2021 8:08:00 PM

Please state how long the powerhouse bore could be used for.

Operation phase is 30 years due to this project's BOOT contract.

Also - The Powerhouse must have a potable supply and this is in the Employer's Requirements with the required treatment (UV). HEC has this in their design already. Please at least describe the powerhouse arrangement at a high level, even if you state that a further impact assessment will be done separately for that (since it is associated with permanent works).

PW. The Powerhouse BH is for the whole of operations not required during construction. The demand is extremely low only 7 m3/d or about two thirds of a water truck. Not part of this Groundwater Impact Assessment.

Page 1: [10] Commented [HK26R25] Harrison, Kristy 11/15/2021 9:15:00 AM

All 4 bores required for the project need to be assessed.

The operational bore was queried in the review of the GW Feasibility study, whereupon HEC said that it would be "dealt with in the revised GIA" (18-Oct-21).

Page 1: [11] Commented [PW27R25] Paul Whincup 11/17/2021 10:18:00 AM

7 m3 is a very low demand and probably the BH will be shallower than at Office. That can only be determined after the Camp BH has been constructed and tested. We can add a sentence but realistically any impacts would be on a much lesser scale than those identified at Camp.

Page 1: [12] Commented [GJ28] Grinter, Jessica 9/27/2021 8:09:00 PM

This statement is inappropriate and not relevant.

If the results have been independently checked (hopefully this has been done) it will become very obvious that the tests were not "great value", in fact they provided almost no reliable information.

Please delete.

PW. Deleted. We have reviewed the data provided in this 150 mins drawdon test followed by recovery test and found it useful and fit for purpose for a BH of low capacity and of very limited use. An understanding of the extensive nature of the l aquifer and absence of boundary conditions allow a reasonable interpretation. When the new deeper BH is installed a 48 hr test will be conducted. This is discussed in more detail in the Pump Test Paper.

Page 1: [13] Commented [GJ29] Grinter, Jessica 9/27/2021 8:11:00 PM

Where? In this report, or in EWP report? What information is this referring to?

PW. deleted, it was referring to geological, rainfall and streamflow data which is actually in the Groundwater Feasibility Study,

Page 1: [14] Commented [GJ30] Grinter, Jessica 9/27/2021 8:42:00 PM

Please describe/demonstrate how these daily averages have been estimated. E.g. occupancy rates, assumptions for use.

Please reference any assumptions with peer-reviewed or industry accepted technical reports/guidelines (e.g. WHO publications)

PW. The figures and assumptions have been updated.

Page 1: [15] Commented [GJ31] Grinter, Jessica 9/27/2021 8:14:00 PM

Please define what 'sanitation' would include.

We need more clarity on what water will be used for if it is not treated to drinking water standard. Water used for drinking, cooking and health care (e.g. taps in Camp kitchen, and supply to the health clinic) needs to be compliant with WHO DWQG. This is potable water.

Water used for anything else (non-potable use) including personal hygiene (hand washing, bathing, laundry) and sanitation (toilet flushing, cleaning) would ideally be of potable quality. Workers may have this expectation/preference. However untreated bore water from a deep aquifer is likely to be OK, and can be used as long as "do not drink" notices are prominently displayed.

It is very important that some understanding of groundwater quality is obtained during testing/initial bore development, so that HEC can decide if treatment will be necessary (and understand the level of risk). For example, if pesticides or other volatile substances (e.g. TPH) are detected, this would limit the range of uses for the water and either some additional treatment measures will be required, or the supply will not be viable.

Page 1: [16] Commented [WW32R31] Waddell, William 9/29/2021 8:55:00 AM

The cold and hot water at the camp bore is most likely plumbed to all showers and basin for all personal hygiene washing. I believe there is no separate plumbing system currently to even recycle MBR water through toilets seperately. From what you say above the Camp bore must supply potable water as HEC they will only import drinking water. The office will have toilets and therefore must have hand basins, therefore from the comment above potable water must be supplied to Office site as well. HEC has not mentioned treatment of water treatment anywhere should bore quality be lacking but supply is still adequate.

Page 1: [17] Commented [Shin33R31] Shin 10/13/2021 9:08:00 AM

HEC will use the commercial drinking water in this country. MBR water will not be recycled for toilet.

Page 1: [18] Commented [HK34R31] Harrison, Kristy 11/15/2021 9:26:00 AM

The original comment is valid but relates to water quality and testing. Both the camp and office bore will need to comply with drinking water standard. This comment will be resolved in this section but remains relevant for other sections.

Page 1: [19] Commented [PW35R31] Paul Whincup 11/17/2021 10:28:00 AM

The BH groundwater will be drinking water quality. The only potential contaminant of concern would be e-coli and if present a simple chlorination process would be used to meet drinking water standard.

Page 1: [20] Commented [HK37R36] Harrison, Kristy 11/15/2021 9:29:00 AM

Relevance is potential loss in groundwater recharge to the river which is not discussed in this section. Therefore resolved.

Page 11: [21] Commented [PW94R90] Paul Whincup 11/17/2021 1:56:00 PM

The Garivera BH is 100 m from existing Camp BH near the septic. The other is 800 m to east-northeast. Do not have map or air photo. We can provide after the new BH has been installed when we start the monitoring programme.

Page 11: [22] Commented [Shin95R90] Shin 11/20/2021 8:50:00 AM

We already have a written agreement on this matter with Landowner. Please refer to the above layout.

Page 11: [23] Commented [GJ98] Grinter, Jessica 9/27/2021 9:22:00 PM

Was there any vertical variation? i.e. from surface to depth?

Also – these results are based on a single monitoring event. While it is better than no results (which is what we had in 2020), all it gives us is one snapshot in time. Lenders will likely point this out as a lack of baseline evidence, and potentially require a more precautionary approach to bore development and use of groundwater supply as a result (and I would agree – it would be the best practice approach).

Suggest you include a statement on the limits of this data and link to commitments (in Section 4) to conduct further monitoring as part of pump testing / bore development prior to production.

Page 11: [24] Commented [PW99R98] Paul Whincup 10/4/2021 11:10:00 AM

No vertical measurments were made, unlikely to show much variation over these shallow depths. And these results are for TWSRP they show that the proposed BHs will have groundwater salinity well below WHO DWS of 500 mg/l. The monitoring we propose for groundwater quality is only in the three proposed BHs,

Page 11: [25] Commented [HK100] Harrison, Kristy 11/16/2021 6:51:00 AM

Table 1-6 appears to have 3 samples. Were there 3 replicate samples taken? Or were they at different times?

Page 11: [26] Commented [GJ103] Grinter, Jessica 9/28/2021 3:44:00 PM

This section is seriously lacking in detail, given the potential risks (for potable use in kitchens, health clinic).

TDS is not the only parameter used to determine drinking water quality.

Other parameters including nitrate, sulphate, pH, turbidity and bacteria (total faecal coliforms, *E.coli*) need to be tested regularly during bore production at minimum in line with the C7-WSRP testing, and also preferably heavy metals (As, B, Cu, Cr, Cd, Hg) and cyanide need to be tested (at minimum, prior to commissioning) given the land uses existing within Tina catchment.

There also needs to be at least an initial screening test for selected Organo-Chlorine Pesticides (OCP) to determine if there is any health risk (from surrounding land uses) if the water will be used for potable supply. This is due to historic pesticide contamination issues across Guadalcanal Province (including within Tina catchment) particularly associated with oil palm plantations and their intensive use of herbicides/pesticides.

Suggest using a limited suite of pesticides from Table 8.13 of the WHO Drinking water quality guidelines (4th ed) – chemicals from agricultural activities that are of health significance in drinking water.

Most labs such as ALS Brisbane will be able to test for this standard suite in a single sample preserved in amber glass vials (obviously recognising these will need to be shipped from Honiara). At least a once off sample prior to commissioning the bore should be used to assess health risk. If pesticides are detected, they should then be monitored at least 2 times per year (once in dry, once in wet season) for surveillance while the bore is in use.

If testing indicates any issues (limits exceeded), HEC will either need to find an alternative supply, or propose treatment to improve quality to the standard required to avoid risks to human health.

Page 11: [27] Commented [WW104R103] Waddell, William 9/29/2021 9:17:00 AM

If testing fails then does HEC propose treatment?

PW. Further test data has been provided in this report, HEC submitted this to OE previously. A comprehensive suite of parameters will be analysed during testing and at regular intervals thereafter. We were not aware of any sources of heavy metals in the catchment nor were we aware of any existing evidence of existing evidence of pesticide contamination of groundwater, if so that is alarming. If a source-pathway- receptor analysis is done we can see no justification for unnecessary analyses. However given the concern has been raised HEC feel obliged to conduct the

pesticide analysis. We have a quote from ALS Brisbane and although we believe pesticide contamination of the Camp bore is extremely unlikely we are preparedto do an analysis. in the extremely unlikely event a positive analysis is returned then the implications for the Palm Oil industry and hundreds of community wells will be enormous.

Subsequent videocon with Jessica and OE agreed neither heavy metal analyses nor pesticde analyses are warranted given the alarm it would cause in community.

Page 15: [28] Commented [GJ122] Grinter, Jessica 9/28/2021 4:08:00 PM

What does the landowner intend to use the water for? If potable, then it needs to be treated to drinking water quality standard. Please confirm the landowner's intention and describe the exact use here.

Bear in mind that by supplying water to a third party, HEC takes on liability for any illness or other adverse effect that may be experienced (or claimed) by third party using the supply. It opens HEC and the project up to risk of litigation and reputational damage.

My advice would be for HEC not to enter into this arrangement to limit liability to THL and the project, however obviously that is a decision for HEC to make.

PW. HEC is already providing temporary replacement supply to communities. The landholders bore is same depth as Camp BH and if anything Camp BH quaity will be better.

Page 15: [29] Commented [Shin123R122] Shin 10/14/2021 8:40:00 AM

His borehole is located within camp premises and near the septic tank. So HEC suggested him to discontinue the borehole and he agreed on HEC's approach.

He expressed his intention verbally to use the water for purposes other than drinking water.

Page 15: [30] Commented [HK124R122] Harrison, Kristy 11/16/2021 8:48:00 AM

As this is water supplied to a third party, and no written agreement is in place, the Project need to test the water and ensure drinking water quality. To be address under Section 4

Page 15: [31] Commented [GJ125] Grinter, Jessica 9/28/2021 4:05:00 PM

Why is groundwater needed at the office for "sanitation" in this case? Please explain further to match the uses which are described in Section 1.1 (Table 1-1)

PW. There will be 180 employees needing 50 lpd for toilets and wash room.

Page 15: [32] Commented [Shin126R125] Shin 10/14/2021 8:45:00 AM

50 lpd for toilets, 7 lpd for basin and 32 lpd for shower. However, the amount for shower was calculated based on 50% of Maximum workforce.

Page 15: [33] Commented [GJ127] Grinter, Jessica 9/28/2021 4:11:00 PM

Surely it will be a combination, because office site is only providing 14.8 m^3/day of treated wastewater (assuming full occupation? See comments for Table 1.1 above). That would leave a gap of between 35.2 – 55.2 m^3/day to be supplied from groundwater.

Please check and revise as needed to ensure these numbers are reflecting the expected demand and sources as accurately as possible.

PW. STP will not be installed at Office.. Figures revised.

Page 15: [34] Commented [GJ129] Grinter, Jessica 9/28/2021 4:06:00 PM

In this case, the groundwater would need to be treated to drinking water quality, if it is to be supplied as a replacement for potable water.

Otherwise, HEC can only use groundwater as a contingency for Community NON-POTABLE Water Supply (and this needs to be stated in this table). This would also need to be communicated clearly to the community, to manage expectations and prevent adverse health impacts.

This comment also applies for Camp site.

PW. Analyses indicate potable water quality. Commitment to treatment if non potable given earlier.

Page 18: [35] Commented [GJ158] Grinter, Jessica 9/27/2021 7:52:00 PM

What about other impacts during the drilling process?

Noise - mitigate as much as possible; dirlling only during day time? Drilling will only be done during daytime. The BHs will take about 3 weeks each to complete. The Camp and BP120 BH drilling will be noisy but daytime only and short term.

Vibration (see existing NVMP for examples) Should not be an issue, no blasting involved.

Impacts on fauna sensitive to noise/vibration (e.g. bats, cuscus). Short term only.

Accidental breach / interception of unconsolidated sediments (screen in only one aquifer). These will be drilled with bentonite to avoid hole collapse.

Anoxic or explosive atmosphere conditions/release of trapped gas/vapour – (have a portable gas meter available on site). There are no explosive gases, no entrapped methan if the sediments. No gas detector required.

Hydraulic machinery / moving parts. Refer relevant ESMP

Heavy lifting. Refer relevant ESMP.

Transport and installation of drill rig – especially for the deeper bores (use of heavy vehicles, machinery, possibly suspended loads?). Refer relevant ESMP.

Page 19: [36] Commented [GJ164] Grinter, Jessica 9/28/2021 4:47:00 PM

This approach seems very reactive, although I can understand HEC's nervousness given grievance history to date.

I think HEC have missed the point here. If the WSRP was implemented properly (which is hasn't always been, to date), then grievances should be minor and infrequent. It is up to HEC to improve their reputation and gain the trust of communities. If this is achieved, you shouldn't need to have this contingency.

I would recommend removing this and instead focusing on how HEC can improve their implementation of temporary water supply obligations under the WSRP. Such as properly installing and maintaining rain tanks (not just dropping them off and expecting communities to install the collection system themselves); conducting regular water quality testing (which to date I have not seen results for) and communicating results to communities etc. There is also the option to bring in water tankers from Honiara (as HEC have done to fill rain tanks so far, I understand) as an absolute back stop.

PW. Discussed in TWSRP